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UNIVERSIDADE Ð COIMBRA

Miguel Ângelo Susano Jacinto

EFFECTS OF PHYSICAL EXERCISE ON INDIVIDUALS WITH INTELLECTUAL AND DEVELOPMENTAL DISABILITIES – FROM A THEORETICAL TO A PRACTICAL APPROACH

Thesis in the field of Ph.D in Sport Sciences, the branch of Special Education Needs – Adapted Physical activity, supervised by Doctors José Pedro Ferreira, Maria João Campos and Rui Matos and presented to the Faculty of Sports Sciences and Physical Education of the University of Coimbra.

June, 2023

Faculty of Sports Sciences and Physical Education of the University of Coimbra

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To you grandfather, I will open a bottle in your wine cellar.

This is just the beginning of a life. My sincere and profound thanks!

Abstract

This document aims to present the thesis, carried out as a conclusion of the doctoral program in Sports Science at the Faculty of Sports Science and Physical Education - University of Coimbra.

Individuals with Intellectual and Developmental Disabilities are characterized by the existence of a deficit of intellectual and adaptive functioning in the conceptual, social and practical domain, identified with the mild, moderate, severe and profound degrees and develops before the age of 22. Being aware of the importance of physical exercise to delay some changes caused by inactivity, sedentary lifestyle, and aging, as well as to prevent the onset of metabolic and cardiovascular diseases, we intend to develop two physical exercise programs for this population, analysing the effects on physical fitness, general health, dementia/cognitive function, and quality of life.

For this purpose, this thesis was written in the format of articles, divided into 12 chapters. There was an initial introduction (brief report - chapter 1), five systematic review studies (chapter 2-5), a study protocol (chapter 6-7), two cross-sectional studies (chapter 8-9), two experimental studies (chapter 10-11), and a global discussion and final considerations (chapter 12).

This thesis continues the new paradigm of physical exercise being the basis for the quality of life of individuals with Intellectual and Developmental Disabilities, promoting more active and healthier lifestyles, namely through structured physical exercise. It is a useful tool for reference by all exercise professionals who want to assess and prescribe exercise for individuals with Intellectual and Developmental Disabilities.

Keywords: Intellectual and Developmental Disabilities; Physical exercise; Strength training; Cardiorespiratory training; Quality of life.

Resumo

Este documento tem como objetivo apresentar a tese, realizada como conclusão do programa doutoral em Ciências do Desporto da Faculdade de Ciências do Desporto e Educação Física - Universidade de Coimbra.

Os indivíduos com Dificuldade Intelectual e Desenvolvimental são caracterizados pela existência de um défice de funcionamento intelectual e adaptativo no domínio conceptual, social e prático, identificado com os graus ligeiro, moderado, severo e profundo e desenvolve-se antes dos 22 anos. Conscientes da importância do exercício físico para retardar algumas alterações provocadas pela inatividade, sedentarismo e envelhecimento, bem como para prevenir o aparecimento de doenças metabólicas e cardiovasculares, pretendemos desenvolver dois programas de exercício físico para esta população, analisando os efeitos na aptidão física, saúde geral, demência/função cognitiva e qualidade de vida.

Para o efeito, esta tese foi construída em formato de artigos, divididos em 12 capítulos. Apresentamos uma introdução inicial (formato *brief report* - capítulo 1), cinco estudos de revisão sistemática (capítulo 2-5), um protocolo de estudo (capítulo 6-7), dois estudos transversais (capítulo 8-9), dois estudos experimentais (capítulo 10-11), e uma discussão global e considerações finais (capítulo 12).

Esta tese dá continuidade ao novo paradigma do exercício físico como base para a qualidade de vida dos indivíduos com Dificuldade Intelectual e Desenvolvimental, promovendo estilos de vida mais ativos e saudáveis, através da prática de exercício físico estruturado. Constitui uma ferramenta útil e de referência para todos os profissionais do exercício físico que pretendam avaliar e prescrever exercício para indivíduos com Dificuldade Intelectual e Desenvolvimental.

Palavras-chave: Dificuldade Intelectual e Desenvolvimental; Exercício físico; Qualidade de vida; Treino de força; Treino cardiorrespiratório.

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List of abbreviations

AAIDD: American Association on Intellectual and Developmental Disabilities

ACSM: American College of Sports Medicine

BMI: body mass index

CG: control group

DS: Down Syndrome

DSM-V: Diagnostic and Statistical Manual

EG: exercise group

HF: absolute power of the high-frequency band, 0.15–0.4 Hz, in ms^2

HR_{max}: maximum heart rate

HRV: heart rate variability

ICF: International Classification of Functioning, Disability and Health

IDD: Intellectual and Developmental Disability

IG: indoor group

$I^{2:}$ I squared test

LF: absolute power of the low-frequency band, 0.04–0.15 Hz, in ms^2

LF/HF: ratio of LF-to-HF power

Mean RR: mean of the RR intervals in ms

MeSH: Medical Subject Headings

MMSE: Mini-Mental State Examination

OG: outdoor group

PICOS: P-participants; I-intervention; C-Comparison; O-outcomes; S-study design

pNN50: percentage of successive RR intervals that differ by more than 50 ms

Q: Cochran's Q statistic

QI: quotient intelligence

QoL: quality of life

RCT: randomized controlled trials

RM: repetition maximum

RMSSD: root mean square of successive RR interval differences in ms

SD: standard deviation

SDNN: standard deviation of RR intervals in ms

SPSS: Statistical Package for Social Sciences

T^2: Tau square tests

VO_{2max}: maximum oxygen consumption

WC: waist circumference

WHO: World Health Organization

List of publications

This doctoral thesis is comprised of the following papers (ordered by thesis sequence):

Study 1 - Jacinto, M., Vitorino, A. S., Palmeira, D., Antunes, R., Matos, R., Ferreira, J. P., & Bento, T. (2021). Perceived Barriers of Physical Activity Participation in Individuals with Intellectual Disability—A Systematic Review. *Healthcare*, *9*(11), 1521. https://doi.org/10.3390/healthcare9111521. **(JCR; IF: 3.16; Q2).**

Study 2 - Jacinto, M., Monteiro, D., Antunes, R., Matos, R., Ferreira, J.P., & Campos, M.J. (2023). Effects of exercise on body mass index and waist circumference of individuals with Intellectual and Developmental Disabilities: a systematic review with meta-analysis. *Frontiers in Physiology*, *14*:1236379. https://doi.org/10.3389/fphys.2023.1236379 **(JCR; IF: 4; Q2).**

Study 3 - Jacinto, M., Oliveira, R., Martins, A. D., Brito, J. P., Matos, R., & Ferreira, J. P. (2023). Prescription and Effects of Cardiorespiratory Training in Individuals with Intellectual Disability: A Systematic Review. *Healthcare*, *11*(14). https://doi.org/10.3390/healthcare11142106 **(JCR; IF: 2.8; Q3).**

Study 4 - Jacinto, M., Oliveira, R., Brito, J. P., Martins, A. D., Matos, R., & Ferreira, J. P. (2021). Prescription and Effects of Strength Training in Individuals with Intellectual Disability—A Systematic Review. *Sports*, *9*(9), 125. https://doi.org/10.3390/sports9090125. **(SJR; IF: 0.89; Q1).**

Study 5 - Assessment of isokinetic strength of the lower limbs of individuals with Intellectual and Developmental Disabilities – systematic review with protocol proposal. **Under review in Strength and Conditioning Journal (JCR; IF: 2.5; Q2) since August 11, 2023**

Study 6 - Ferreira, J.P., Monteiro, D., Matos, R., Campos, M., Antunes, R., Jacinto, M. (2022). Effects of physical exercise program in adults with Intellectual and

Developmental Disabilities – A study protocol. *Journal of Clinical Medicine*, *11*(24), 7485. https://doi.org/10.3390/jcm11247485 **(JCR; IF: 4.964; Q2).**

Study 7 - Jacinto, M., Rodrigues, F., Monteiro, D., Antunes, R., Ferreira, J.P., Matos, R., Campos, M.J. (2023). Quality of Life in Individuals with Intellectual and Developmental Disabilities: The Congruency Effect between Reports. *Healthcare*, *11*(12),1748. https://doi.org/10.3390/healthcare11121748 **(JCR; IF: 2.8; Q3).**

Study 8 - Jacinto, M., Matos, R., Gomes, B., Caseiro, A., Antunes, R., Monteiro, D., Ferreira, J. P., & Campos, M. J. (2023). Physical Fitness Variables, General Health, Dementia and Quality of Life in Individuals with Intellectual and Developmental Disabilities: A Cross-Sectional Study. *Healthcare*, *11*(19). https://doi.org/10.3390/healthcare11192688 **(JCR; IF: 2.8; Q3).**

Study 9 - Effects of 24-week exercise program on functional capacity, dementia and quality of life in individuals with Intellectual and Developmental Disabilities. **Under review in Journal of Sports Sciences (JCR; IF: 3.943; Q2) since February 17, 2023.**

Study 10 - Jacinto, M., Matos, R., Monteiro, D., Antunes, A., Caseiro, A., Gomes, B., Campos, M.J.C., & Ferreira, J.P. (2023). Effects of a 24-week exercise program on anthropometric, body composition, metabolic status, cardiovascular response and neuromuscular capacity, in individuals with Intellectual and Developmental Disabilities. *Frontiers in Physiology*, 14:1205463. https://doi.org/10.3389/fphys.2023.1205463 **(JCR; IF: 4.755; Q1).**

Study 11 - Jacinto, M., Ferreira, J.P., Monteiro, D., Antunes, R., Campos, M.J., & Matos, R. (2023). An overview of the effects of physical exercise programs on individuals with Intellectual and Developmental Disabilities. *Motricidade*. https://doi.org/10.1007/10.6063/motricidade.30665. **(SJR; IF: 0.18; Q4).**

Chapter 1 – General introduction

1.1. Background

The International Classification of Functioning, Disability and Health (ICF) (World Health Organization - WHO, 2004), promotes the terms disability and impairment to designate a multidimensional phenomenon that results from the interaction of people with their physical environment. However, it does not adopt a universal recommendation and recommends that people should be recognized the right to be called as they wish.

More specifically, the term Intellectual and Developmental Disabilities (IDD), proposed by American Association on Intellectual and Developmental Disabilities - AAIDD (2010) (previously American Association on Mental Retardation), has been applied to substitute the term intellectual disability or mental retardation. This term (1) better aligns with current professional practices focused on functional behaviours and contextual factors; (2) provides a rationale for individualized support because of its basis in a social-ecological framework; (3) is a less offensive term to people with disabilities; (4) is more consistent with international terminology.

In the same sense, the American Psychiatric Association also updated the terminology in the fifth edition of the Diagnostic and Statistical Manual (DSM-V) changing mental retardation to IDD to refer to deficits in cognitive ability that begin in the developmental period, in a clear effort to adopt the terminology already use by the WHO and the AAIDD. As a result of the recommendations of prominent institutions in this area, the term disability is also adopted by the United Nations, in the text of the Convention on the Rights of Persons with Disabilities (United Nations, 2006).

The population with IDD is characterized by a deficit in intellectual and adaptative functioning in the conceptual, social, and practical domains and is based on three criteria: (1) deficit in intellectual functions (reasoning, problem solving, planning, summarizing, thinking, judgment, school learning, and learning from experience), supported by clinical assessment and standardized, individualized intelligence testing; (2 deficit in one or more adaptive behaviours, which affect activities of daily living (communication, social participation, independent living in diverse environments, such as home, school, work, or community); (3) identified as mild, moderate, severe or profound, developing before age 22 (Schalock et al., 2021). Intellectual functioning concerns the mental capacity of each individual, namely the ability to learn, solve problems, think, among others, usually assessed by the Wechsler Adult Intelligence

Scale (2008) - WAIS-IV, validated for the Portuguese population, being one of the best known methods to assess intellectual functioning. Adaptive behaviour concerns acquisitions made by the individual in their daily lives, such as conceptual, social, and practical skills. In turn, conceptual ability concerns the ability to communicate, orientation and domains of some concepts such as numbers or time. Social skills refer to the ability to solve social problems, respect and follow rules, social responsibility, as well as self-esteem. Practical skills relate to daily activities, such as routines, personal care, health care, money management, cell phone use, among others (Schalock et al., 2010).

Although the life expectancy of these individuals has been increasing over the years (Dieckmann et al., 2015), they still have shorter longevity (Emerson et al., 2014; Emerson & Hatton, 2013; Glover et al., 2017; Glover & Ayub, 2010; Heslop & Glover, 2015; McCallion & McCarron, 2014; Tyrer et al., 2007). When compared to people without disabilities, individuals with IDD age prematurely (namely around age 40-50 (Lin et al., 2011; WHO, 2000)), much due to the lifestyle they lead (Coppus, 2013). The sedentary and inactive lifestyles that they adopt (Dairo et al., 2016; Harris et al., 2017, 2019) are directly related to low physical fitness (Borji et al., 2014; Chow et al., 2018; Gawlik et al., 2016; Wouters et al., 2020), which makes them at higher risk of developing chronic diseases, particularly metabolic and cardiovascular diseases (Winter et al., 2012a) and consequent early death (O'Leary et al., 2018). In the same sense, an increased risk of developing chronic health problems or multimorbidity (Cooper et al., 2015; Hermans & Evenhuis, 2014; Timmeren et al., 2017), represents high health costs, namely with more frequent medical care, acquisition of prescribed medication, among others (Anderson et al., 2013; Krahn & Fox, 2014; Lunsky et al., 2018).

Although improved medical care has gradually improved, increasing the average life expectancy, alternative and innovative strategies to maintain/increase the quality of life (QoL) of these individuals and related variables must be implemented.

The concept and study of QoL in individuals with IDD has been of interest to various stakeholders and has practical implications for interventions for and with this population (Schalock & Verdugo, 2002).

For Barbosa (1998), QoL is expressed by the relationship between man, nature and the environment that surrounds him, forming a whole. Minayo et al. (2000) states that QoL is a personal concept, related to the degree of satisfaction in family, love, social, environmental and existential aesthetics. For this author, the QOL concept expresses knowledge, individual values and experiences, as well as the associations and cultures belonging to certain moments, spaces, times and histories. On the other hand, Vilarta (2004) defines QoL as the way in which subjects live, feel and understand their daily lives, encompassing aspects such as housing, health, education, transport, work and participation in decision-making about them. This notion delimits the conditions in which human beings live, resulting from a set of individual, environmental and social factors (Nahas, Barros & Francalacci, 2000). It can also be defined as the distance between individual expectation and reality, given that the greater the distance, the worse the QoL (Martin & Stockler, 1998).

For WHO, QoL concerns the individual's perceptions of their position in life, in the context, culture and value system to which they are inserted, considering the relationship with their goals, expectations, standards and concerns. The multidimensional construct was validated assuming seven domains: i) physical health; ii) psychological domain; iii) level of independence; iv) social relationships; v) environment; vi) spirituality; vii) personal domain (WHOQOL GROUP, 1994; 1998).

For Schalock et al. (2002), QoL refers to a set of facts that determine the individual's well-being or perception of their social position within the context to which they belong, including individual needs, experiences, sociocultural values and preferences. It is a multidimensional phenomenon composed of domains and factors (Table 1) influenced by individual characteristics and extrinsic factors. Although they may differ from persons with regard to value and importance, these domains cut across all people (Schalock et al., 2011). Specifically in individuals with IDD, assessing QoL allows: i) understanding their degree of satisfaction; understanding personal perceptions; ii) evaluating intervention; iii) supporting decision; iv) evaluating theoretical models. The assessment of QoL allows us to direct the subject toward the life they enjoy and appreciate (Schalock & Verdugo, 2002).

Table 1. Conceptual Model of (Schalock et al., 2002).

Factor	Domain	Indicators
Independence	Personal development	Activities of daily living, adaptive behaviour
	Self-determination	Personal choices, decisions and objectives
Social Participation	Interpersonal relations	Social activities and friendships
	Social inclusion	Social inclusion/community involvement
	Rights	Human and legal
Well-being	Emotional	Protection and security and absence of stress

	Physical	Health, nutrition, sport, recreation and leisure (variables that talk about physical variables)
	Material	Employment and economic status

These alternative and innovative strategies to maintain/increase physical fitness, health and QoL should include physical exercise (Bartlo & Klein, 2011). Physical exercise is a systematic planning of physical activity, which needs structure and repetition in order to develop or maintain physical abilities such as strength, resistance, balance and flexibility (Caspersen et al., 1985). The implementation of physical exercise in individuals with IDD, seems to be a good strategy for improving health and well-being, and promoting healthy aging (Reppermund & Trollor, 2016) and success in performing activities of daily living (Alghadir et al., 2020; Calders et al., 2011; Jeon & Son, 2017; Raulino et al., 2014), influencing their independence (Hilgenkamp et al., 2011; Oppewal et al., 2014).

Regular physical exercise seems to promote QoL in individuals with IDD (Lante et al., 2014; Pestana et al., 2018; Tamin et al., 2015). In Pérez-Cruzado and Cuesta-Vargas study (2016), an 8-week physical exercise intervention program promoted physical fitness and QoL in 40 participants. In turn, Carbó-Carreté et al. (2016), with 529 participants, identifies benefits in each of the domains of the model presented above, when practicing physical exercise.

Although the benefits of regular physical exercise among individuals with IDD seem clear, namely regarding their QoL, the involvement in this type of program is limited. On the other hand, the literature has indicated that one of the main reasons for the adoption of sedentary and inactive lifestyles is the existence of barriers to physical exercise, namely family, social, architectural, and financial factors (Cartwright et al., 2017; Mahy et al., 2010; Rimmer et al., 2017; van Schijndel-Speet et al., 2014), and tools that reduce/attenuate these barriers are needed in order to promote healthy aging and the QoL of these individuals.

1.2. General objectives

Although there is some evidence that exercise induces positive changes in physical fitness in short-term programs, the adherence remains a critical point, especially when the prescription is not well accepted by the participants. The main purpose of this thesis is to prescribe and assess the effects of two physical exercise programs on physical fitness, general health, dementia/cognitive function, and QoL of institutionalized individuals with IDD. It is also pretended that this thesis will be a useful tool for physical exercise technicians, either by identifying barriers to physical activity, by the recommendations for evaluation and prescription, or even by the effectiveness of the two programs presented.

1.3. Study relevance

It is also pretended that this thesis will be a useful tool for physical exercise professionals, either by identifying barriers to physical activity, by the recommendations for evaluation and prescription, or even by the effectiveness of the two programs presented.

1.4. Organization of PhD thesis document

After a brief introduction/characterization of the population (chapter 1), chapters 2 aimed to update the knowledge about the existing barriers to physical activity. Barriers are defined as any constraints or obstacles that impede/difficult the practice of physical activity in the same way as other people. It consists of a systematic review study, which aimed to survey the perception of various stakeholders about the barriers faced by individuals with IDD to physical activity, in the broad sense of the word. This systematic review is an update of a previously published one, to understand if there had been any changes. The chapters presented below assume the reduction/decrease of some identified barriers, namely: i) lack of adapted physical exercise programs (in its tangible form with the presentation of two exercise programs - one indoor and one outdoor); ii) high financial cost of the practice (outdoor exercise program - low-cost).

After identifying the barriers to practice, the aim was to prescribe physical exercise adapted to individuals with IDD. Therefore, it was necessary to determine the best training method to prescribe. Considering that individuals with IDD have a high risk of cardiovascular and metabolic diseases, a review study was conducted (chapter 3), to understand which type of training is more effective to promote these variables. We selected two body composition variables that are associated with the risk of cardiovascular and metabolic diseases in individuals with IDD: waist circumference (WC) and body mass index (BMI). In addition to being associated with the diseases presented above, these body composition indicators are related to QoL. The study of strategies that promote such variables in this population is important, not only to reduce healthcare costs, but also to promote QoL. After the conclusion of this chapter, the most effective training method to promote WC (cardiorespiratory training) and BMI (strength training) was identified to carry out the prescription.

Considering the results of chapter 3, we conducted two systematic reviews (chapter 4 and 5), to identify some important aspects for the assessment and prescription of cardiorespiratory and strength exercise for individuals with IDD. Along with the American College of Sports Medicine - ACSM (2021) recommendations, these two chapters will contribute to assessing and prescribing in the most adapted way possible, in order to reduce one of the barriers to the practice evidenced: lack of adapted physical exercise programs.

As the isokinetic dynamometer is a robust and valid tool for assessing neuromuscular capacity, which in turn is an indicator of functional ability, independence, and QoL, chapter 6 presents a suggested isokinetic assessment protocol. This chapter provides insight into the development of a useful tool for the various stakeholders interested in assessing lower limb isokinetic strength of individuals with IDD, for clinical, rehabilitation, or performance purposes.

The next chapter (7) describes in detail the prescription of exercise in an indoor and outdoor context. Before that, it presents all the procedures to be taken into consideration at the possible moment of evaluation. This study will assist in the development of more effective strategies, recommendations, and interventions to ensure better and greater adherence to physical exercise by individuals with IDD, namely recommendations for assessment, prescription, and implementation of physical exercise for this population.

Considering chapter 7, an institutionalized sample of individuals with IDD was recruited and assessed. In chapter 8, we analysed the congruence between responses on QoL perception. Emphasizing that it is important not only to measure the QoL perceptions of individuals with ID through the perceptions of their family members, but also through self-reports, both reports being complementary. It can have a negative impact on the QoL of individuals with ID if their opinions are not considered when planning strategies. In chapter 9, we analysed anthropometric values, physical fitness variables, general health, dementia/cognitive function and QoL. This initial assessment is important, not only for the initial anamnesis but also for the design and implementation of an adapted, effective, and safe exercise programs according to their characteristics.

The sample recruited for chapters 8 and 9 was divided by convenience into an indoor training group (IG), outdoor training group (OG) and control group (CG), performing the protocol presented and described in chapter 7. Chapter 10 presents the results of the impact of the intervention on functional capacity, dementia/cognitive function, and QoL. In turn, chapter 11 presents the results of the impact of the intervention on the health indicator and neuromuscular capacity.

Finally, a last chapter (11) is presented, where a general discussion of the thesis is carried out, where we discuss the practical implications of each chapter presented. We will also present in this chapter the limitations of this thesis, as well as some ideas for future research.

Chapter 2 – Perceived barriers to physical activity participation in individuals with Intellectual and Developmental Disabilities – a systematic review (study 1)

Jacinto, M., Vitorino, A. S., Palmeira, D., Antunes, R., Matos, R., Ferreira, J. P., & Bento, T. (2021). Perceived Barriers of Physical Activity Participation in Individuals with Intellectual Disability — A Systematic Review. *Healthcare*, *9*(11), 1521. https://doi.org/10.3390/healthcare9111521.

2. Abstract

Individuals with IDD tend to have a sedentary lifestyle, with low physical fitness and an increased risk of chronic diseases. One reason for the prevalence of a sedentary lifestyle is the existence of barriers to participation in physical activity. The purpose of this systematic review is to update knowledge about the perceived barriers of physical activity participation in individuals with IDD. Electronic searches were carried out in the PubMed, Scopus, SPORTDiscus and Web of Science databases, from September 2020 to May 2021, and included articles published between January 2016 and May 2021. The terms used were: "mental retardation", "intellectual disability", "intellectual disabilities", "physical activity", "motor activity", "barriers", "obstacles", "embarrassment" and "constraint", in combination with the Boolean operators "AND" or "OR". After the methodological process, five studies were included for analysis. These studies revealed the existence of several perceived barriers to regular physical activity participation, which were grouped into five main groups: personal (6 topics), family (4 topics), social (13 topics), financial (1 topic) and environmental (1 topic). The knowledge and identification of participation barriers can be of extreme importance both to institutions and professionals aiming to enhance the participation of individuals with IDD in regular physical activity programs.

Keywords: Barriers; Intellectual Disability; Interview; Physical activity; Sedentary lifestyle.

2.1 Introduction

IDD is characterized by a deficit in intellectual and adaptive functioning in the conceptual, social and practical domain, being identified with deep, severe, moderate and mild degrees, developing before the 22 years old (American Psychiatric Association, 2013).

In this population, sedentary lifestyles prevail (Dairo et al., 2016; Hsieh et al., 2017), not meeting the WHO physical activity guidelines (Bull et al., 2020).

Due to their sedentary lifestyles, individuals with IDD have low levels of physical fitness (Borji et al., 2014; Chow et al., 2018; Gawlik et al., 2016), with an increased risk of acquiring other comorbidities such as type II diabetes, hypertension, cholesterol and metabolic syndrome (Winter et al., 2012a,b). On the other hand, adopting a healthy active lifestyle and regular physical activity participation positively affect their physical ability (aerobic capacity, strength, balance and flexibility), cognition, health and QoL (Bartlo & Klein, 2011; Calders et al., 2011; Pestana et al., 2018; Ptomey, Szabo, et al., 2018).

One of the reasons found in the literature that can justify the fact that these individuals adopt sedentary lifestyles is the existence of barriers/obstacles/constraints that make the practice of physical activity difficult (Bossink et al., 2017; McGarty & Melville, 2018).

Previous research has already mentioned the existence of these barriers, such as Bossink's study (2017), which reported that there are 14 personal barriers and 23 environmental barriers to physical activity participation. Additionally, and according to McGarty and Melville's study (2018), the barriers to physical activity participation are associated with three main factors: (i) family members, (ii) personal factors and (iii) social factors.

Over the years, the barriers identified by these authors may have already been overcome and new ones may have emerged, and some of these studies are limited in time and fail to analyse other perspectives and perceptions rather than those expressed by family members.

For this reason, the purpose of the present systematic review is to contribute to a better understanding of the perceived barriers of physical activity participation in individuals with intellectual disability, analyse the reasons and the factors involved and to identify the main strategies to be used by professionals based on the perception of the different stakeholders (individuals with IDD, their families or technical caregivers).

2.2 Materials and Methods

The systematic review was carried out in accordance with the PRISMA protocol (Moher et al., 2015; Page et al., 2021) and the methods suggested by Bento (2014). The protocol was registered in the INPLASY, with number INPLASY2021100092 (DOI:10.377667inplasy2021.10.0092). The PICOS strategy (Methley et al., 2014; Nang et al., 2015) was defined in order to obtain a final sample of studies that: included participants (P) with IDD (Down syndrome—DS included), of any age, gender, ethnicity or race; that intended to identify the effects of the perceived barriers to physical activity (I) on these individuals' participation in physical activity (O).

2.2.1 Information Sources and Search Strategy

Exploratory research was performed in the databases (from September 2020 to the 12 of May 2021) to better understand the potential for this review and to define the research question and methodology to be used. The next day (13 of May 2021), an electronic search was carried out using the following databases: PubMed (all fields), SPORTDiscus, Web of Science and Scopus (article title, abstract and keywords), and this included the period between 2016, i.e., the end date of Bossink et al.'s (2017) systematic review, and May 2021. The following search indexed descriptors were used in all databases: "mental retardation" (Medical Subject Headings - MeSH Terms), "intellectual disability" (MeSH Terms), "intellectual disabilities" (MeSH Terms), "physical activity" (MeSH Terms), "motor activity" (MeSH Terms), "barriers", "obstacles", "embarrassment" (MeSH Terms) and "constraint", in the following format: ("mental retardation" OR "intellectual disability" OR "intellectual disabilities") AND ("physical activity" OR "motor activity") AND ("barriers" OR "obstacles" OR "embarrassment" OR "constraint"). In the first phase, articles were organized, and duplicates were identified and excluded using EndNote software. Subsequently, articles were analysed and selected based on the fulfilment of the defined inclusion and exclusion criteria. In addition, the reference lists were revised, and articles of interest were identified and included in the systematic search.

2.2.2 Information Sources and Search Strategy

To be included in the present systematic review, studies had to meet the following criteria: (i) full-text scientific publication in the English language; (ii) no restrictions regarding race or ethnicity; (iii) studies with any age group or gender; (iv) studies without restrictions on the number of participants; (v) studies that described the assessment instruments used; (vi) studies that clearly and objectively present the results related to the impact of potential barriers to physical activity participation in individuals with IDD. The major exclusion criteria used in the study were the following: (i) review articles, comments, theses or abstracts published in minutes of congresses or conferences; (ii) individuals with pathologies other than IDD and DS, such as, for example, autism, motor disabilities, hypertension, among others; (iii) studies with athletes registered in sports federations.

2.2.3 Selection and Data Collection Process

After completing the systematic search, duplicates were eliminated and all the articles that did not meet the inclusion criteria were removed. The studies selected in the previous phase were reviewed in their entirety by two independent reviewers (MJ and DP) according to the specific eligibility criteria. The main reviewer (MJ) identified the relevant information about each one of the studies and organized it in summary tables by: authorship, year of publication, country (origin of the research team), objectives, participants, type of study, evaluation techniques, main results/conclusions and quality of information index (see Table 2). After reading the full text of the studies, and according to the eligibility criteria previously defined, the study sample was constituted by five studies.

Table 2. Characteristics of the studies

Author, Reference, Country	Aims	Participants	Type of Study	Evaluation Techniques	Barriers to PA Practice	Quality Score
Alesi (2017) Italy	Compare the perceptions about the practice of physical activity between parents of children with and without DS.	19 families of individuals with DS (children: 10 boys and 9 girls, 20.94 years); Recruitment: support institutions for people with DS.	Exploratory study.	Semi-structured interview with family members; Maximum duration of 25 min.	Lack of technical specialists in adapted physical activity; Lack of adapted physical activity programs; Lack of inclusive programs; Characteristics of the disability itself (physical, physiological and psychological); Parent's preoccupation; Lack of time for parents to engage in physical activity with their children; Transport difficulties (high costs, lack of transport); Limitation on economic resources.	Poor
Cartwright et al. (2017) United Kingdom	Analyse the perspectives of individuals with IDD and their caregivers about physical activity.	N = 42 (12 individuals who were part of the project, 10 family members, 10 technical caregivers and 10 individuals with IDD); Recruitment: day centres in Scotland.	Qualitative study.	Semi-structured interviews, with different questions for the 4 groups.	Acceptance of the inactive lifestyle of people with IDD—technical caregivers, family members and individuals with IDD; Limitation of human resources—technical caregivers and project leaders; Other preferences of intitution-techical caregivers; Communication problems between caregivers and family members regarding the dynamization of physical activity —technical caregivers, family members and project leaders.	Poor
McGarty et al. (2021) United Kingdom	Explore parents' experience in promoting physical activity to their children with IDD.	N = 8 family members (4 mothers, 3 fathers and a stepfather—a recruited couple, who responded separately); Age of children: 10 to 18 years old (6 male; 1 female) Recruitment: support schools and clubs for people with IDD in Glasgow.	Exploratory study.	Semi-structured interviews with family members; Duration: 20 to 55 min.	Lack of information about adequate and inclusive physical activity; Social exclusion; Fear of parents in relation to bullying; Other preoccupation of parents; Lack of support; Lack of inclusive opportunities; Stigma and lack of understanding about disability; Barriers related to disability itself.	Poor
Salomon et al.	Perception of barriers and facilitators to the	N = 14; 6 renumbered workers and 8	Qualitative study.	Semi-structured interviews.	Both groups: (i) aging; (ii) health problems; (iii) lack of adapted spaces; (iv) lack of	Poor

(2019) Australia	practice of physical activity and healthy eating (separately).	people with IDD; >60 years; Recruitment: support service for people with IDD.			inclusion; IDD group: (i) chronic diseases; (ii) climatic conditions; Group of workers (i) low concentration; (ii) challenging behaviours; iii) social stigma; (iv) lack of adapted places; (v) sensory issues (example: loud music in spaces; (vi) limitation of financial resources; (vii) limitation of human resources.	
Stanish et al. (2016) USA	Compare pleasure with physical activity, perceived barriers, beliefs and self-efficacy between IDD and the general population.	N = 98; IDD group (N = 38, 3–21 years, mean age:16.8 years); general population group (N = 60, 13–18 years, mean age 15.3 years); Recruitment: agencies, organizations and schools to support individuals with IDD.	Cross-sectional study.	Structured interview of 33 closed response items; Duration: 15 to 20 min.	IDD group: (i) physical activity is difficult to learn; (ii) lack of places to practice physical activity.	Poor

Note: IDD, Intellectual and Developmental Disabilities; Min, Minutes; N, Participants; DS, Down syndrome.

2.2.4 Evaluation of the Quality of the Studies

The Downs and Black Scale (1998) was used to assess the methodological quality of studies. This scale consists of 27 items, punctuated with "one value" or "zero", characterizing the different parts of an article. The methodological quality of studies was independently assessed by two researchers (MJ and DP). The results obtained by both were compared and discussed, so that a consensus was reached. When consensus was not possible, a third researcher was invited to collaborate (AV). The scale's scoring intervals received corresponding levels of quality: excellent (26–28); good (20–25); fair (15–19); and poor (≤14). However, as fifteen questions (questions 8, 10–12, 14–17 and 21–27) were not applicable to all studies analysed, they were removed. The scale, after being modified, had a maximum of 12 points in relation to the original.

In the present study, no study was excluded due to a low-quality score.

2.3 Results

2.3.1 Selection of Studies

The initial search carried out in the four databases revealed a total number of 159 articles identified. In the first phase, and after reading the titles and abstracts, seven potentially relevant studies were identified for the next phase. Considering the applicability of inclusion and exclusion criteria previously defined for this systematic review, and after the complete reading of the articles, a sample of five studies was considered for full analysis.

Figure 1 represents the PRISMA flowchart diagram for the selection of studies in this systematic review.

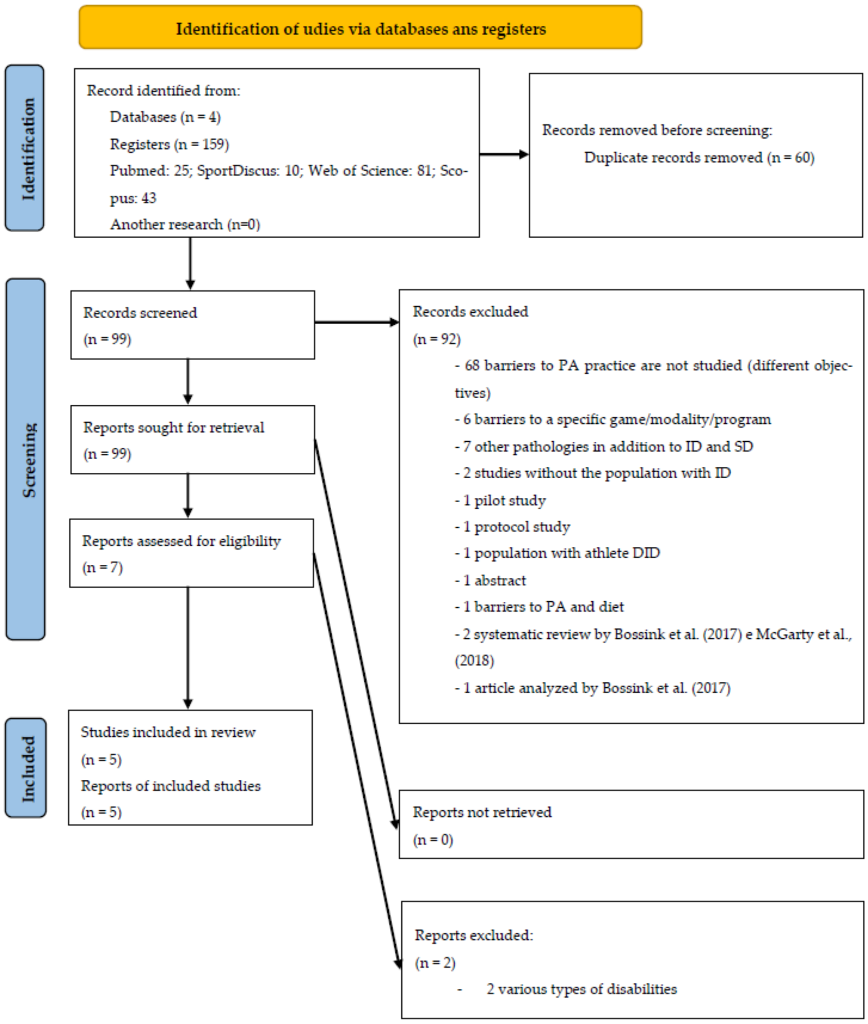

Figure 1. PRISMA flow diagram illustrating each phase of the search and selecting process.

2.3.2 Methodological quality

The methodological quality of the studies was assessed as poor in all studies; however, no study was excluded due to the low-quality score. The quality classification is shown in Table 2.

2.3.3 Characteristics of the Studies

Table 2 presents the characteristics, results and methodological quality of the studies included for final review.

2.3.4 Origin

Through the systematic review process, we identified five studies: three other studies from Europe (Italy (Alesi, 2017), United Kingdom (Cartwright et al., 2017; McGarty et al., 2021), one from Oceania (Australia (Salomon et al., 2019)) and another from North America (USA (Stanish et al., 2016)). Although all studies use a qualitative methodology, we can see different designs.

2.3.5 Type of Studies

Two exploratory studies, two qualitative studies and one cross-sectional study were included.

2.3.6 Participants

From a total of 181 participants, only 56 were individuals with IDD. All the other participants were family members, technical caregivers or project leaders. Three studies underlined the importance of self-reported responses by individuals with IDD (Cartwright et al., 2017; Salomon et al., 2019; Stanish et al., 2016). All studies emphasize the importance of the perception of physical activity participation barriers in individuals who are supported by institutions that support people with disabilities. At the same time, some studies analysed facilitators and recommendations for participating in physical activity. In terms of age group, one of the studies does not refer the age of the individuals with IDD (Cartwright et al., 2017), three other studies have samples from young adolescents (Alesi, 2017; McGarty et al., 2021; Stanish et al., 2016) and one study is focused on elderly participants (Salomon et al., 2019).

2.3.7 Evaluation Techniques

All studies used as instrument or evaluation technique, a semi-structured or rigid interview; however, in two studies we do not have information on the questions or topics. Cartwright et al. (2017) used different topics for different groups: seven for individuals with IDD themselves, seven for family members and caregivers and four topics for the project leaders. McGarty et al. (2021) used four main topics in the semi-structured interview (to family members). Stanish et al. (2016) chose to use the questionnaire and passed it on to the participants in the form of a rigid interview, which is easy to answer, in both groups of participants. Two studies did not report the duration of the interview, which lasted a maximum of 55 minutes in two studies (Alesi, 2017; McGarty et al., 2021) and 20 minutes in another study (Stanish et al., 2016).

2.3.8 Barriers to physical activity practice

Considering the results of the studies of this systematic review, we can classify the following barriers to physical activity participation into five different factors, as shown in Table 3.

Table 3. Barriers to physical activity practice divided by different factors.

Personal	Characteristics of the disability itself (physical, physiological and psychological); acceptance of inactive lifestyles; aging; health problems; lack of concentration; challenging behaviours.
Family members	Parents' concerns (bullying, among others); acceptance of inactive lifestyles; communication problems with technical caregivers; lack of time to engage in physical activity with their children.
Social	Acceptance of inactive lifestyles; lack of information on adapted physical activity; lack of adapted physical activity programs; lack of inclusive opportunities; lack of technicians specialized in adapted physical activity; lack of places to practice physical activity; limitation of human resources; other preferences of the institution providing support services; communication problems between family members and caregivers; social exclusion (stigma and lack of understanding in relation to disability); lack of support; sensory issues (music too loud in training places); difficulties in transportation (high costs, lack of transport).
Financial	Limited financial resources.
Environmental	Climate.

Complementarily to previous results, in a study assessing IDD athletes' perceptions about barriers to physical activity participation (Abellán & Januário, 2017), social barriers were also identified, namely the lack of adapted transport, in addition to environmental barriers specific to their condition such as travel time to the training site and the time it takes to arrive at the next appointments. As athletes, they were expected to adopt more active lifestyles and have already overcome a set of a posteriori barriers.

Regarding the perception of physical activity participation barriers in individuals with IDD that received support from institutions, they can be divided by personal, social and environmental factors (Table 4), which we highlight:

Table 4. Barriers to physical activity practice in the perception of individuals with IDD.

Personal	(i) Preference for inactive lifestyles (Cartwright et al., 2017); (ii) Aging (Salomon et al., 2019);

	(iii) Health problems (Salomon et al., 2019).
Social	(i) Lack of adapted spaces (Salomon et al., 2019); (ii) Lack of inclusion (Salomon et al., 2019); (iii) Lack of places to practice physical activity (Stanish et al., 2016); (iv) Lack of adapted physical activity (Stanish et al., 2016).
Environmental	(i) Adverse weather conditions (Salomon et al., 2019).

On the other hand, Table 5 shows the physical activity participation barriers from the perspective of the interviewed family members.

Table 5. Barriers to physical activity practice in the perception of family members.

Personal	(i) Characteristics of the disability itself (Alesi, 2017; McGarty et al., 2021).
Social	(i) Lack of specialists in adapted physical activity (Alesi, 2017); (ii) Lack of adapted physical activity programs (Alesi, 2017); (iii) Lack of inclusive programs (Alesi, 2017; McGarty et al., 2021); (iv) Difficulties in transportation (Alesi, 2017); (v) Lack of information about adequate and inclusive physical (McGarty et al., 2021); (vi) Social exclusion (McGarty et al., 2021); (vii) Lack of support (McGarty et al., 2021); (viii) Stigma and lack of understanding of disability (McGarty et al., 2021).
Family members	(i) Parents' concerns (Alesi, 2017; McGarty et al., 2021); (ii) Lack of time for parents to engage in physical activity with their children (Alesi, 2017); (iii) Acceptance of children's inactive lifestyles (Cartwright et al., 2017); (iv) Communication problems between family members and caregivers (Cartwright et al., 2017).
Financial	(i) Limitation of economic resources (Alesi, 2017).

Analysing the technical caregivers perceived physical activity participation barriers, we highlight, in Table 6, the following barriers:

Table 6. Barriers to physical activity practice in the perception of technical caregivers.

Personal	(i) Aging (Salomon et al., 2019); (ii) Health problems (Salomon et al., 2019); (iii) Low concentration capacity (Salomon et al., 2019); (iv) Challenging behaviours (Salomon et al., 2019).
Social	(i) Lack of adapted spaces (Salomon et al., 2019); (ii) Lack of inclusion (Salomon et al., 2019); (iii) Stigma (Salomon et al., 2019); (iv) Sensory issues (Salomon et al., 2019); (v) Lack of human resources in institutions (Salomon et al., 2019); (vi) Acceptance of inactive lifestyles (Cartwright et al., 2017; Salomon et al., 2019); (vii) Other preferences of technical caregivers and institutions (Cartwright et al., 2017); (viii) Communication problems between family members and caregivers (Cartwright et al., 2017).
Financial	(i) Limitation of financial resources (Salomon et al., 2019).

The present study also included an article that analysed the perception of project leaders about physical activity participation barriers in the population with IDD

(Cartwright et al., 2017), stating that such barriers are related to the following social factors, as shown in Table 7.

Table 7. Barriers to physical activity practice in the perception of project leaders.

Social	(i) Limitation of human resources; (ii) Communication problems between family members and caregivers.

The studies included in this systematic review also provide some recommendations for reducing and attenuating barriers, which are presented in Table 8.

Table 8. Summary of study recommendations

Greater participation by families	Alesi (2017); McGarty et al. (2021); Stanish et al. (2016)
Creating more adapted sports offerings	Alesi (2017)
Organize environments that aim to stimulate sports participation	Alesi (2017)
Organizational change, in the sense of giving greater importance to physical activity in the lives of people with IDD	Cartwright et al. (2017)
Local authorities or organizations to increase the offer of adapted physical activity and finance services	Cartwright et al. (2017); Stanish et al. (2016)
Pay more attention to the sporting preferences of individuals	Cartwright et al. (2017)
Greater cooperation between all parties in order to promote physical activity	Cartwright et al. (2017)
More and better support and information	McGarty et al. (2021)
Personal training	Stanish et al. (2016)
Physical activity instruction carried out carefully and with quality	Stanish et al. (2016)
Development of group activities	Stanish et al. (2016)

Note: IDD, Intellectual and Developmental Disabilities.

2.4 Discussion

The major purpose of this study is to increase knowledge for a better understanding of the perceived barriers of physical activity participation in individuals with IDD, identify and discuss the reasons and factors associated with those participation barriers and to identify appropriate strategies to be used by professionals based on the perception of individuals with IDD, their families and their technical caregivers.

The social barriers to physical activity participation are those that present a greater set of topics. In the studies included in the present systematic review, individuals with IDD themselves and project leaders are the groups that perceive the least barriers, unlike family members and technical caregivers. In the same sense, a behavioural change in the direct support from professionals is suggested in order to promote physical activity among individuals with IDD (Bossink et al., 2020), increasing interpersonal interaction between both stakeholders as well as the commitment to encourage, adopt and maintain physical activity participation (Chow et al., 2020). On the other end, family members recognize that they are the main barrier to physical activity participation, since they describe themselves as overprotective of their children, given their characteristics (Alesi, 2017). They must mitigate these attitudes and stimulate physical activity participation since physical activity patterns in childhood are seen as relevant predictors of physical activity participation in adulthood (Hartman et al., 2015; Telama et al., 2005). They are preponderant in the process of starting and adhering to physical activity participation in its quantity, duration and complexity (Temple & Stanish, 2011; Trost et al., 2001).

We also highlight those topics such as the characteristics of the disability itself, lack of spaces and adapted activities, which are referenced by the various studies included in the systematic review. The previous reported results are transversal to other types of disability. For motor disabilities, Jaarsma et al. (2014) highlighted the following barriers to physical activity practice: (i) characteristics of the disability itself; (ii) health; (iii) lack of facilities for the practice of physical activity; (iv) transportation; (v) accessibility. Additionally, Marmeleira et al. (2018) identified a set of barriers in the visually impaired population: (i) problems on sidewalks; (ii) lack of adapted facilities; (iii) lack of support from public entities; (iv) need for a guide; (v) lack of adapted physical activity supply; (vi) lack of security in existing facilities. Tsai and Fung (2005) reported the following barriers to physical activity participation in the hearing-impaired population: (i) uncomfortable feelings with society's negative attitudes towards disability; (ii) lack of adapted information; (iii) physical discomfort; (iv) lack of physical fitness; (v) lack of direction; (vi) interpersonal restrictions; (vii) lack of adapted facilities. These barriers lead us to the conclusion that there is an important need to create physical exercise programs that are as personalized and adapted as possible to individuals' needs.

Our study included articles from various age groups, including most perceived barriers to physical activity participation at different ages, except for aspects inherent to aging, climate, sensory issues and limited human resources that are only identified by the elderly population (Salomon et al., 2019).

The results of the present study confirm the existence of clear barriers to physical activity participation in individuals with IDD at all levels. Some of them have been identified in the literature for quite a long time, as is the case for Messent et al.

(1998), where intrinsic and extrinsic barriers are mentioned, or in more recent studies, as is the case for Bossink et al. (2017), where 14 personal barriers and 23 environmental barriers were identified, and McGarty and Melville's (2021) study that, despite asking only family members, suggested that barriers to physical activity participation were related to three factors: (i) family members; (ii) personal; and (iii) social. All barriers found through the present study have already been identified and mentioned by previous systematic reviews. However, based on Bossink et al.'s study (2017), the barriers seem to have attenuated/decreased, since in this systematic review there were no topics such as: (i) individual fears; (ii) lack of motivation; (iii) anxiety on the part of the technicians (fear of doing something wrong). Aiming to increase the regular practice of physical activity, the results of this systematic review can be seen to indicate that recommendations/strategies are being put into practice, and this may be at the origin of the decrease in some barriers. Some studies analysed in this systematic review provide a set of strategies/recommendations (Alesi, 2017; Cartwright et al., 2017; McGarty et al., 2021; Stanish et al., 2016) that can be seen as contributions to mitigate/decrease barriers to physical activity practice that must be taken into account. This fact may lead individuals to adopt more active lifestyles, which lead us back to the Ecological Model for Health Promotion (McLeroy et al., 1988), in a perspective that can support the process of behavioural change and promote health (Table 9). The Ecological Model for Health Promotion (McLeroy et al., 1988) emphasizes the importance of social environments for health promotion and requires more active participation by various stakeholders, where the Personal, Interpersonal, Organizational, Community and Public Policy factors have a fundamental role in the structuring, promotion and implementation of physical activity programs, reducing and attenuating the barriers to the practice of physical activity and highlighting the very interventional role of the organization in this process.

Table 9. Relationship between Ecological Model for Health Promotion and study recommendations

	Personal	Interpersonal	Organizational	Community	Public Policy	Author
Greater participation by families		X				Alesi (2017); McGarty et al. (2021); Stanish et al. (2016)
Creating more adapted sports offerings			X	X		Alesi (2017)
Organize environments that aim to stimulate sports participation			X	X	X	Alesi (2017)
Organizational change, in the sense of giving greater importance to physical activity in the lives of people with IDD			X			Cartwright et al. (2017)
Local authorities or organizations to increase the offer of adapted physical activity and finance services			X	X	X	Cartwright et al. (2017); Stanish et al. (2016)
Pay more attention to the sporting preferences of individuals		X	X	X	X	Cartwright et al. (2017)
Greater cooperation between all parties in order to promote physical activity	X	X	X	X	X	Cartwright et al. (2017)
More and better support and information		X	X	X	X	McGarty et al. (2021)
Personal training		X	X			Stanish et al. (2016)
Physical activity instruction carried out carefully and with quality;		X				Stanish et al. (2016)
Development of group activities		X	X	X	X	Stanish et al. (2016)

Note: IDD, Intellectual and Developmental Disabilities.

A limitation of this systematic review is the fact that the studies selected for analysis did not separate the barriers by degree of IDD (mild, moderate, severe or profound), because their impact may be differentiated since they require different support and physical inactivity is greater as the degree of IDD increases. However, self-reports are important, although we are aware that not all individuals have the capacity to respond. That said, in future studies, it is important to analyse the barriers to the practice of physical activity at different degrees/levels, even if through the perception of third parties, so that the support/strategies/interventions are the most adapted possible.

Accordingly, the analysis of barriers to the practice of physical activity, by age and gender, should also be considered in future studies. No studies were found with the Portuguese population, which should be the object of study in future works. Future works should also analyse barriers to the degree of disability (mild, moderate, severe and profound IDD) separately.

2.5 Conclusions

Individuals with disabilities faces a set of barriers to the practice of physical activity. Specifically in IDD, the main barriers to physical activity practice, perceived by individuals with IDD themselves, their families, caregivers/technicians or even from the perspective of project leaders, can be systematized into personal factors (6 topics), family members (4 topics), social (13 topics), financial (1 topic) and environmental (1 topic).

Since the last published systematic review, the number of perceived barriers to the practice of physical activity by individuals with IDD has decreased. This fact may presuppose basic work carried out, considering the strategies and recommendations that have been presented, aiming to promote the practice of physical activity and therefore influencing this change.

The present work reinforces the existence of a set of barriers to the practice of physical activity by several interested parties, being a useful tool for researchers and professionals in the process of structuring, promoting and implementing physical activity programs among individuals with IDD, which should be as adapted as possible to the individual and their preferences in order to contribute to an increase in healthy lifestyles and to an improvement in physical fitness, health and QoL.

Chapter 3 – Effects of exercise on body mass index and waist circumference of individuals with Intellectual and Developmental Disabilities: a systematic review with meta-analysis (study 2)

Jacinto, M., Oliveira, R., Martins, A. D., Brito, J. P., Matos, R., & Ferreira, J. P. (2023). Prescription and Effects of Cardiorespiratory Training in Individuals with Intellectual Disability: A Systematic Review. *Healthcare*, *11*(14). https://doi.org/10.3390/healthcare11142106.

3. Abstract

This systematic review with meta-analysis aims to assess the magnitude of the effects of physical exercise programs on BMI and WC of individuals with IDD, metabolic and cardiovascular health markers. Considering the eligibility criteria, a final sample of nine articles was obtained. For BMI, the *Z*-value obtained to test the null hypothesis (difference between means is zero), showed a Z=-2.176 and p=0.03. The highest magnitude of the effect was from the intervention with combined training (difference in means: -0.399), with a value of Z=-1.815 and p=0.07. For WC, the Z-value is zero, showing a Z=-3.306 and p=0.001. The highest magnitude of the effect was from the intervention with continuous cardiorespiratory training of -0.786, with a value of Z=-2.793 and p=0.005. Physical exercise prevents increases in BMI and WC in individuals with IDD. Aerobic training seems to be more effective in promoting WC and combined training in BMI.

Keywords: Anthropometric assessment, Body Mass Index, Obesity, Overweight, Waist circumference.

3.1 Introduction

Obesity is a major public health problem due to its growing prevalence, particularly in individuals with IDD, as it increases the risk of developing various diseases such as cardiovascular or metabolic diseases (Winter et al., 2009; Vancampfort et al., 2020), increasing mortality in earlier ages when compared to the general population (Hosking et al., 2016). Excessive adiposity results from an imbalance between energy intake and expenditure.

BMI and abdominal adiposity assessed using WC, body composition and anthropometric variables, are essential markers to assess overweight and obesity and are associated to metabolic disease and QoL (Klein et al., 2007; Kobo et al., 2019). This measure are non-evasive methods widely used in individual with IDD to measure nutritional status (Temple et al., 2010; Waninge et al., 2010), with higher values being found when compared to the general population (Zwierzchowska et al., 2021), i.e., individuals with IDD are more likely to be overweight or obese.

A narrative review by and a systematic review with meta-analysis carried out by Maïano and collaborators (2016) showed that children and adolescents with IDD were 1.54 and 1.89 times more likely to be overweight and obese, when compared to the general population. This prevalence of overweight and obesity is transversal to all age groups, from children (Wang et al., 2018), to adolescents (Krause et al., 2016) and adults (Winter et al., 2012b). Several factors may influence this prevalence, such as: i) being female (Winter et al., 2012b); ii) advancing in age (Ranjan et al., 2018); iii) having DS (Krause et al., 2016); iv) having a degree of mild or moderate disability (Ranjan et al., 2018); v) genetic factors (Wang et al., 2018). Other additional factors such as socioeconomic level, perceptions and attitudes towards physical activity, health problems and other characteristics of the disability itself (McGillivray et al., 2013), may also play a determinant role in this prevalence.

Considering the BMI variable, Temple and collaborators (2014), when evaluating 11643 individuals with IDD, verified that 5.5% of the sample was underweight, 36.1% in the normal range, 24.7% overweight, and 32.1% obese, concluding that levels of overweight and obesity were very high. Likewise, Foley and collaborators (2017), evaluating 4174 individuals with IDD, he also found that 32% were overweight and 11% were obese. At the same time, 21% of the participants were above the cut-off for abdominal obesity.

Such evidence, namely the high values of BMI and WC, show a high prevalence of overweight and obesity in individuals with IDD. These values are associated with high risk metabolic and cardiovascular disease, excessive health costs (Vohra et al., 2017; Wyszyńska et al., 2017) and increased risk of incidence and mortality (Parra-Soto et al., 2021). BMI and WC are recommended by ACSM (2021) as two possible measures of anthropometric and body composition for individuals with IDD.

The global impact of physical activity and physical exercise on BMI and WC in people with IDD is not known, nor is the most effective type of exercise training for promoting these variables. International guidelines recommend by WHO (2020) and ACSM (2021) identify physical activity and exercise as important tools to improve daily life and well-being with a positive impact in different age groups (Kim et al., 2019). For people with IDD, regular exercise has been associated with improvements not only in physical fitness but also in metabolic and cardiovascular disease as well as in QoL reducing health costs (Jacinto et al., 2021b; Pestana et al., 2018).

Since all of this work is based on the *Guidelines for Exercise Testing and Prescription* for individual with IDD (ACSM, 2021), we consider aerobic, resistance and flexibility training. According to ACSM (2021) aerobic exercise is the ability of the circulatory and respiratory system to supply oxygen during sustained physical activity, resistance training is the capacity of muscle to exert force and flexibility is the range of motion available at a joint.

The main purpose of the present systematic review with meta-analysis is to measure the magnitude of effects of different types of physical exercise on BMI and WC, metabolic and cardiovascular health parameter, in individual with IDD aiming to provide relevant information to sport sciences and health sciences professionals when planning, implementing and monitoring exercise intervention programs in people with IDD.

3.2 Method

The present systematic review with meta-analysis followed the guidelines defined in the original checklist of Preferred Reporting Items for Systematic Reviews and Meta-Analyses - PRISMA (Page et al., 2021). The protocol has been registered at the PROSPERO International Propective Regiter of Sytematic Review, with a number 2021: CRD42021255316.

The PICOS strategy (Methley et al., 2014; Nang et al., 2015) was used to ensure rigor defining of the research question, in which: i) "P" corresponded to participants with IDD of any age, regardless of ethnicity or gender; ii) "I" corresponded to any physical exercise program implemented in the population with IDD (DS included), regardless of the intervention time, according to ACSM (2021); iii) "C" (Comparison) corresponded to the comparison between the CG versus the EG or pre-training/exercise to post-training/exercise; iv) "O" corresponded to BMI and WC as the first or second variable in focus; v) "S" (Study Design) corresponded to randomized controlled clinical trials (RCT).

3.2.1 Data sources

The search was conducted in the English language, in the following electronic databases: PubMed (title and abstract), Web of Science, and Scopus (title, abstract and key words), accessed between February 2021 and December 2022, using the advanced search option, with randomized exercise intervention studies. The search has been updated until the 10th of December. The search strategy combined Key Medical Subject Heading and indexed search descriptors to refine the data, following the recommendation from the Cochrane Handbook for Systematic Review of Intervention (Higgins & Altman, 2008), as shown in table 10.

Table 10. Search Strategy

Research Content
("intellectual disability" OR "intellectual disabilities" OR "mental retardation" OR "Down Syndrome" OR "Intellectual Developmental Disorder" OR “Intellectual Developmental Disabilities” OR “Intellectual Developmental Disability”) AND ("exercise" OR "training") AND ("body mass index" OR "waist circumference")

3.2.2 Eligibility criteria and studies selection

To be included in the present systematic review with meta-analysis, studies must meet the following inclusion criteria: i) RCT studies with exercise intervention, with any prescription in terms of intensities and duration, according to ACSM guidelines (2021); ii) All participants mut have an IDD diagnosis, whatever the degrees, including other subgroups with IDD; iii,) Participants with IDD of any age, gender, race or ethnicity; iv) Studies focusing on aerobic, neuromuscular, flexibility or combined capacity (training that combines more than one physical capacity, e.g., strength and aerobic capacity), which recommended by ACSM (2021). In turn, all studies with the following characteristics were excluded: i) Studies published in a language other than English; ii) Studies that do not describe the intervention protocol; iii) Studies with participants with another type of disability or other associated pathologies; iv) Studies in which the intervention is multidimensional (studies involving exercise and nutrition, exercise and health education sessions); v) Studies that do not show anthropometric data (BMI and WC); vi) Studies that the intervention protocol is through virtual reality (institution where we want to replicate the protocol does not have access to this material, as well as other institutions where most of this population usually spends their day). All studies that did not meet the initial selection criteria and did not report results adequately (mean, standard deviation and sample size) or if the respective authors did not reply to our inquiries sent by email, were excluded. Finally, articles presented in abstracts, letters to the editor, systematic reviews, study protocols, and book chapters were excluded.

3.2.3 Data Extraction

Studies were imported into EndNote X7 software, and duplicates were removed. The study selection procedure was carried out in phases. In the first phase, the search for potentially relevant studies was carried out with the participation of two independent reviewers, based on the titles and the abstract. These studies would proceed to the next evaluation phase in case of doubt following. In the second phase, the studies from the previous stage were reviewed by the same independent reviewers based on the application of the previously defined eligibility criteria. In case of doubt or disagreement regarding the inclusion of a study, this was solved through a third reviewer's opinion playing the mediator's role and whose decision was used as a tiebreaker. Finally, the first two reviewers involved in the selection of the studies participated independently in the analysis of the studies extracting all relevant information and characteristics, namely the author's name, year and country where it was carried out, objective, participants, instruments/techniques, duration/frequency, and results. In this phase, discrepancies about the extracted data were resolved by consensus among reviewers.

3.2.4 Quality assessment of studies

The PEDro Scale from the Physiotherapy Evidence Database, was used (Maher et al., 2003) to assess the quality of each study. The scale consists of 11 items, which analyse the different characteristics of each study, one of which is not counted (item 1) and the two others are not applicable in the field of sports science (items 5 and 6). The results obtained by both were compared and discussed so that there was a consensus. When there was no consensus, a third researcher was invited to collaborate.

3.2.5 Statistical analysis

Meta-analysis was performed using Comprehensive Meta-analysis Version 3.0 statistical software. The standardised difference in means was calculated based on information on pre and post-intervention means, number of participants, and standard deviation, using the randomized effects model to measure the effect size, the confidence interval (CI) of 95%, the magnitude of effects and level of statistical significance ($p<0{,}05$). Favours A corresponds to EG and Favour B correspond to CG. Heterogeneity was measured using chi-square, Cochran's Q statistic, Higgin I squared (I^2), and Tau square tests (T^2). The Q statistic was used to test the null hypothesis, according to which all studies under analysis share a typical magnitude of effects. If all studies share the same effect-size, the expected values of Q would be equal to the number of degrees of freedom (N-1). I^2, which represents the percentage of variance attributed to the heterogeneity of the study, ranged from low (25%) to high (50%), with 50% being considered moderate (Batterham & Hopkins, 2006). T^2 is the variance of the true effect dimensions (in log units) between studies (Higgins et al., 2003), assuming that $T^2>1$ suggests the presence of substantial heterogeneity. The homogeneity was verified by visualizing the asymmetry of the funnel-shaped scatter plot (Egger et al., 1997), considering that there was no publication bias when the graph had an inverted funnel (Higgins & Altman, 2008). Since the funnel-shaped scatter plot interpretation is sometimes subjective, the Egger test was used to check for publication bias (Rosenblad, 2009). Four meta-analyses were carried out, two to investigate the impact of exercise on the BMI and WC and another two to find out which type of training is most effective in provoking such adaptations.

3.3 Results

3.3.1. Data search

With the search carried out in different databases PubMed, Web of Science, and Scopus) 329 studies were identified. Subsequently, after eliminating the duplicate studies and reading the titles and abstracts, 47 studies with potential relevance to the study were identified. Considering the eligibility criteria previously defined for this systematic review with meta-analysis, from the complete reading of the articles, a sample of nine studies was constituted for their full analysis (Figure 2).

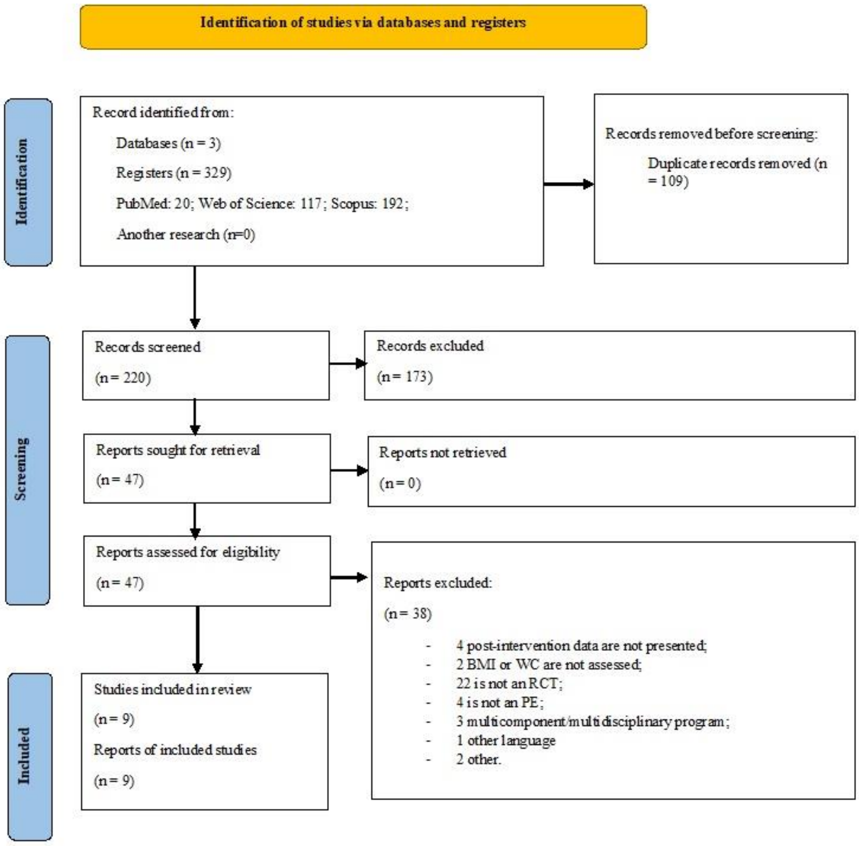

Figure 2. PRISMA flow diagram

3.3.2. Characteristics of the studies

Details of the 9 studies included in the systematic review and assessed for quantitative analysis are presented in Table 11.

Table 11. Characteristics of the 9 selected studies.

Author	Aims	Participants	Assessment tools	Exercise program	Results	Quality score
Boer et al. (2014)	Effects of sprint interval training on metabolic and physical fitness.	N=46; 17 ± 3 years; IDD (fragile X syndrome, fetal alcohol syndrome, Prader–Willi and others); Randomized groups: interval training - Intervention A (N=17); continuous aerobic training - Intervention B (N=15); control (N=14).	BMI (kg/m2); WC (tape).	15 weeks; 2 x week; 40 min/session; Intervention A - Interval training: a sprint interval block (10 min), continuous aerobic exercise (10 min), and another sprint interval block (10 min); each sprint interval block consisted of 10 sprint bouts (>100 r/min) of 15s at a resistance matching with the VTR, alternated with 45s relative rest (50 r/min at VTR); 100% to 110% of VTR; Intervention B – Continuous aerobic training: cycling (10 min), walking/ running (10 min), stepping (10 min); 100% to 110% of VTR.	BMI (pre vs post) Intervention A: 28.4 ± 4.7 vs 27.7 ± 4.7; Intervention B: 27.5 ± 2.7 vs 26.9 ± 3.1; Control: 26.9 ± 3.2 vs 26.9 ± 2.9. WC (pre vs post) Intervention A: 95.8 ± 13.1 vs 91.5 ±13.1; Intervention B: 95.9 ± 9.6 vs 93.4 ± 9.6; Control: 95 ± 8.8 vs 95.9 ± 8.2.	5/8
Boer & Moss (2016)	Determine the effect of continuous aerobic training vs. interval training on several parameters.	N=42; 33.8 ± 8.6 years; DS; Randomized groups: continuous aerobic training - Intervention A (N=13), interval training - Intervention B (N=13); control (N=16).	Body weight; Height; WC (tape).	12 weeks; 3 x week; 30 min/session; Intervention A - Continuous aerobic training: cycling or walking at an intensity of 70%-80% of VO_{2max}; Intervention B - Interval training: 10–30s all out sprints with the 90s (1:3 work-rest ratio) of low cadence, low intensity walking or cycling.	BMI (pre vs post) Intervention A: 30.6 ± 6.1 vs 30.2 ± 6.3; Intervention B: 29.3 ± 4 vs 28.5 ± 4; Control: 31.2 ± 4.6 vs 30.9 ± 4.2. WC (pre vs post) Intervention A: 95 ± 11.1 vs 93.7 ± 11.9; Intervention B: 94.2 ± 8.1 vs 93.8 ± 8; Control: 99.4 ± 10.9 vs 98 ± 10.6.	7/8

Diaz et al. (2021)	Analyze the impact of circuit RT on markers of muscle damage.	N=36; mean age 28.1 ± 3.3 years; DS; Randomized groups: exercise (N=18); control (N=18).	BMI (kg/m2); WC (tape).	12 weeks; 3 x week; Duration of session: NA; Resistance circuit training: 40-65% 8RM; 2 sets; 6 to 10 reps; 90s rest between stations; Exer: arm curl (elbow flexion), triceps extension (elbow extension), leg extension, seated row, leg curl (knee flexion), and leg press (combined hip and knee extension)	BMI (pre vs post): EG: 31.4 ± 5.7 vs 31.6 ± 6; CG: 30.8 ± 5.2 vs 31 ± 5.5. WC (pre vs post): EG: 91.4 ± 12.8 vs 90.8 ± 13.4; Control group: 88.9 ± 13.3 vs 89 ± 13.4.	7/8
González-Agüero et al. (2012)	Effect of training on bone mass.	N=28; 10 to 19 years; DS; Randomized groups: exercise (N=14); control (N=14).	Height; Weight; BMI (kg/m^2);	21 weeks; 2 x week; 25 min/session; 1 or 2 rotations in a four-stage circuit: jumps, press-ups on the wall, fitness bands and medicine balls.	BMI (pre vs post): EG: 19.6 ± 2.7 vs 20.2 ± 2.6; CG: 22.4 ± 3.4 vs 22.3 ± 3.2.	5/8
Ordonez et al. (2014)	Influence of aerobic training on pro-inflammatory cytokines and acute phase proteins.	N=20; 8-30 years; DS; Randomized groups: exercise (N=11); control (N=9).	Height; Body weight; BMI (kg/m2); WC (tape).	10 weeks; 3 x week; 45-65 min/session. Aerobic training: 30-40 min treadmill exercise at 55–65% of peak heart rate.	BMI (pre vs post): EG: 30.2 ± 0.9 vs 29.8 ± 0.7; CG: 30.7 ± 0.8 vs 30.9 ± 0.8. WC (pre vs post): EG: 94.7 ± 3.3 vs 91.5 ± 3.1; CG: 93.5 ± 3.1 vs 93.7 ± 3.2.	5/8
Ortiz-Ortiz et al. (2019)	Effect of a exercise on body composition and isometric strength.	N=22; 8-16 years; DS; Randomized groups: exercise (N=13); control (N=9).	Height; Weight; BMI (kg/m^2).	16 weeks; 5 x week; 55 min/session; Strength training: circuit and “tabata” exercises; Different materials were used, such as weight discs, tension ropes, dumbbells, medicine balls, and handgrips; Exer: biceps curl, triceps extension, chest press, and handgrip with different degrees of tension.	BMI (pre vs post) Males: 21.1 ± 1.8 vs 19.7 ± 1.8; Females: 23.2 ± 2.9 vs 21.5 ± 3; CG: Males: 23.3 ± 6.3 vs 21.8 ± 5.9; CG Females: 23.3 ± 1 vs 22.2 ± 0.9;	7/8

Rosety-Rodriguez et al. (2014)	Determine for how long the anti-inflammatory effect induced by aerobic training.	N=20 ; 18-30 years; DS; Randomized groups: exercise (N=11); control (N=9).	WC (tape).	10 weeks; 3 x week; 60 min/session. Aerobic training: 30-40 min – treadmill; 55–65% of peak heart rate.	WC (pre vs post): EG: 94.7 ± 3.3 vs 91.5 ± 3.1; CG: 93.5 ± 3.1 vs 93.7 ± 3.2.	4/8
Shields & Taylor (2015)	Feasibility of a physical activity program.	N=16; 18-35 years; DS; Randomized groups: exercise (N=8); control (N=8).	WC (tape).	8 weeks; 3 x week; 150 min of moderate intensity PA per week Aerobic training: walking.	WC (pre vs post): EG: 95.6 ± 17.2 vs 90.1 ± 12.1; CG: 89.3 ± 8.8 vs 94.1 ± 7.4.	8/8
Yu et al. (2022)	Effectiveness school-based adapted physical activity.	N=61; 12-18 years; Randomized groups: EG (N=39); CG (N=22).	BMI (kg/m2); WC (tape).	36 weeks; 2 x week; 45-60 min/session; Aerobic training: 30-60% peak heart rate – walk/run; Strength training: jumping jacks, high kness, sit-ups; 10 to 30s/sets; 4 sets; 1 min to 40s break between sets.	BMI (pre vs post): EG: 28.16 ± 3.69 vs 27.5 ± 3.97; CG: 27.37 ± 3.99 vs 28.05 ± 3.75. WC (pre vs post): EG 93.55 ± 10.11 vs 91.54 ± 11.1; CG: 90.51 ± 11.72 vs 92.27 ± 9.26.	6/8

Note: CG, control group; EG, exercise group; Exer, Exercise/s; Min, minutes; N, participants; Rep, repetitions; RM, Maximum repetition; s, Seconds; SD, standard deviation; VO_{2max}, maximum oxygen consumption; VTR, ventilatory threshold; *, Only analysed the exercise and control group.

3.3.3. Quality of the information

Rosety-Rodriguez and collaborators (2014) were the studies that obtained the lowest quality score (4 points - 40%), and the studies with the best scores had 8 points (80%) (Shields & Taylor, 2015), showing a good quality of the methodological procedures.

3.3.4. Participants

The total number of participants included in the different studies was 291, 172 in experimental groups and 119 in CG. The studies included different types of IDD, whether it is DS, autism, or others.

3.3.5. Duration

The exercise intervention programs ranged from 8 to 36 weeks, however is more prevalent a prescription of 10 to 12 weeks (Boer & Moss, 2016; Diaz et al., 2021; Ordonez et al., 2014; Rosety-Rodriguez et al., 2014), i.e., short duration programs. The two combined exercise programs included in this systematic review lasted for 21 to 36 weeks (González-Agüero et al., 2012; Yu et al., 2022), one of neuromuscular capacity exercise programs lasted 16 weeks (Ortiz-Ortiz et al., 2019) and other 12 weeks (Diaz et al., 2021) and the five aerobic exercise programs lasted from 8 to 15 weeks, with half being implemented over 10 weeks (Boer & Moss, 2016; Boer et al., 2014; Ordonez et al., 2014; Rosety-Rodriguez et al., 2014; Shields & Taylor, 2015).

The frequency varied between 2 to 5 times per week, with most studies implementing 3 times per week (Boer & Moss, 2016; Diaz et al., 2021; Ordonez et al., 2014; Rosety-Rodriguez et al., 2014; Shields & Taylor, 2015). The two combined exercise programs included in this systematic review with meta-analysis have a frequency of 2 times per week (González-Agüero et al., 2012; Yu et al., 2022). Regarding neuromuscular capacity, one of the exercise programs have a frequency of 5 times per week (Ortiz-Ortiz et al., 2019) and other 3 times per week (Diaz et al., 2021). Finally, the 5 aerobic exercise programs have a frequency of 2 and 3 times per week, with the majority implemented 3 times per week (Boer & Moss, 2016; Boer et al., 2014; Ordonez et al., 2014; Rosety-Rodriguez et al., 2014; Shields & Taylor, 2015). Regarding the duration of the exercise intervention session, sessions varied between 25 and 65 minutes including a brief warm-up and a return to calm period. The duration of the training session in the two combined exercise programs varied from 25 to 60 minutes (González-Agüero et al., 2012; Yu et al., 2022), one of the exercise programs for neuromuscular capacity were implemented for 55 minutes (Ortiz-Ortiz et al., 2019), with the other one not showing the session duration (Diaz et al., 2021), and from the five aerobic exercise programs four lasted from 30 to 60 minutes (Boer & Moss, 2016; Boer et al., 2014; Ordonez et al., 2014; Rosety-Rodriguez et al., 2014). One of the studies did not mention the duration of the training session, but mentions the weekly volume, namely 150 minutes per week (Shields & Taylor, 2015).

3.3.6. Type of exercise program

Concerning aerobic training, different intensities were reported following the global recommendations/guidelines presented of the ACSM (2021) for efforts within the interval of 60% to 85% of maximum heart rate (HR_{max}).

Some studies used an intensity of 40% to 65% HR_{max} (Diaz et al., 2021; Ordonez et al., 2014; Rosety-Rodriguez et al., 2014), others used 100% to 110% of the ventilatory threshold (Boer et al., 2014) while others reported a 70% to 80% maximum oxygen consumption ($VO_{2max)}$ (Boer & Moss, 2016) intensity value, with gradual increments throughout the intervention. These studies use different equipment such as stationary cycling, treadmills, or other materials such as steps or walking/running.

Interval training programs demonstrate a reduced volume compared to continuo training and used periods of 10 seconds of maximum speed, followed by 90s of rest (Boer & Moss, 2016) or 15s of full speed followed by 45s of rest (Boer et al., 2014) using cycle ergometers or simple walks/runs.

All the exercise programs focused on neuromuscular capacity used a training circuit with different materials. The study by Diaz et al. (2021) worked at loads of 40-65% of 8 repetition maximum (RM). One of the combined training programs is based time set (10 to 30 seconds per set; 4 sets) and aerobic intensity interval with a HR_{max} between 30% to 60% (Yu et al., 2022), and a second one is a four-stage circuit based on training with body weight, fitness bands and medicine balls (González-Agüero et al., 2012).

3.3.7. Results of intervention on BMI

Figure 3 show the impact of exercise on BMI.

Study name	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value	Relative weight
Boer et al. (2014) Intervention A	-0,223	0,362	0,131	-0,933	0,486	-0,616	0,538	11,17
Boer et al. (2014) - Intervention B	-0,258	0,373	0,139	-0,989	0,473	-0,691	0,489	10,51
Boer & Moss (2016) - Intervention A	-0,024	0,373	0,139	-0,756	0,707	-0,065	0,948	10,49
Boer & Moss (2016) - Intervention B	-0,152	0,374	0,140	-0,885	0,581	-0,407	0,684	10,46
Diaz et al. (2021)	-0,000	0,333	0,111	-0,653	0,653	-0,000	1,000	13,17
González-Agüero et al. (2012)	-0,301	0,380	0,144	-1,046	0,444	-0,793	0,428	10,13
Ordonez et al. (2014)	-0,945	0,474	0,224	-1,874	-0,017	-1,996	0,046	6,52
Ortiz-Ortiz et al. (2019) - Males	-0,029	0,577	0,333	-1,160	1,103	-0,050	0,960	4,39
Ortiz-Ortiz et al. (2019) - Females	-0,298	0,693	0,481	-1,657	1,061	-0,430	0,668	3,04
Yu et al. (2022)	-0,448	0,270	0,073	-0,977	0,080	-1,663	0,096	20,11
	-0,263	0,121	0,015	-0,500	-0,026	-2,176	0,030	

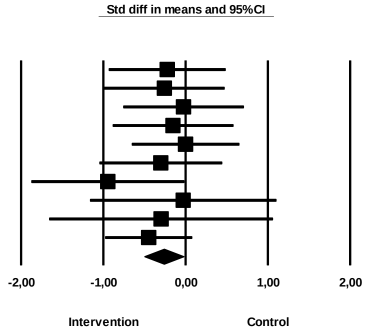

Figure 3. Difference of means of effect size comparing pre versus post intervention (BMI)

The sum of the effects is -0.263, which means that individuals in the EG are 0.263 times more likely to report decreases when compared to the CG when the inclusion and exclusion criteria previously described in the study are met. The CI for the difference in means is from -0.5 to -0.026, which means that the gross disparity in means, in the universe of studies, may fall somewhere in this interval. On the other hand, this range does not include the difference of zero, which means that the true difference in means is different from zero. The Z values obtained to test the null hypothesis, according to which the difference between means is zero, showed a Z=-2.176, with the corresponding value of p=0.03. The obtained value of Q is 3.856 with 9 degrees of freedom and with a $p \geq 0.05$. We can't reject the null hypothesis that the true magnitude of effects is the same across studies, and we can say that the true extent of effects does not varies from study to study. In the present meta-analysis, the I^2 value obtained is 0, which means that the variance in the observed effects reflect 0% the variance in the true results. On the other hand, T^2 corresponds to the variance of the true magnitude of the impact (true effect sizes) between studies that, in the present study, have a value of 0, as well as the value of T, concerning the deviation pattern of the true magnitude of the effects.

Figure 4 show the publication bias.

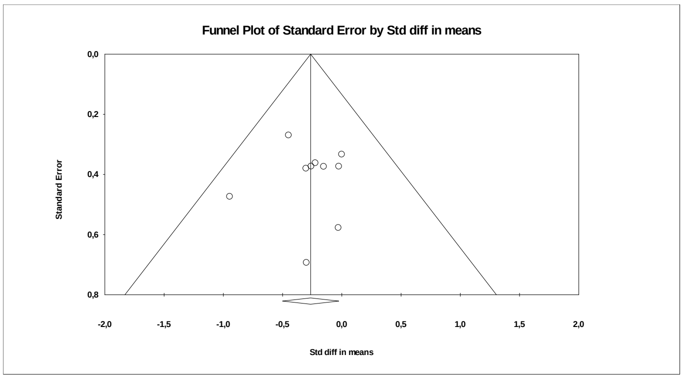

Figure 4. Scatterplot in funnel format for verification of publication bias (BMI).

In addition, the Egger test was carried out, which proposes to test the null hypothesis according to which the intercept is equal to zero in the population. For Figure 4, the intercept is -0.03655, 95% CI (-2.20324, -2.13014), with t=0.0389, degrees of freedom=8 The recommended value of p (2-tailed) is 0.96. There is no statistical evidence for the existence of publication bias.

3.3.7.1. Most effective type of training to improve BMI

Figure 5 show the impact of different exercise on BMI.

Group by Type of training	Study name	Statistics for each study: Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value	Relative weight
Aerobic training	Boer et al. (2014) - Intervention B	-0,258	0,373	0,139	-0,989	0,473	-0,691	0,489	37,50
Aerobic training	Boer & Moss (2016) - Intervention A	-0,024	0,373	0,139	-0,756	0,707	-0,065	0,948	37,45
Aerobic training	Ordonez et al. (2014)	-0,945	0,474	0,224	-1,874	-0,017	-1,996	0,046	25,05
Aerobic training		-0,343	0,253	0,064	-0,839	0,154	-1,352	0,176	
Combined training	González-Agüero et al. (2012)	-0,301	0,380	0,144	-1,046	0,444	-0,793	0,428	33,49
Combined training	Yu et al. (2022)	-0,448	0,270	0,073	-0,977	0,080	-1,663	0,096	66,51
Combined training		-0,399	0,220	0,048	-0,830	0,032	-1,815	0,070	
Interval training	Boer et al. (2014) Intervention A	-0,223	0,362	0,131	-0,933	0,486	-0,616	0,538	51,62
Interval training	Boer & Moss (2016) - Intervention B	-0,152	0,374	0,140	-0,885	0,581	-0,407	0,684	48,38
Interval training		-0,189	0,260	0,068	-0,699	0,321	-0,726	0,468	
Strength training	Diaz et al. (2021)	-0,000	0,333	0,111	-0,653	0,653	-0,000	1,000	63,92
Strength training	Ortiz-Ortiz et al. (2019) - Males	-0,029	0,577	0,333	-1,160	1,103	-0,050	0,960	21,30
Strength training	Ortiz-Ortiz et al. (2019) - Females	-0,298	0,693	0,481	-1,657	1,061	-0,430	0,668	14,78
Strength training		-0,050	0,266	0,071	-0,572	0,472	-0,188	0,851	

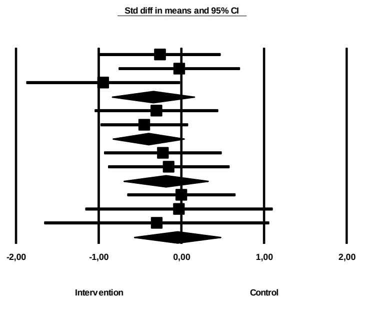

Figure 5. Difference in effect size means comparing different exercise (BMI).

Continuous aerobic training – The magnitude of the effect of the intervention with aerobic training was -0.343, with a value of Z=-1.352 and p=0.176. Combined training – The effect of the intervention with interval training was -0.399, with a value of Z=-1.815 and p=0.07. Interval training – The effect of the intervention with interval training was -0.189, with a value of *Z*=-0.726 and *p*=0.468. Strength training – The magnitude of the effect of the intervention with strength training was -0.05, with a value of *Z*=-0.188 and *p*=0.851. In this case, *Q*=1.202 with 3 degrees of freedom and *p*>0.05. We can accept the null hypothesis that the actual effect size is the same in all studies. However, the study that shows the greatest effectiveness is combined training, which has a higher magnitude of effect, although the difference between the effects of different studies is not significant.

3.3.8. Results of intervention on WC

Figure 6 show the impact of exercise on WC.

Study name	Statistics for each study							Relative weight
	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value	
Boer et al. (2014) - Intervention A	-0,595	0,369	0,136	-1,318	0,128	-1,614	0,107	11,92
Boer et al. (2014) - Intervention B	-0,482	0,377	0,142	-1,221	0,257	-1,279	0,201	11,57
Boer & Moss (2016) - Intervention A	-0,012	0,373	0,139	-0,743	0,720	-0,031	0,975	11,72
Boer & Moss (2016) - Intervention B	-0,134	0,374	0,140	-0,866	0,599	-0,358	0,720	11,71
Diaz et al. (2021)	-0,068	0,333	0,111	-0,722	0,585	-0,205	0,838	13,58
Ordonez et al. (2014)	-1,379	0,500	0,250	-2,358	-0,400	-2,760	0,006	7,65
Rosety-Rodriguez et al. (2014)	-1,379	0,500	0,250	-2,358	-0,400	-2,760	0,006	7,65
Shields & Taylor (2015)	-1,051	0,533	0,285	-2,097	-0,006	-1,971	0,049	6,89
Yu et al. (2022)	-0,453	0,270	0,073	-0,982	0,076	-1,678	0,093	17,30
	-0,515	0,156	0,024	-0,820	-0,210	-3,306	0,001	

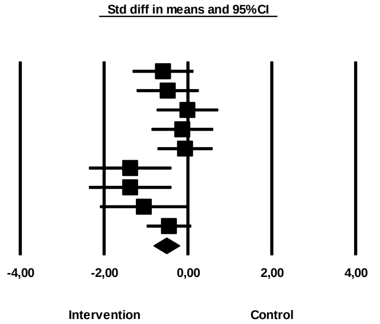

Figure 6. Difference in mean effect size comparing different exercise (WC).

The sum of the effects is -0.515, which means that individuals in the EG are 0.515 times more likely to report decreases when compared to the CG when the inclusion and exclusion criteria previously described in the study are met. The CI for the difference in means is from -0.82 to -0.21, which means that the gross disparity in means, in the universe of studies, may fall somewhere in this interval. On the other hand, this range does not include the difference of zero, which means that the true difference in means is different from zero. The *Z* values obtained to test the null hypothesis, according to which the difference between means is zero, showed a *Z*=-3.306, with the corresponding value of *p*=0.001. The obtained value of *Q* is 11.683 with 8 degrees of freedom and with a *p*=0.166. We cannot reject the null hypothesis that the true magnitude of effects is the same across studies, and we cannot say that the true extent of effects varies from study to study. In the present meta-analysis, the I^2 value obtained is 31.526, which means that the variance in the observed effects does not reflect the variance in the true results (just reflect 31%). On the other hand, T^2

corresponds to the variance of the true magnitude of the impact (true effect sizes) between studies that, in the present study, have a value of 0.067, as well as the value of *T*, concerning the deviation pattern of the true magnitude of the effects.

Figure 7 show the publication bias.

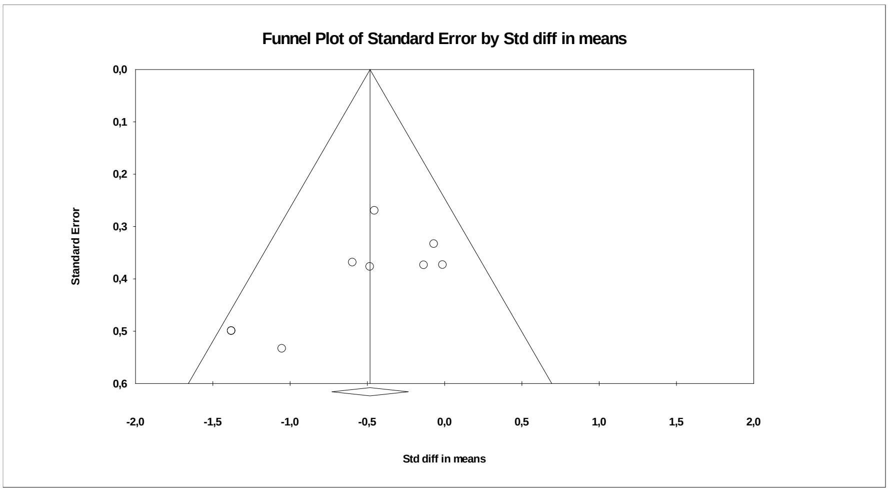

Figure 7. Scatterplot in funnel format for verification of publication bias (WC)

In addition, the Egger test was carried out, which proposes to test the null hypothesis according to which the intercept is equal to zero in the population. For Figure 7, the intercept is -3.7287, 95% CI (-7.40536, -0.04837), with t=2.39572, degrees of freedom=7. The recommended value of p (2-tailed) is 0.04777. There is statistical evidence of the existence of publication bias.

3.3.8.1. Most effective type of training to improve WC

Figure 8 show the impact of different exercise on WC.

Group by Type of training	Study name	Statistics for each study: Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value	Relative weight
Aerobic training	Boer et al. (2014) - Intervention B	-0,482	0,377	0,142	-1,221	0,257	-1,279	0,201	23,68
Aerobic training	Boer & Moss (2016) - Intervention A	-0,012	0,373	0,139	-0,743	0,720	-0,031	0,975	23,87
Aerobic training	Ordonez et al. (2014)	-1,379	0,500	0,250	-2,358	-0,400	-2,760	0,006	17,92
Aerobic training	Rosety-Rodriguez et al. (2014)	-1,379	0,500	0,250	-2,358	-0,400	-2,760	0,006	17,92
Aerobic training	Shields & Taylor (2015)	-1,051	0,533	0,285	-2,097	-0,006	-1,971	0,049	16,60
Aerobic training		-0,786	0,281	0,079	-1,337	-0,234	-2,793	0,005	
Combined training	Yu et al. (2022)	-0,453	0,270	0,073	-0,982	0,076	-1,678	0,093	100,00
Combined training		-0,453	0,270	0,073	-0,982	0,076	-1,678	0,093	
Interval training	Boer et al. (2014) - Intervention A	-0,595	0,369	0,136	-1,318	0,128	-1,614	0,107	50,68
Interval training	Boer & Moss (2016) - Intervention B	-0,134	0,374	0,140	-0,866	0,599	-0,358	0,720	49,32
Interval training		-0,368	0,263	0,069	-0,882	0,147	-1,400	0,161	
Strength training	Diaz et al. (2021)	-0,068	0,333	0,111	-0,722	0,585	-0,205	0,838	100,00
Strength training		-0,068	0,333	0,111	-0,722	0,585	-0,205	0,838	

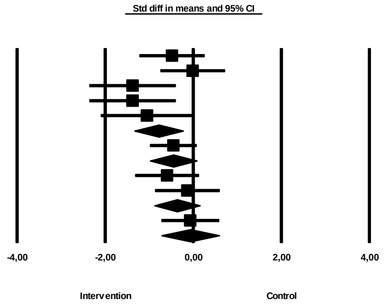

Figure 8. Difference in mean Effect size comparing different exercise (WC).

Continuous aerobic training – The effect of the intervention with continuous aerobic training was -0.786, with a value of *Z*=-2.793 and *p*=0.005. Combined training – The effect of the intervention with combined training was -0.453, with a value of *Z*=-1.678 and *p*=0.093. Interval training – The effect of the intervention with interval training was -0.368, with a value of *Z*=-1.4 and *p*=0.161. Strength training – The magnitude of the effect of the intervention with strength training was -0.068, with a value of *Z*=-0.205 and *p*=0.838. In this case, *Q*=2.831 with 3 degree of freedom and *p*>0.05, so we can accept the null hypothesis that the actual effect size is the same in all studies. However, the study that shows the greatest effectiveness is continuous aerobic training, which has a higher magnitude of effect, although the difference between the effects of different studies is not significant.

3.4 Discussion

This systematic review with meta-analysis aimed to assess the magnitude of the effects of different types of exercise programs on BMI and WC, variables related to metabolic and cardiovascular health of individuals with IDD.

The results of exercise programs are varied, depending on the objectives and the assessment tools/techniques. However, taking into account the purposes of this systematic review with meta-analysis, we found that all studies that assess the BMI (Boer & Moss, 2016; Boer et al., 2014; Ordonez et al., 2014; Ortiz-Ortiz et al., 2019; Yu et al., 2022) and WC (Boer & Moss, 2016; Boer et al., 2014; Ordonez et al., 2014; Rosety-Rodriguez et al., 2014; Shields & Taylor, 2015; Yu et al., 2022) had a decrease in the values of these same variables through the implementation of exercise programs, except studies by González-Agüero and collaborators (2012) and Diaz and collaborators (2021), where there were an increases in BMI.

All studies used the same paradigm, whereby individuals with IDD were randomly placed in the experimental group (with exercise) or the CG. There is a shortage of exercise programs with randomized controlled methodology that assesses the impact on BMI and WC, along with only the population with IDD. The results were reported regarding the improvement of the BMI or WC.

Exercise was different in the studies, also differing in the physical capacity for training (aerobic training, strength, and/or combined training). The most used training methodology is the continuous aerobic type (Boer & Moss, 2016; Boer et al., 2014; Ordonez et al., 2014; Rosety-Rodriguez et al., 2014; Shields & Taylor, 2015), with observing a reduced or null number of interventions focusing on other physical fitness components. Therefore, which presupposes that the results of this study should be taken with caution.

Considering the present systematic review with meta-analysis, exercise had superior effects in most studies. However, the differences were not significant in some studies. Thus, we can reject the null hypothesis that exercise does not affect the BMI or WC of individuals with IDD, on the other hand, exercise seems decreases BMI and WC values. This is the strength of the study, since previous research shows that exercise interventions did not promote BMI and WC of individuals with IDD (Harris et al., 2015), even multi-component weight management interventions, namely inclusion of an energy deficit diet, physical activity, and behaviour change techniques, are effective (Harris et al., 2018) and that only exercise and diet interventions could promote the variables under study (Harris et al., 2018; Ptomey et al., 2018). Currently, more researchers interested in promoting the QoL of these individuals may be at the origin of the results of the present study (Schalock et al., 2002), since recommendations for the assessment and prescription of exercise in individuals with IDD are frequently published, adapted, from previously implemented studies (ACSM, 2021). This increased interest increases knowledge of effective strategy and methodologies for QoL improvement. Since individuals with disabilities usually have high levels of overweight and obesity, the results of this study highlight the importance of regular exercise practice by individuals with IDD, to prevent the increase in values such as BMI and WC and, consequently, prevent the onset of metabolic and cardiovascular diseases. On the other hand, a follow-up by the technical of exercise, in order to assess and prescribe exercise in a correct and adapted way should be considered (ACSM, 2021).

According to this systematic review with meta-analysis, combined training appears to be the most efficient method for the promotion of BMI and aerobic training for WC and, in turn, the metabolic health of individuals with IDD. The literature is not clear about the training methodology that best promotes the variables under study. For Skrypnik and collaborators (2015) there are no significant differences between the different methods. Aerobic training reduces fat mass but has little effect on maintaining fat free mass (Garrow & Summerbell, 1995), and some authors point out that it is effectively the best method to reduce body mass (Willis et al., 2012). However, strength training, which produces fat-free mass gain, also increases resting energy expenditure (Hunter et al., 2000). exercise combined resistance and aerobic training showed to be a good alternative for increasing fat-free mass and reducing fat mass (Willis et al., 2012), with authors claiming that it is the best method for losing weight and fat mass and maintaining fat free mass (Ho et al., 2012).

This article investigates which type of intervention best promotes BMI and WC in individuals with IDD. However, the small number of articles included in the meta-analysis and a higher prevalence of studies with continuous aerobic methodology may have limited the results. It is recommended to continue implementing exercise programs with different methods, focusing on physical abilities in isolation or combination, so that further studies can measure these results way more precisely and robustly. At the same time, we recommend that future studies investigate the impact of a multidisciplinary intervention on these variables. Seeing if it can have more impact than exercise alone. We also recommend that future interventions are aimed at reducing energy intake and not just energy expenditure through the exercise.

3.5 Conclusion

Based on the results of the systematic review with meta-analysis, we can affirm that exercise programs prevent BMI and WC increments of individuals with IDD. Although without significant results, combined training looks to be more effective in promoting BMI and continuous aerobic training for WC since it had a greater effect size. The interest of various stakeholders in studying the QoL of individuals with IDD has increased, and the results of this systematic review with meta-analysis should be considered when planning interventions with the focus populations, in the sense that exercise programs promote BMI and WC, which, in turn, is associated with metabolic and cardiovascular health. The practice of exercise, in addition to promoting physical capacity, reduces the risk of diseases, being an essential aspect for a better QoL in individuals with IDD.

Chapter 4 – Prescription and effects of cardiorespiratory training in individuals with Intellectual and developmental Disabilities: a systematic review (study 3)

Jacinto, M., Rodrigues, F., Monteiro, D., Antunes, R., Ferreira, J.P., Matos, R., Campos, M.J. (2023). Quality of Life in Individuals with Intellectual and Developmental Disabilities: The Congruency Effect between Reports. *Healthcare*, *11*(12),1748. https://doi.org/10.3390/healthcare11121748.

4. Abstract

This manuscript aims to systematize effects of cardiorespiratory training programs in individuals with IDD and DS and identifying the fundamental and structuring aspects for the prescription. This systematic review was carried out through four databases (Pubmed, Web of Science, Scopus and SPORTDiscus), considering data from the period between 2013 and 2022. From 257 studies, 10 studies were included in this systematic review. Three studies used interval cardiorespiratory training while seven used continuous cardiorespiratory training. Moreover, seven were carried out in the population with DS while only three were carried out with participants with IDD. The cardiorespiratory training programs had the following characteristics: duration of 8 to 12 weeks, weekly frequency of 3 sessions, for 20 to 60 minutes, the intensity of 50% to 80% of maximal heart rate or 70% to 80% of peak oxygen consumption, using an ergometer cycle or an outdoor walking. The studies reported improvements in cardiorespiratory function, lipid, hemodynamic and metabolic profile, body composition, neuromuscular and cognitive capacity. This review presents characteristics and recommendations that technicians can follow when structuring, prescribing, and implementing cardiorespiratory training programmes to individuals with ID.

Keywords: Cardiorespiratory function; Cardiorespiratory protocols; intellectual disabilities; training programs.

4.1. Introduction

Persons with IDD are characterized by a deficit of intellectual and adaptive functioning in the conceptual, social and practical domain (American Psychiatric Association, 2013). This population is currently considered as a social group that demands special attention (Bouzas et al., 2019; Pryce et al., 2017), due to their low average life expectancy correlated with the degree of IDD (Bittles et al., 2002; Dolan et al., 2019). Even so, there has been an increase in the average life expectancy of this population over the years (Dieckmann et al., 2015).

Greater longevity is associated with an increase in comorbidities and health care costs in order to provide adequate care to adults with IDD, in particular when they live longer than their parents (Baumbusch et al., 2017). The premature aging of individuals with IDD starts around the fifth decade of life (Janicki & Dalton, 2000) and also represents serious health concerns (Reppermund & Trollor, 2016). Those health problems are partially attributed to their sedentary lifestyle behaviors and to the impaired physical fitness associated with several factors such as possible lack of motivation and task understanding, and an unhealthy diet (McKeon et al., 2013). These factors are associated with low physical fitness and health problems such as osteoporosis, diabetes, musculoskeletal disorders, dementia, hypertension and peripheral arterial disease (de Winter et al., 2012a,b; de Winter & Evenhuis, 2014; Hsu et al., 2012; Kinnear et al., 2018; Zaal-Schuller et al., 2015). The lower rates of physical activity (de Winter et al., 2015) and higher incidence of obesity (de Winter et al., 2011; Rimmer et al., 2010; Rimmer & Yamaki, 2006), lead to a major decrease in cardiorespiratory function compared to persons without ID (de Winter et al., 2009; Flore et al., 2008; Skowroński et al., 2009; Vohra et al., 2017). Several factors may justify the physical inactivity of this population and the prevalence of sedentary lifestyles, namely the existence of barriers to the practice of physical activity (personal, family, social, financial and environmental) (Jacinto et al., 2021c).

The characteristics aforementioned and comorbidities, such as diabetes, hypertension, dyslipidemia, among others, can lead to an increase in healthcare costs and mortality rate for individuals with IDD (Finkelstein et al., 2009; Florio & Trollor, 2015; Glover et al., 2017). Those also exhibit higher healthcare resource utilization such as outpatient office visits, inpatient hospitalizations, emergency room use and prescription drug use is higher as compared to individuals without ID (Calders et al., 2011; Chanias et al., 1998; Vohra et al., 2017).

Low cardiorespiratory function has been associated with increases in body mass, BMI, percentage of fat mass, waist and hip perimeter (Frey & Chow, 2006; Gawlik et al., 2016). Also, some studies reported that individuals with IDD have lower values of HR_{max} and VO_{2max} than the general population (Hilgenkamp & Baynard, 2018; Oppewal et al., 2013), which are directly linked to lower cardiorespiratory and ventilatory capacity (Boonman et al., 2019).

In this regard, some studies with cardiorespiratory training intervention programs have report large positive effects on cardiorespiratory function and muscle endurance, with a small positive effect on body composition and flexibility (Calders et al., 2011; Chanias et al., 1998; Fernhall, 1993; Millar et al., 1993; Varela et al., 2001). Based on published studies, it seems that cardiorespiratory training could help to improve cardiorespiratory endurance, muscle endurance, flexibility, and body composition in individuals with IDD.

Considering that some individuals with IDD have not the opportunity to participate in strength training sessions due to financial costs or comorbidities (Jacinto et al., 2021c), cardiorespiratory training can be a good alternative. In this sense, it is needful to identify the characteristics and structure such as intensity, type of exercise, duration, frequency and progression in order to increase health-related outcomes in these individuals. For this purpose, we analyse studies that have provided information about the prescription of cardiorespiratory training and its effects on the health-related parameters of adults with IDD. An in-depth description of the proposed cardiorespiratory training programs performed with people with IDD can provide useful data that could help fitness and rehabilitation professionals to develop better practice guidelines and interventions.

Therefore, the main objective of the present review is to answer the two following research questions: i) What are the health-related outcomes of cardiorespiratory training programs in individuals with IDD? ii) What are the most common and effective characteristics of the intervention cardiorespiratory training programs for individuals with IDD? This study follows on from a previous study on the strength intervention and it is expected to draw relevant conclusions that allow practical, evidence-based exercise recommendations to be made for maximizing the optimal cardiorespiratory training response to exercise.

4.2. Methodology

This systematic review was carried out following the items of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2021) and was carried out in the period from January 2021 to June 2022 The protocol was registered in the PROSPERO, with the number CRD42021286402. The PICOS strategy (Methley et al., 2014; Nang et al., 2015) was defined as follows: i) "P" (Patients) corresponded to participants with ID, of all ages, regardless of gender, race and ethnicity; ii) "I" (Intervention) corresponded to any cardiorespiratory training program performed with IDD (including DS), regardless of the intervention time; iii) "C" (Comparison) corresponded to the comparison between the CG versus the EG or pre and post-intervention; iv) "O" (Outcome) corresponded to cardiorespiratory training as the first or second variable under study; v) "S" (Study Design) corresponded to randomized controlled clinical trials.

4.2.1. Eligibility criteria

Studies that provided information regarding the effects of cardiorespiratory training interventions on the health-related and physical fitness outcomes of individuals with IDD were considered eligible if they met the following inclusion criteria: i) randomized controlled studies; ii) intervention studies in any type of cardiorespiratory training and with any duration; iii) population with IDD, in different degrees, including DS; iv) studies with individuals of any race, ethnicity, gender and age group (since the ACSM also makes no distinction); v) studies with any number of participants. In turn, all studies with the following characteristics were excluded if: i) were published before 2010 (studies published in a time-frame near from the current guidelines); ii) the research was not written in English; iii) articles with participants with another type of disability or pathologies; iv) articles that do not describe the intervention protocol, namely the prescription of cardiorespiratory training program; v) articles in which the intervention is focused on a sport modality; vi) articles in which the intervention combines several physical abilities (example: cardiorespiratory training with strength training; cardiorespiratory training with nutrition) (since one intervention may influence the prescription of the other intervention and/or the results may not be caused by the cardiorespiratory training); and vii) articles in which the intervention is not just cardiorespiratory training in the same group (example: combined training, cardiorespiratory training and nutrition, among others).

4.2.2. Information sources and research strategies

Electronic searches were carried out in the PubMed (title and abstract), Web of Science, Scopus and SPORTDiscus (tittle/abstract/keywords) databases, in June (15th) of 2022, encompassing articles published between January 2013 and June 2022, thus encompassing only recent literature and current evidence. At the same time, the period of retreat of the literature search coincides with the first time that the ACSM published a chapter on guidelines for exercise testing and prescription for individuals with IDD and DS (ACSM, 2013). Some MeSH descriptors and natural language (Névéol et al., 2009) that we consider to complement the research were used, namely: “aerobic exercise”, “aerobic training”, “cardio training”, “cardiorrespiratory training”, “cardiorespiratory training”, “cardio exercise”, “cardiorrespiratory exercise”, “cardiorespiratory exercise”, “continuous exercise”, “continuous training”, “high-intensity interval training”, “HIIT”, “interval training”, “interval exercise”, “Mental Retardation”, “Intellectual Disability”, “Intellectual Disabilities”, “Down Syndrome”, as indicated in Table 12.

Table 12. Research strategy

Search number	Research Content
1	(aerobic exercise* OR aerobic training* OR cardio training* OR cardiorrespiratory training* OR cardiorespiratory training* OR cardio exercise* OR cardiorrespiratory exercise* OR cardiorespiratory exercise* OR continuous exercise* OR continuous training* OR high-intensity interval training* OR HIIT* OR interval training* OR interval exercise*) AND ("mental retardation" OR "intellectual disability" OR "intellectual disabilities" OR "down syndrome")

4.2.3. Selection and data collection process

The aim was to search for intervention studies, based on a cardiorespiratory training program, regardless of its purpose. The research was carried out autonomously by two authors (MJ and RO) and, after excluding duplicate articles, reading the titles and abstracts, according to the eligibility criteria, the results of both were compared and discussed. When differences arose between these two authors, a third author (JB) was available to collaborate and make a final decision. One of the authors (MJ) downloaded the main information from the articles, namely: authors’ names, year of publication, country, aims, participants, type of study, assessment instruments, duration/frequency, exercises, intensities and main results.

4.2.4. Data Items

One of the authors (MJ) downloaded the main information from the articles, namely: authors’ names, year of publication, country, aims, participants, type of study, assessment instruments, duration/frequency, exercises, intensities and main results.

4.2.5. Methodological quality

The quality assessment of each study was performed based on the PEDro scale and its database, from the Physiotherapy Evidence Database (Maher et al., 2003; Shiwa et al., 2011). The scale consists of 11 items, which characterize the different parts of each study. One of the items is not scoreable in the field of sports science (item 1) and two other items have no applicability (items 5 and 6). Scores were independently calculated, avoiding any potential bias of the authors. When a study was not available on the PEDro databases, two authors alone (M.J. and A.M.) rated the risk of bias. Disagreements between authors were solved by consensus in a meeting with a third author (R.O.). When this was not achieved, a third investigator (R.O.) was used to carry out the analysis and debate with the first two investigators to reach an agreement.

4.2.6. Certainty assessment

Based on the Physiotherapy Evidence Database scale and to assess the interventions' evidence, the van Tulder et al. (2003) criteria were applied. Therefore, the selected studies were grouped by levels of evidence, according to their methodological quality. A study with a PEDro score of 6 or more is considered level 1 (high methodological quality) (6–8: good, 9–10: excellent) and a score of 5 or less is considered level 2 (low methodological quality) (4–5: moderate; <4: poor). Due to the clinical and statistical heterogeneity of the results, a qualitative review was performed, conducting a best-evidence synthesis (Kollen et al., 2009; Vaughan-Graham et al., 2015). This classification indicates that if the number of studies displaying the same level of evidence for the same outcome measure or equivalent is lower than 50% of the total number of studies found, no evidence can be concluded regarding any of the methods involved in the study.

4.3. Results

4.3.1. Selection of studies

A total of 257 studies were identified, through research carried out in the databases. In a first phase, which included the reading of titles and abstracts, 20 studies potentially relevant to the study were identified. Considering the previously defined eligibility criteria and after the full reading of the articles, 10 studies were identified as meeting the criteria for inclusion and were assessed for quality using the PEDro scale and included in this systematic review for full analysis. Figure 9 represents the flowchart of this systematic review.

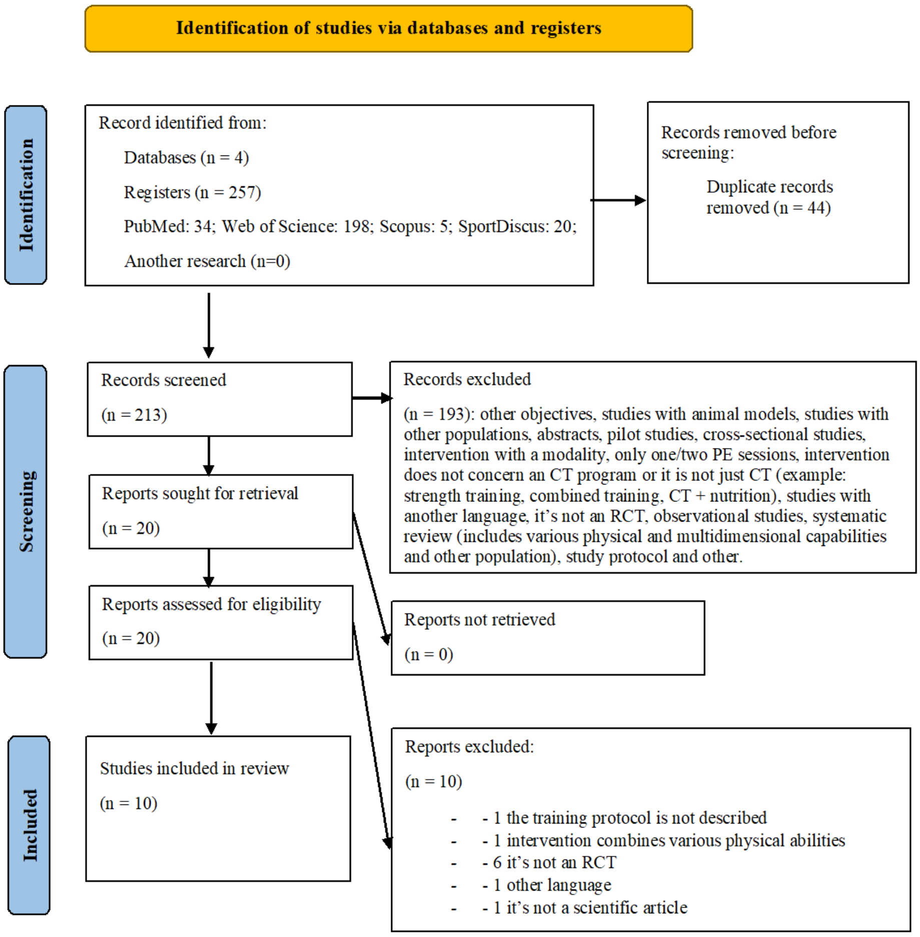

Figure 9. Flow chart of study design by PRISMA 2020.

4.3.2. Studies characteristics

The Table 13 presents the characteristics of the studies, namely: authors' names, year of publication, aims, participants, assessment instruments, duration/frequency, exercises and intensities.

Table 13. Characteristics of cardiorespiratory training programs.

Studies	Aims	Participants	Duration/ frequency	Exercise/intensity	Measurements
Boer & Moss, (2016)	Effects of training on health anthropometrical, physical and functional parameters in participants from South Africa.	N=42 (males=25; females=17); 33.8 ± 8.6 years; DS; Randomised groups: interval cardiorespiratory training (N=13), continuous cardiorespiratory training (N=13) and CG (N=16).	12 weeks; 3 x week; 30 min/session.	Continuous cardiorespiratory training: Walking or cycling 70% - 80% VO_{2max}; Interval cardiorespiratory training: 10–30 s all out sprints with 90s (1:3 work-rest ratio) of low cadence, low intensity walking or cycling.	Body weight - electronic scale (Beurer, Germany); Height – stadiometer (Siber-Hegner GPM, Switzerland); BMI (kg/m2); WC – tape (Lufkin, Cooper Tools, Apex, NC); Hip circumference – tape (Marfell-Jones et al. 2007); Fat mass and fat-free mass– bioelectrical impedance (Bodystat 1500 MDD, Douglas, Isle of Man, UK); Systolic and diastolic Blood pressure– sphygmomanometer (MicroLife, Widnau, Switzerland); Blood samples (finger prick); Total cholesterol, glucose (Roche Diagnostic Mannheum, Germany); Hand grip strength (hand dynamometer - Takei, Grip D,T.K.K.5401; Niigata City, Japan); 6-min walk distance, Sit-to-stand, Up and go test, (Boer & Moss, 2016) (Rikli & Jones, 2013); VO_{2max} (MetaLyzer 3B system – Cortex, Leipzig, Germany); Electrocardiogram (Custo Med, Schiller, Switzerland).
Boer et al., (2014)	Effect of sprint interval training on metabolic and physical fitness in participants from South Africa.	N=46; 17 ± 3 years; IDD; Randomised groups: interval cardiorespiratory training (N=17); continuous cardiorespiratory training (N=15) e CG (N=14)	15 weeks; 2 x week; 40 min/session.	Interval cardiorespiratory training: sprint interval block (10 min) continuous cardiorespiratory training (10 min), another sprint interval block (10 min); Each sprint interval block consisted of 10 sprint bouts (>100 r/min) of 15s at a resistance matching with the ventilatory threshold (VTR), alternated with 45 second's relative rest (50 r/min at VTR); Starting from week 8 the intensity was increased up to 110% of VTR; Continuous cardiorespiratory training: 3 blocks of 10 min (cycling, running, stepping); ventilatory threshold (60 r/min), which was increased to 110% of ventilatory threshold from week 8	Stadiometer; Digital balance scale; BMI; WC; BIA; VO_{2max}; Electrocardiogram; Sphygmomanometer; Respiratory gas (Metalyzer 3B); 6-min walk test, Sit-to-stand test, (Rikli & Jones, 2013); Hand grip strength (hand dynamometer); Lipid profile (Roche Diagnostic kits);

				onwards.	
El Kafy & Helal, (2014)	Effects of a rowing exercise regimen versus a chest physical therapy program on pulmonary function in Egyptian children.	N=29; 9.36 ± 1.35 years; DS; Randomized groups: Chest physical therapy (N=15, 9.22±1.3 years) and rowing ergometer (N=14, 9.5±1.4).	12 weeks; 3 x week; 20 to 30 min/session.	Rowing ergometer; Level of resistance: 1 to 4; 2-min work and 1-min rest; 50% to 80% HRmáx.	Weight and height scale; Vital capacity, forced vital capacity, forced expiratory volume after 1 second, and peak expiratory flow rate (PEFR) - Zan-680 Ergospirometry; Rowing ergometer (Kettler Coach, 8 speeds, Henze Kettler GMPH and Co. D 59469. ENSE-PARSIT – Type 7985, Germany).
Holzapfel et al., (2016)	Effects assisted cycling therapy on short-term and working memory in USA adolescents.	N=44; DS; Randomly assigned to assisted cycling therapy (N = 17, 19.4 ± 4.9 years) or voluntary cycling (N = 16, 18.4 ± 3.4 years). Non-randomized CG (N=11, 17.2 ± 4.3).	8 weeks; 3 x week; 35 min/session.	Modified motorized stationary recumbent bicycle (Exercycle; Franklin, MA); Voluntary cycling: participants pedaled at a self-selected rate Assisted cycling therapy: 35% to 180% faster than the voluntary cadence; not exceed 60% HRmáx or 95 rpm.	Assess verbal mental age - The Peabody Picture Vocabulary Test IV (PPVT-IV; Dunn & Dunn, 2007); Height and weight were measured to obtain the BMI (kg/m2); Short-term and WM assessment – verbal memory digit span memory test (Lezak, 2004; Wechsler Memory Scale III, The Psychological Association, 1997).
Holzapfel et al., (2015)	Effects of eight weeks of voluntary cycling, and no cycling on manual dexterity and cognitive planning ability in USA adolescents.	N=48; DS; Randomly assigned to assisted cycling therapy (N=18, 19.4 ± 4.9 years) and voluntary cycling (N=16; 18.4 ± 3.4 years). Non-randomized CG (N=14, 17 ± 4 years).	8 weeks; 3 x week; 30 min/session.	Modified motorized stationary recumbent bicycle (Exercycle; Franklin, MA); Voluntary cycling: participants pedalled at a self-selected rate Assisted cycling therapy: 35 % to 80% more faster than the voluntary cadence; not exceed 60% HRmáx or 95 rpm.	Weight; Height; Manual dexterity - PPT (Lafayette Instrument Company); Executive function test of cognitive planning ability- ToL (Jurado & Rosselli, 2007; Lezak, 1995); Handedness, vision, hearing, and verbal mental age - (Oldfield, 1971), a standard or modified Snellen Eye Chart, an audiometer (Maico Ma 25), and the Peabody Picture Vocabulary Test 4th ed. (PPVT-IV; Dunn & Dunn, 2007);
Kim, (2017)	Effects of training and half-bath on body composition, cardiorespiratory system, and arterial	N=24; IDD; Randomised groups: continuous	12 weeks; 5 x week; 50 min/session.	Two 15-min exercise periods; treadmill and stationary bicycle; 50–70% da HRmáx	BIA; Balke-Ware protocol; Heart rate, respiratory, and circulatory variables (electrocardiograph instrument); Gas analyzer (Quark b2, Italy); Vessel compliance (vessel compliance equipment - PWV 3.0-K_M TEC, Korea).

	pulse wave velocity in participants from Republic of Korea.	cardiorespiratory training (N=8, 19.3 ± 1.2 years), half-bath group (N=8, 18.9 ± 2.5y) and CG (N=8, 20.2 ± 1.1y).			
Ordoñez et al., (2013)	Influence of aerobic training on plasma adipokines in Spain obese women.	N=20 females; 18 – 30 years; DS; Randomised group: continuous cardiorespiratory training (N=11, 24.7 ± 3.6 years) and CG (N=9, 25.1 ± 3.9).	10 weeks; 3 x week; 60 min/session.	Ergometer session (treadmill); 55-65% HRmáx.	Maximal continuous incremental test on a treadmill; Fat-mass percentage – bioelectrical impedance analysis (Tanita TBF521); Waist and hip circumference - anthropometric tape (Holtain Ltd); Blood samples were collected from the antecubital vein; Plasma levels of adiponectin and leptin - immunoenzymatic methods using commercial ELISA kits (R&D, Minneapolis, MN, USA).
Ordonez et al., (2014)	Influence of aerobic training on pro-inflammatory cytokines and acute phase proteins.	N=20 females; 18 – 30 years; DS; Randomised group: continuous cardiorespiratory training (N=11, 24.7 ± 3.6 years) and CG (N=9, 25.1 ± 3.9 years).	10 weeks; 3 x week; 30 a 40 min/session.	Treadmill; 55% to 65% HRmáx.	Continuous maximal incremental test on a treadmill; Gas exchange - breath metabolic system; Electrocardiogram - 12 lead stress analysis system; Fat mass percentage - bioelectrical impedance (Tanita TBF521); Fat-free - prediction equations BMI [=weight (kg)/height (m)^2]; Height – stadiometer; Body weight - electronic balance; WC and hip circumference - anthropometric tape (Holtain Ltd); Blood samples - antecubital vein; Plasmatic levels of tumour necrosis factor (TNF)-α, interleukin (IL)-6, a1-antitrypsin and fibrinogen were assessed by commercial enzyme-linked immunosorbent assay kits (Immunotech,Westbrook, MA, USA); C-reactive protein - nephelometry on a BN-II analyser (Dade-Behring Diagnostics, Marburg, Germany).
Ringenbach et al., (2016)	Effects of 8 weeks of assisted cycling therapy on measures of reaction times, set-shifting, inhibition and language fluency.	N=44; males=25; females=19; DS; Randomised group: assisted cycling therapy (N=17, 19.4 ± 4.9 years) and voluntary cycling (N=16, 18.4 ±	8 weeks; 3 x week; 30 min/session.	Modified Theracycle (Exercycle, Franklin, MA, USA); Assisted cycling therapy: 35% faster than the voluntary cadence during the 5-min warm-up. From session to session, but not within sessions, the cadence was increased by 3 to 5 rpm;	Information processing speed was assessed through simple reaction times – reaction time to visual stimulus (Lafayette, IN, EUA); Set-shifting ability - modified Wisconsin Card Sorting Test (MCST) adapted from Wilson et al. (1996); Response inhibition was assessed with the NEPSY Knock-Tap task (KT; Korkman et al. 1998); Language fluency (NEPSY, Pennington et al. 2003).

		3.4 years). Non-randomized CG (N=11, 17.2 ± 4.3 years).		Voluntary cycling: o pedal at a self-selected rate.	
Rosety-Rodriguez et al., (2014)	Determine how long the anti-inflammatory effect induced by CT is maintained in Spain participants.	N=20 females; 18 to 30 years; DS; Randomised group: continuous cardiorespiratory training (N=11, 24.7 ± 3.6 years) and CG (N=9, 25.1 ± 3.9 years).	10 weeks; 3 x week; 60 min/session.	Treadmill: 30–40 min (increasing 2-min and half each two weeks) at a work intensity of 55–65% of peak heart rate (increasing a 2.5% each two weeks).	Fat mass percentage and visceral fat - bioelectrical impedance (Tanita, IL, USA) TBF521); Plasma level of IL-6 was assessed by commercial ELISA kits (Immunotech, MA, USA); High-sensitive C-reactive protein (hs-CRP) in plasma was assessed by nephelometric methods on a BN-II analyser (Dade-Behring Diagnostics, Marburg, Germany); Maximal continuous incremental test on a treadmill; Waist and hip circumference.

Note: BIA, Bioelectric impedance; BMI, Body mass index; CG, Control group; min – Minutes; N, Participants; s, Seconds; VO_{2max}, Maximim Oxygen Consumption; $HR_{máx}$, Maximum heart rate; RPM, Rotations per minute; WC, waist circumference.

4.3.3. Characteristics of interventions

Two of the selected studies used both methodologies with interval cardiorespiratory training and continuous cardiorespiratory training (Boer & Moss, 2016; Boer et al., 2014), one used a methodology with interval cardiorespiratory training only (El Kafy & Helal, 2014) and the other seven studies included a continuous cardiorespiratory training (Holzapfel et al., 2015, 2016; Kim et al., 2017; Ordonez et al., 2014; Ordoñez et al., 2013; Ringenbach et al., 2016; Rosety-Rodriguez et al., 2014).

Continuous cardiorespiratory training is a form of exercise performed "continuously without any periods of rest involved". Continuous cardiorespiratory training usually involves cardiorespiratory activities (e.g., walking, running, cycling), in turn, interval cardiorespiratory training alternates shorts bursts of moderate to intense activity with longer intervals (about 1-2 minutes) of less intense activity. For example, if the exercise is walking, alternate with short runs (ACSM, 2021; Daussin et al., 2008; Ito, 2019).

Participants

From all selected studies, the total number of participants involved was 337, with 165 being included in the EG and 172 in the CG. The subjects' mean age from all the studies was 20.67 ± 3.64 years, which included children and young adults. Specifically, there was one study with children participants (El Kafy & Helal, 2014). From the 10 studies selected, seven were carried out in the population with DS (Boer & Moss, 2016; El Kafy & Helal, 2014; Holzapfel et al., 2015, 2016; Ordonez et al., 2014; Ordoñez et al., 2013; Ringenbach et al., 2016; Rosety-Rodriguez et al., 2014) while only two were carried out with participants with ID (Boer et al., 2014; Kim, 2017).

Cardiorespiratory training Programs

All selected studies presented assessment protocols, namely the anthropometric assessment of weight and height, which were present in six studies (Boer & Moss, 2016; Boer et al., 2014; El Kafy & Helal, 2014; Holzapfel et al., 2015, 2016; Ordonez et al., 2014) or the assessment of body composition, such as calculating the BMI, measuring the perimeter of the WC, abdominal and thigh, presented in six studies (Boer & Moss, 2016; Boer et al., 2014; Holzapfel et al., 2016; Ordoñez et al., 2013; Ordonez et al., 2014; Rosety-Rodriguez et al., 2014).

Considering cardiorespiratory function, six studies used continuous load increment tests (Boer & Moss, 2016; Boer et al., 2014; Kim, 2017; Ordoñez et al., 2013; Ordonez et al., 2014; Rosety-Rodriguez et al., 2014) in which two of them also applied the functional test known as the 6-minute walk test (Boer & Moss, 2016; Boer et al., 2014).

Only two studies (Boer & Moss, 2016; Boer et al., 2014) assessed neuromuscular capacity using a manual dynamometer. One study also applied the functional test of 30 seconds chair stand (Boer & Moss, 2016).

Six studies evaluated physiological parameters such as lipid profile, haematological, immunological and metabolic rate parameters (Boer & Moss, 2016; Boer et al., 2014; Kim, 2017; Ordoñez et al., 2013; Ordonez et al., 2014; Rosety-Rodriguez et al., 2014). Three studies performed the assessment of cognitive ability (Holzapfel et al., 2015, 2016; Ringenbach et al., 2016).

Structure (duration/frequency)

Regarding the intervention durations, the studies presented programs with a duration of 8 to 15 weeks, with most studies prescribing a duration of 8 to 12 weeks (8, 10 or 12 weeks) (Boer & Moss, 2016; El Kafy & Helal, 2014; Holzapfel et al., 2015, 2016; Kim, 2017; Ordonez, et al., 2014; Ordoñez et al., 2013; Ringenbach et al., 2016; Rosety-Rodriguez et al., 2014).

Concerning weekly frequency, the studies ranged from 2 to 5 sessions per week, being 3 the most common weekly frequency (Boer & Moss, 2016; El Kafy & Helal, 2014; Holzapfel et al., 2015, 2016; Ordonez et al., 2014; Ordoñez et al., 2013; Ringenbach et al., 2016; Rosety-Rodriguez et al., 2016; Rosety-Rodriguez et al. al., 2014), lasting from 20 to 60 minutes, using cycle ergometers (treadmill, exercise bike, elliptical, step or simply walking).

Continuous cardiorespiratory training and main results

The continuous cardiorespiratory training method was the most used in the prescription of cardiorespiratory training for individuals with IDD, being transversal to most of the studies analysed in this systematic review (Boer & Moss, 2016; Boer et al., 2014; Holzapfel et al., 2015, 2016; Kim, 2017; Ordonez et al., 2014; Ordoñez et al., 2013; Ringenbach et al., 2016; Rosety-Rodriguez et al., 2014).

Continuous cardiorespiratory training was carried out through walking, running or using ergometers such as treadmills, steps or stationary bikes, in which intensities vary from 70% to 80% VO_{2max}, 100% to 110% of the ventilatory threshold or between 50% to 75% HR_{max}. All studies started the continuous cardiorespiratory training program with low (very light to light) intensity, with the exception of the study by Boer & Moss (2016) which started with moderate intensity. All studies prescribed a progressive increase in intensity, (low to moderate and/or moderate to vigorous), with the exception of the studies by Holzapfel et al. (2015, 2016) where there is no intensity progression.

Regarding the body composition effects of continuous cardiorespiratory training, there was a reduction in body weight, percentage of fat mass, WC and waist-to-hip-ratio, as shown in table 14 and Appendix 1.

Table 14. Percentage change in anthropometric variables with continuous cardiorespiratory training programs intervention

Author	Variable	Percentage
Boer & Moss (2016)	Weight (kg)	-1.4
Kim (2017)		-7
Boer et al. (2014)	Fat mass (%)	-3.2
Kim (2017)		-17.4
Ordonez et al. (2014)		-11.1
Ordoñez et al. (2013)		-11.1
Boer et al. (2014)	WC (cm)	-2.7
Ordonez et al. (2014)		-3.5
Ordoñez et al. (2013)		-3.5
Ordonez et al. (2014)	Waist-to-hip-ratio	-12
Ordoñez et al. (2013)		-12

At the same time, as shown in table 15 and Appendix 1, continuous cardiorespiratory training promoted positive changes in the lipid profile, hemodynamic parameters and metabolic markers.

Table 15. Percentage change in lipid profile, hemodynamic parameters and metabolic markers with continuous cardiorespiratory training programs.

Author	Variable	Percentage
Ordoñez et al. (2013)	Plasma leptin levels (ng/ml)	-18.6
Ordonez et al. (2014)	Plasmatic levels of tumour necrosis factor (pg/ml)	-27.1
Ordonez et al. (2014)	High sensitive C-reactive protein (mg/dl)	-17
Rosety-Rodriguez et al. (2014)		-17
Ordonez et al. (2014)	Interleukin-6 (pg/ml)	-34.4
Rosety-Rodriguez et al. (2014)		-34.4
Boer et al. (2014)	Homeostasis model assessment of insulin resistance	-11.5
Ordonez et al. (2014)	Fibrinogen (g/L)	-15.2
Kim (2017)	Pulse wave velocity (m/sec/height)	-6.5

Regarding changes in cardiorespiratory function, as shown in table 16 and Appendix 1, studies reported improvements in several variables.

Table 16. Percentage gained of cardiorespiratory outcomes with continuous cardiorespiratory training programs.

Author	Variable	Percentage
Boer & Moss (2016)		6.4%
Kim (2017)	VO_{2max} (L/min)	24%%
Rosety-Rodriguez et al. (2014)		14.8%
Ordoñez et al. (2013)	Maximum oxygen uptake (ml/kg/min)	14.8%%
Boer & Moss (2016)	Rel. peak VO_2 (ml/kg/min)	4.8%
Kim (2017)	HR_{max}	3.9%%
Boer et al. (2014)	Ventilatory threshold (w)	8.1%
Boer et al. (2014)	Ventilatory threshold (VO_2, L/min)	6.6%
Boer & Moss (2016)	Ventilatory threshold (VO_2, L/min)	16.2%
Boer & Moss (2016)	Time to exhaustion (s)	13.8%

Note: HR_{max}: maximum heart rate.

In the functional capacity assessment tests, performance improvements were reported in the 6-minute walk test (Boer & Moss, 2016; Boer et al., 2014), time up and go (8-foot and go) test (Boer & Moss, 2016), 30 seconds chair stand (Boer & Moss, 2016), and muscle fatigue resistance (Boer et al., 2014), in accordance with Table 17 and Appendix 7.

Table 17. Percentage of changes in the functional capacity tests performance with continuous cardiorespiratory training programs

Author	Variable	Percentage
Boer & Moss (2016)	6-minute walk test (m)	11.4%
Boer et al. (2014)		12.9%
Boer & Moss (2016)	8-ft up and go (s)	-22.9%
Boer & Moss (2016)	30 seconds chair stand (s)	13.8%
Boer et al. (2014)	Muscle fatigue resistance (s)	13.3%

In tests that assessed cognitive function, the outcomes of measures of visual-perceptual organization, nonverbal reasoning, and trial-and-error learning, improvements were also reported, namely in unimanual dexterity (Holzapfel et al., 2015), assembly subtest (Holzapfel et al., 2015), cognitive planning ability (Holzapfel et al., 2015), semantic language fluency (Ringenbach et al., 2016), set shifting ability (Ringenbach et al., 2016) and working memory (Holzapfel et al., 2015). In neural function, there was a decrease in reactions times (Ringenbach et al., 2016), inhibitory control (Ringenbach et al., 2016), and an improvement in semantic language fluency (Ringenbach et al., 2016), set shifting ability (Ringenbach et al., 2016) and working memory (Holzapfel et al., 2016) (see Appendix 1).

Interval cardiorespiratory training and main results

Considering the interval cardiorespiratory training method, several variables showed improvements which were presented in table 18 and in Appendix 1.

Table 18. Health related outcomes of interval cardiorespiratory training programs

Author	Variables	Variable	Percentage
Boer & Moss (2016)	Anthropometry	Weight (kg)	-3.3%
Boer & Moss (2016)		BMI (kg/m^{-2})	-2.8%
Boer et al. (2014)		WC (cm)	-4.7%
Boer et al. (2014)		Fat (%)	-12.5%
Boer et al. (2014)	Lipid profile, hemodynamic parameters and metabolic markers	Cholesterol (mg/dL)	-11.6%
Boer et al. (2014)		HDL (mg/dL)	7.6%
Boer et al. (2014)		LDL (mg/dL)	-10%
Boer et al. (2014)		Triglyceriden (mg/dL)	-11.9%
Boer et al. (2014)		Fasting nsulin (IU/mg)	-27.3%
Boer et al. (2014)		Insulin resistance (HOMA-IR))	-26.1%
Boer et al. (2014)	Cardiorespiratory function	Systolic blood pressure (mmHg)	-9.7%
Boer & Moss (2016)		VO_{2max} (L/min)	15.4%
Boer et al. (2014)			7.7%
Boer et al. (2014)		Peak power (w)	13.3%
Boer & Moss (2016)		Time to exhaustion (s)	18.8%
Boer & Moss (2016)		Rel. peak VO_2 (ml/kg/min)	12.1%
Boer & Moss (2016)		Ventilatory threshold (L/min)	23.6%
Boer et al. (2014)		Ventilatory threshold (w)	13.3%
Boer et al. (2014)		Ventilatory threshold (w and L/min)	11.1%
El Kafy & Helal (2014)		Vital capacity (L)	6.4%
El Kafy & Helal (2014)		Forced vital capacity (L)	7.4%
El Kafy & Helal (2014)		Forced expiratory volume (L)	7.2%
El Kafy & Helal (2014)		Peak expiratory flow rate (L/min)	6.2%
Boer & Moss (2016)	Functional capacity	6-minute walk test (m)	11.4%
Boer et al. (2014)			10.2%
Boer & Moss (2016)		8-ft up and go (s)	-22.9%
Boer & Moss (2016)		30 seconds chair stand (s)	13.8%
Boer et al. (2014)		Muscle fatigue resistance (s)	31.2%

Note: BMI, body mass index; HDL, high-density lipoprotein; LDL, low-density lipoprotein; VO_2, oxygen consumption; WC, waist circumference.

The study by El Kafy and Helal (2014) was performed with children participants (8 to 12 years), showing that this age group can also improve their cardiorespiratory function, namely: vital capacity, forced vital capacity, forced expiratory volume, peak expiratory flow rate.

The studies selected in this review had the following characteristics in interval cardiorespiratory training: a shorter volume with a duration of 10 seconds at maximum speed, followed by 90 seconds of rest (Boer & Moss, 2016) or 15 seconds of full speed with 45 seconds of rest (Boer et al., 2014) or 2 minutes of work for 1 minute of rest (El Kafy & Helal, 2014). In the Boer et al. (2014) study, intensity was not quantified, while Boer and Moss (2016) used an intensity of 100% of the ventilatory threshold (aerobic threshold), increased up to 110% (anaerobic threshold) and El Kafy and Helal (2014) carried out a prescription based on the VO_{2max}, specifically between 70% to 80% VO_{2max}.

Regarding the exercise modes, interval cardiorespiratory training was performed through walking (Boer & Moss, 2016), jogging/sprint (Boer et al., 2014) or using cycle ergometers such as stationary bikes (Boer & Moss, 2016) or rowing (El Kafy & Helal, 2014) at 50% to 80% HR_{max}.

The most common parameters used for the prescription and control of the effort intensity were the % HR_{max}, with percentages ranging from 50% to 80%, however, a prescription based on VO_{2max} (70% to 80%) or ventilatory threshold (100% to 110%) were also applied (Boer & Moss, 2016; Boer et al., 2014; El Kafy & Helal, 2014).

4.3.4. Methodology Quality

The analysis of the quality of the 10 studies presents scores ranging between 4 and 7 on the PEDro scale, showing a moderate to good quality of the methodological procedures (Maher et al., 2003), as mentioned in Table 19. Items 5 and 6 were not applicable to the studies included.

Table 19. Assessment of the quality of articles through the PEDro scale

Author (year)	PEDro Scale											Total score	Methodological quality
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**		
Boer & Moss, (2016)	S	1	0	1	-	-	1	1	1	1	1	7	Good
Boer et al., (2014)	S	1	0	1	-	-	0	1	0	1	1	5	Moderate
El Kafy & Helal, (2014)	S	1	0	1	-	-	0	0	0	1	1	4	Moderate
Holzapfel et al., (2016)	S	0	0	1	-	-	0	1	1	1	1	5	Moderate
Holzapfel et al., (2015)	S	0	0	1	-	-	0	1	1	1	1	5	Moderate
Kim, (2017)	S	1	0	1	-	-	0	0	0	1	1	4	Moderate
Ordoñez et al., (2013)	N	1	0	1	-	-	0	0	0	1	1	4	Moderate

Ordonez et al., (2014)	S	1	0	1	-	-	0	0	0	1	1	5	Moderate
Ringenbach et al., (2016)	N	1	0	1	-	-	0	0	0	1	1	4	Moderate
Rosety-Rodriguez et al., (2014)	N	1	0	1	-	-	0	1	0	0	1	4	Moderate

Note: 1, yes; 0, no; "-", no applicability.

4.4. Discussion

The present study aimed to describe the effects on the health-related and functional capacity outcomes of cardiorespiratory training for individuals with IDD and DS as well as to characterize programs implemented in these individuals and the type of exercise and the guidelines for the prescription of effective cardiorespiratory training programs. The health-related and functional capacity outcomes of the cardiorespiratory training programs from all studies included in the SR will be discussed and all main points of the cardiorespiratory training programs applied in the studies analysed.

Tables 14 to 18 in Appendix 1 showed that cardiorespiratory training programs applied in selected studies have positive effects on improving the following outcomes: cardiorespiratory function (Boer & Moss, 2016; Boer et al., 2014; El Kafy & Helal, 2014; Kim, 2017; Ordoñez et al., 2013; Rosety-Rodriguez et al., 2014), lipid profile, hemodynamic parameters and metabolic markers (Boer et al., 2014; Kim, 2017; Ordonez et al., 2014; Ordoñez et al., 2013; Rosety-Rodriguez et al., 2014), functional function (Boer & Moss, 2016; Boer et al., 2014), body composition (Boer & Moss, 2016; Boer et al., 2014; Kim, 2017; Ordonez et al., 2014; Ordoñez et al., 2013) and improve cognitive capacity in people with IDD, inclusive DS, meeting the benefits found for the general population (Cao et al., 2021; Seals et al., 2019; Young et al., 2015).

From the 10 studies analysed, one involved children as participants and demonstrated that they too could improve cardiorespiratory function too (El Kafy & Helal, 2014). In addition to promoting cardiorespiratory function, the literature shows that cardiorespiratory training in children also improves lipid profile, hemodynamic parameters and metabolic markers (Cao et al., 2021).

Cardiorespiratory training also promotes improvements in neuromuscular capacity of upper and lower limbs (Boer & Moss, 2016; Boer et al., 2014). Neuromuscular capacity was assessed using a manual dynamometer or functional tests such as sit-to-stand (Boer & Moss, 2016; Boer et al., 2014). Boer and Moss (2016) and Boer et al. (2014) reported an increase in neuromuscular capacity, especially in the continuous cardiorespiratory training group. Our results are supported in the literature namely by Konopka and Harber (2014) study where authors reported that cardiorespiratory training alters protein metabolism and induces skeletal muscle hypertrophy. These findings are important when prescribing a physical exercise program, in order to achieve maximum benefits.

Although non-RCT's were not included in this study, there are other studies that show relevant benefits in the population with ID through the application of cardiorespiratory training programs. Some benefits were the improvement of cognitive ability, fine motor skills, speed, agility, coordination, balance and flexibility, which shows a lack of studies on the effects of applying a cardiorespiratory training program in the population with IDD without another associated condition (Aleksander-Szymanowicz et al., 2014; Alghadir et al., 2020; Kastanias et al., 2015; Seron et al., 2017; Seron et al., 2014; Son et al., 2016).

Although we know that individuals with DS have different physiological responses than individuals with just IDD due to an underlying autonomic dysfunction (Cilhoroz et al., 2022) and taking into account the heterogeneity of assessment methodologies and variables evaluated, we cannot conclude whether the results are different in such individuals.

Cardiorespiratory training was recognized as the best training method to improve some variables such as those indicated in Tables 14 to 18 and Appendix 1 (Morze et al., 2021). Since these variables were associated with the onset of cardiovascular and metabolic diseases (Kaess et al., 2009; Mišigoj-Duraković et al., 2014), their improvement through cardiorespiratory training seemed particularly relevant. In recent decades, there has been a significant increase in the years of life expectancy of individuals with IDD and with DS, justifying the greater need to study the effects of intervention strategies that improve health and reduce the impact of comorbidities associated with ageing (de Winter et al., 2011). According to the results of several studies the cardiorespiratory training seems to be an effective type of exercise in people with IDD.

The literature showed that two cardiorespiratory training methods such as continuous cardiorespiratory training and interval cardiorespiratory training, can be prescribed for individuals with IDD and considered as safe and effective options, given the absence of adverse events, the low dropout rate and excellent adherence to training. Although several studies have implement continuous cardiorespiratory training (Boer &

Moss, 2016; Boer et al., 2014; Holzapfel et al., 2015, 2016; Kim, 2017; Ordonez et al., 2014; Ordoñez et al., 2013; Ringenbach et al., 2016; Rosety-Rodriguez et al., 2014), the interval cardiorespiratory training may be more effective, particularly for individuals with some training experience, since this is a method with higher intensity (Boer & Moss, 2016; Boer et al., 2014). Nonetheless, continuous cardiorespiratory training is the most recommended by ACSM (2021) for the population with IDD and DS.

Results of the present systematic review were supported by other studies which showed that exercise intensity is an important factor for the improvement cardiorespiratory function and reversing the risk factors of the metabolic syndrome (Haram et al., 2009; Tjønna et al., 2008). A recent meta-analysis (Pattyn et al., 2018), compared the use of interval cardiorespiratory training and continuous cardiorespiratory method. Interval cardiorespiratory training results showed a greater increase in peak oxygen uptake, peak heart rate, first ventilatory threshold and a reduced ejection fraction compared with continuous cardiorespiratory training, in patients with coronary artery disease or heart failure. Another meta-analysis reported more significant increase in VO_{2max} in interval cardiorespiratory training when compared with continuous cardiorespiratory training, in healthy, young to middle-aged adults (Milanović et al., 2015). However, it appears to be more exhausting and stressful for individuals with ID which appear to have a lower degree of resilience to the stress imposed by physical exertion (Boer & Moss, 2016; Boer et al., 2014). Although the present systematic review was not able to find which type of cardiorespiratory training is better, interval cardiorespiratory training due to the higher exertion intensities would provide better results which should be analysed in future studies with IDD and/or DS participants.

Considering the characterization of cardiorespiratory training programs of all studies included in the present systematic review, there were aspects that are common and more evident, such as: a) duration of 12 weeks b) 3 sessions per week; c) duration of 20 to 60 minutes per session, always encompassing the warm-up and cool down phases; d) exercises performed using ergometers such as cycling exercise, elliptical, stepper or treadmill walking; e) intensity between 50% to 80% of HR_{max} or 70% to 80% VO_{2max}.

The ACSM most recent recommendations for cardiorespiratory training prescription for the population with ID and DS (ACSM, 2021) show an intensity of 40% to 80% of VO_{2max} or HR_{max}, 30 to 60 minutes per session, suggesting activities like walking-based activities, swimming ergometry (arm and leg). The characteristics of the applied intervention programs included in this systematic review were in accordance with international recommendations, namely the ACSM (2021) and the National Strength and Conditioning Association - NSCA (2016) guidelines. All studies have prescribed intensities recommended by the ACSM (2021), however, all studies started the cardiorespiratory training programs at intensity values higher than those recommended by these guidelines. Considering the heterogeneity of the population with IDD, the prescription of training intensity may be related to the physiological characteristics of the individuals, namely if they also have DS or depending on the degree of disability (mild, moderate, severe and/or profound).

The duration of the cardiorespiratory training program interventions analysed varied between 8 and 12 weeks (Boer & Moss, 2016; El Kafy & Helal, 2014; Holzapfel et al., 2015, 2016; Kim, 2017; Ordonez, et al., 2014; Ordoñez et al., 2013; Ringenbach et al., 2016; Rosety-Rodriguez et al., 2014). However, Rodrigues et al. (2021) points out that, in terms of adherence and maintenance of a physical exercise behaviour, the first 6 months of participation are crucial for the success of the following 6 months. Thus, it´s easier to overcome successfully the critical barrier of the first 6 months of physical exercise, if participants maintain high levels of exercise participation, being more predisposed to maintain this behaviour in the future. Therefore, this systematic review reveals a lack of studies with longer duration (six or more months), which is an aspect to be considered in future intervention studies.

This systematic review shows a lack of studies on the effects of applying a cardiorespiratory training program in individuals with IDD but without another associated condition. At the same time, no intervention studies were found for the elderly population with IDD which leads us to suggest the application of cardiorespiratory training programs in older people with IDD. Equally, more randomized studies are needed to assess the variables shown in Table 14 to 18 and in non-RCT studies since their programs are quite different which difficult comparisons between studies. The longer implementation of cardiorespiratory training programs will also allow the knowledge enlightenment regarding training methods, programs structure, type of exercise and periodization in order to have more adapted and effective exercise prescriptions, as some of the barriers to physical activity are also reduced (Jacinto, et al., 2021c). It is important to take special care in the prescription and implementation of cardiorespiratory training programs in the population with DS, due to its atlantoaxial instability (Rhodes et al., 2011). To increase physical fitness, namely cardiorespiratory fitness or VO_{2max}, Swain and Franklin (2002) suggested that the intensity of the exercise should varie according to the participant initial fitness level.

The present systematic review showed some limitations similar to those recently reported by Jacinto et al. (2021b) concerning strength training for individual with IDD, such as: i) heterogeneity of different studies and ii) little clearness in some studies regarding the randomization process; iii) absence of follow-up; iv) different assessment methodologies which did not allow further discussion or a meta-analysis about the cardiorespiratory training effects produced; and v) the level of IDD was not mentioned in all studies included, which limits the generalization of the results and recommends such description in future studies.

4.5. Conclusion

This manuscript includes a review of studies published in recent years about an in-depth analysis of the basic guidelines for prescribing cardiorespiratory training in individuals with IDD, and about its main benefits for health and well-being. In summary, the basic aspects for cardiorespiratory training prescription are:

a) Duration of 8 to 12 weeks (we emphasize that the essential is that the cardiorespiratory training programs are implemented continuously);
b) Frequency of 3 sessions per week;
c) Duration of 20 to 60 minutes per session, always taking into account the warm-up and cool down phases;
d) Exercises performed using ergometers such as cycling exercise, elliptical, stepper or treadmill walking;
e) Intensity between 50% to 80% of HR_{max} or 70% to 80% VO_{2max}.

Although continuous cardiorespiratory training is more frequently prescribed and recommended, interval cardiorespiratory training also seems to be a good option and more effective in variables such as peak oxygen uptake, peak heart rate, first ventilatory threshold and a reduced ejection fraction. However, it should only be prescribed with some previous training experience, as it is a more exhausting and intense training method.

This systematic review also shows that cardiorespiratory training promotes benefits in cardiorespiratory function, lipid profile, hemodynamic and metabolic markers which have direct effects on body composition, as well as an increase in upper and lower limb strength and cognitive capacity in individuals with IDD, inclusive DS.

The present study includes aspects and recommendations that physical exercise professionals should consider when structuring, prescribing and implementing a cardiorespiratory training program. For a population where a sedentary lifestyle prevails, with several associated comorbidities, the characteristics presented in this document become essential to promote the expected benefits and results, namely the maintenance/increase of physical fitness, QoL and health, thus decreasing, the risk of onset of chronic diseases. Along with the ACSM recommendations, to which this document is intended to be a supplement the conditions for successful evaluation, prescription, implementation and follow-up of cardiorespiratory training in individuals with IDD are met.

Associated with an appropriate lifestyle, the implementation of cardiorespiratory training programs, incorporated into the routine of the target population, provokes a set of adaptations and benefits, promoting healthy aging and fuller health.

Chapter 5 – Prescription and effects of strength training in individuals with Intellectual Disability: systematic review (study 4)

Jacinto, M., Oliveira, R., Brito, J. P., Martins, A. D., Matos, R., & Ferreira, J. P. (2021). Prescription and Effects of Strength Training in Individuals with Intellectual Disability—A Systematic Review. *Sports*, *9*(9), 125. https://doi.org/10.3390/sports9090125. (SJR; IF: 0.89; Q1).

5. Abstract

The practice of physical exercise, especially strength training, has health benefits in the healthy population; however, the literature is scarce in the recommendations related to the population with IDD. This study represents the first analysis on the topic and aims to examine the structure and efficacy of strength training intervention programs in individuals with IDD. This systematic review was carried out between January and April 2021, using the PubMed, Web of Science, Scopus, and SPORTDiscus databases, according to the PRISMA guidelines. From a total of 166 studies, nine were included in the present systematic review. The studies included a total of 280 individuals (18.23 ± 2.86 years old). The main features of the exercise programs are: 12 weeks average duration, three weekly sessions of 45–60 minutes, six to seven exercises targeting the main muscle groups, two to three sets, 6–12 repetitions, and avoiding free weights for safety reasons. The main results showed increments in strength, balance and fat-free mass and decrements in fat mass and WC. It is a useful guideline for physical exercise technicians to prescribe and adjust correctly in order to not only promote physical fitness but improve the QoL of individuals with IDD.

Keywords: intellectual disabilities; neuromuscular training; physical exercise program; resistance training

5.1 Introduction

The WHO (2020) global recommendations have recently highlighted the benefits of physical exercise for the health of youngsters and adults living with IDD. IDD is a deficit in cognitive and adaptive functioning, as well as in the conceptual, social, and practical domains diagnosed before 22 years of age. Individuals can be diagnosed with different degrees: mild, moderate, severe, and profound IDD (Schalock et al., 2021). Several studies in the literature report a high incidence of sedentary behavior in people with IDD (Dairo et al., 2016; Harris et al., 2017). On the other hand, the health risks in these individuals increase when compared to the general population, namely in the higher prevalence of hypertension, obesity, and metabolic syndrome (Brooker et al., 2015; Foley et al., 2017).

Adults with IDD are often referred to as high-cost patients, a designation used as a reference to patients classified in 10% of total annual health care costs (Borji et al., 2014). They register a high number of annual hospital visits and need more medical drugs than adults without IDD. Given the fact that this population tends to have a disproportionate number of comorbidities compared to apparently healthy adults, their QoL may be affected (Carmeli et al., 2012).

Physical inactivity does not promote physical fitness, which leads to lower levels of muscle strength that may also be associated with musculoskeletal problems and insufficiency of the central nervous system in the activation of motor units and some intrinsic dysfunctional muscle properties, namely atrophies or hypotonia (Borji et al., 2014). Since premature physical aging is a characteristic of most individuals with ID, the early loss of muscle mass (Carmeli et al., 2012) is a consequence that is associated with impaired functional capacity, mobility, and other comorbidities (Bastiaanse et al., 2012; Bishop et al., 2013). Sarcopenia negatively affects body composition as well as the rate of basal metabolism (Carmeli et al., 2012; Zafeiridis et al., 2010) and the ability to produce strength, which is related to physical dependence, increased number of falls and hospitalizations, lower perceived QoL, and increased risk of mortality (Duchowny et al., 2018; Willgoss et al., 2010).

Thus, it is important to increase physical exercise in a structured and planned way, so that the results related to health and physical fitness improvement are effective (Caspersen et al., 1985; Dasso, 2019).

Several studies reported promising results from the positive effects of exercise on muscle strength and daily life activities in both healthy individuals (Kilic-Toprak et al., 2012; Liu et al., 2014) and individuals with clinical conditions (Stensvold et al., 2012; Vincent & Vincent, 2006). However, there is little evidence to support whether strength training can improve general health in young adults with IDD (Cowley et al., 2011). Muscular strength is critical for adults with an IDD to promote their mobility, cardiovascular capacity, and performance of daily living/recreational/vocational activities (Cowley et al., 2011; St. John et al., 2020; Temple et al., 2017). Strength training interventions can be effective by improving muscle strength in adults with IDD, especially when not combined with other forms of exercise (Obrusnikova et al., 2021).

Strength training aims to provoke adaptations in the skeletal musculature through overloads, providing an increase in the production of muscle strength and activity of glycolytic enzymes, as well as the production of adenosine triphosphate/phosphocreatine and adaptations in the nervous system, in order to increase the recruitment of motor units (Nogueira et al., 2008; Pereira et al., 2012). During strength training, the lower and upper limbs move against a resistance provided by gravity, body weight, dumbbells, straps, weighted bars, or exercise machines (Chaves et al., 2020; Schoenfeld et al., 2016). This entire process results in cellular micro-lesions, mainly in the eccentric action phase, activating defence systems such as neutrophils, macrophages, and cytokines, which will generate reactive oxygen and nitrogen species (Bloomer & Goldfarb, 2004). These micro-sockets are important for the muscle recovery and regeneration process due to the fusion of satellite cells with a main cell, and the induction of protein synthesis metabolism and muscle tissue recovery (Hawke & Garry, 2001). Thereafter, strength training seems to induce muscle skeletal adaptations as a result of overload, providing an increase in the production of muscular strength and other central nervous system adaptations (Nogueira et al., 2008; Pereira et al., 2012).

Strength training has also demonstrated positive effects on neuromuscular capacity, on daily living performance activities, and on reducing the decline in sarcopenia (Beltran Valls et al., 2014; Savage et al., 2011).

Usually, a typical strength training program for untrained or intermediately trained healthy adults includes the use of all major muscle groups, performing between two to four sets of 8–10 exercises, for 3–12 repetitions with 2–5 minutes rest between sets, with a frequency of two to four times per week (Ratamess et al., 2009; Williams et al., 2007). Meanwhile, a systematic review with meta-analysis found that the effects of training with high loads (i.e., ≥60% of 1 RM) or ≤15 RM) compared to low loads (i.e., <60% of 1 RM or >15 RM) and found a similar effect of hypertrophy independent of the loads (Nogueira et al., 2008). Nonetheless, there is a lack of knowledge about strength training in people with IDD, which reinforces the need verify whether regular strength training leads to the beneficial effects apparently observed in the healthy population. Therefore, the purposes of this study are to answer the two following research questions: (i) What are the benefits of strength training programs in individuals with IDD? ii) What are the most common and effective structural characteristics and guidelines to prescribe strength training programs for individuals with IDD?

5.2 Methodology

5.2.1. Eligibility Criteria

This systematic review was designed following the items of the PRISMA guidelines (Page et al., 2021). The PICOS strategy (Methley et al., 2014; Nang et al.,

2015) was defined with the following format: (i) “P” corresponded to participants with IDD (DS inclusive) of any age, gender, ethnicity, or race; (ii) “I” corresponded to an strength training program, regardless of the intervention time (strength training is considered whenever it is intended to produce muscular tension to overcome any resistance); (iii) “C” corresponded to the pre and postintervention comparison or between CG versus EG; (iv) “O” corresponded to any variable of physical fitness or physiological capacity as a primary or secondary variable under study; (v) “S” corresponded to RCT’s.

5.2.2. Information Sources and Research Strategies

The systematic search for articles was carried out between January and April 2021, in the following databases: PubMed (all fields), Web of Science, Scopus, and SPORTDiscus (title, abstract, and keywords), considering the period of retreat until 2010. The descriptors used were: “Mental Retardation”, “Intellectual Disability”, “Intellectual Disabilities”, “Down Syndrome”, “Resistance Training”, “Strength Training”, “Neuromuscular Training”, “Resistance Exercise”, “Strength Exercise”, “Neuromuscular Exercise”, with the Boolean operator “And” or “OR”. Table 20 shows the content of the search.

Table 20. Research strategy.

Search Number	Research Content
1	(“mental retardation” OR “intellectual disability” OR “intellectual disabilities” OR “down syndrome”) AND (“resistance training” OR “strength training” OR “neuromuscular training” OR “resistance exercise” OR “strength exercise” OR “neuromuscular exercise ”)

5.2.3. Inclusion Criteria

For the selection of studies, the following inclusion criteria were considered: (i) randomized controlled trial studies; (ii) intervention studies of any duration; (iii) individuals with IDD, regardless of the degree of disability, including those with DS; (iv) without limitations regarding the number of participants; (v) studies published in English or Portuguese language.

5.2.4. Exclusion Criteria

Likewise, for the selection of studies, the following exclusion criteria were used: (i) studies published before 2010; (ii) studies with participants with another type of disability or pathologies; (iii) articles that do not describe the intervention protocol for strength training prescription; (iv) studies where the intervention is focused only is a specific sport; (v) studies in which the intervention is not only strength training in the same EG.

5.2.5. Data Extraction Process

After completing the systematic search, duplicates were eliminated and all the articles that did not meet the inclusion criteria were removed. The studies selected in the previous phase were reviewed in their entirety by two independent reviewers (MJ and RO), considering the specific eligibility criteria. One of the reviewers (MJ) selected the relevant information about each one of the studies, organized by: authorship, year of publication, country, objectives, participants, type of study, assessment instruments, duration/frequency, type of exercises, intensity, and main results.

After reading the full text of the studies, and according to the eligibility criteria previously defined, the study sample was constituted with eight studies.

5.2.6. Methodological Quality

The PEDro scale, from the Physiotherapy Evidence Database, was used (Maher et al., 2003), to assess the quality in each study. The scale consists of 11 items, which characterize the different parts of each study. One of the items is not scoreable in the field of sports science (Item 1) and two other items have no applicability (Items 5 and 6). The maximum score on the scale, after being modified, to evaluate the articles is 8 points.

The assessment of the quality in each study was independently estimated by two investigators (MJ and RO) and they were compared and discussed so that there is a consensus.

5.3 Results

5.3.1. Methodological Quality

The initial research carried out in the four databases identified 169 studies. In the first phase, and after reading the titles and the abstracts, 23 potentially relevant studies were identified for the next phase. Considering the inclusion and exclusion criteria, previously defined for this systematic review, of the complete reading of the studies, a sample of nine was constituted for their full analysis.

Figure 10 represents the PRISMA flowchart of this systematic review.

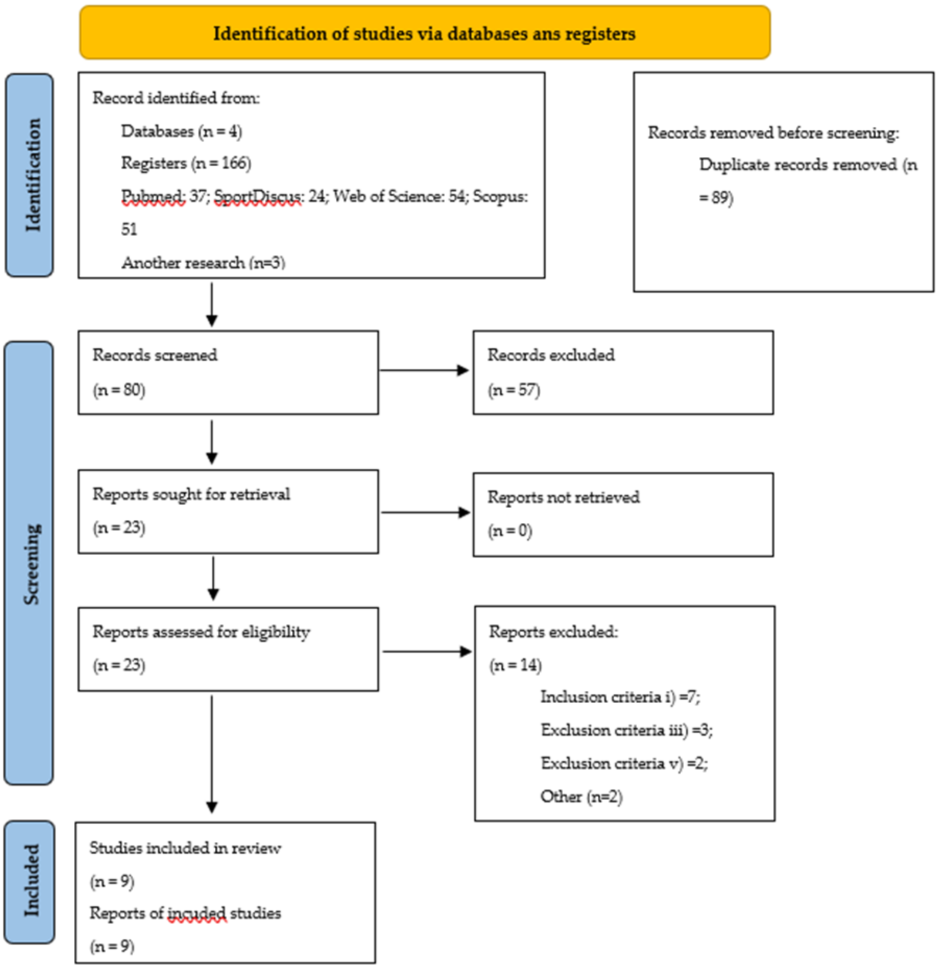

Figure 10. Flow diagram PRISMA.

5.3.2. Characteristics of Studies

Table 21 shows the nine studies included for systematic review, as well as the results of the quality of information assessment. The quality analysis of the studies showed that scores varied between six and eight on the PEDro scale, thus presenting a good quality of the methodological procedures.

Table 21. Assessment of the quality of the articles, using the PEDro scale, as well as their total score.

Author (Year)	PEDro Scale											Total
	1	2	3	4	5	6	7	8	9	10	11	
Fornieles et al. (2014)	s	1	0	1	-	-	0	1	1	1	1	6
Ghaeeni et al. (2015)	s	1	0	1	-	-	0	1	1	1	1	6
Kachouri et al. (2016)	s	1	0	1	-	-	0	1	1	1	1	6
Neto et al. (2010)	s	1	0	1	-	-	0	1	1	1	1	6
Ortiz-Ortiz et al. (2019)	s	1	0	1	-	-	0	1	1	1	1	6
Rosety-Rodriguez et al. (2013)	s	1	0	1	-	-	1	1	1	1	1	7
Rosety-Rodriguez et al. 2021)	s	1	1	1	-	-	0	1	1	1	1	7
Shields and Taylor (2010)	s	1	1	1	-	-	1	1	1	1	1	8
Shields et al. (2013)	s	1	1	1	-	-	1	1	1	1	1	8

Note: Item 1, not scoreable; Items 5 and 6, no applicability.

Table 22 shows the aims, the participants, study designs and the assessment of the instruments/techniques used in the studies included.

Table 22. Characteristics of the strength training programs of the nine studies.

Author, Year, Country	Aims	Participants	Study Design	Assessment Tools/Techniques
Fornieles et al. (2014) Spain	Influence of strength training on salivary immunoglobulin A levels and hormone profile in sedentary DS adults.	N = 40 males; age: 23.7 ± 3.1 years; DS (IQ: 60–69); randomized groups: EG: N = 24 | CG: N = 16).	Prospective cohort.	8 RM test (exercises: bicep curl; leg extension; seated row; leg curl; triceps extension; leg press); saliva samples—analysis of immunoglobulin, testosterone, and cortisol (ELISA kits); box stacking test (ACSM, 2013; Smail and Horvat, 2006).
Ghaeeni et al. (2015) Iran	Effect of 8 weeks core stability training on static balance of DS children.	N = 16; age: 9.7 ± 1.7 years; DS; randomized groups: EG: N = 8 | CG: N = 8.	Prospective cohort.	Static balance—stork test (Rahmani and Shahrokhi, 2011).
Kachouri et al. (2016) Tunisia	Effect of a combined strength and proprioception training program on muscle strength and postural balance in children with IDD.	N = 20 males; age: 11.5 ± 1 years; IDD (IQ: 50–70); randomized groups: EG: N = 10 | CG: N = 10.	Prospective cohort.	Maximum voluntary contraction—quadriceps (dynamometer or manual muscle testing—Bohannon, 2005; Brinkmann, Andres, Medoza, and Sanjak, 1997); centre of pressure—static stabilometric platform (PostureWin©, Techno Concept®, Cereste, France; 12-bits A/D conversion).
Neto et al. (2010) Brazil	Effects of strength training on body composition.	N = 15 (males = 11; females = 4); age: 22.1 ± 7.5 years; DS; randomized groups: EG: males = 6; females = 2 CG: males = 5; females = 2.	Prospective cohort.	Body mass—electronic scale model Filizola (Indústria Filizola S/A, Brazil); percentage of fat—seven thoracic, axillary, tricipital, subscapular, abdominal, supra-iliac, and thigh skinfolds (adipometer); fat mass calculated using the formula: body mass × percentage of fat/100; lean mass calculated using the formula: body mass − fat mass.
Ortiz-Ortiz et al. (2019) Mexico	Effect of a physical fitness program on body composition and isometric strength in DS children.	N = 22; age: 11.8 ± 1.9 years; DS; randomized groups: EG: N = 13 | CG: N = 9.	Prospective cohort.	Body weight—Tanita® InnerScan (BC-533, Tanita Corporation of America, Inc., Clearbrook, IL, USA); BMI = weight ÷ (height^2); percentage of fat—subcutaneous triceps and calf sites; isometric strength—manual dynamometer—(dominant hand) MSD, (model SH5001, Düsseldorf, Germany).
Rosety-Rodriguez et al. (2013) Spain	Effect of strength training on low-grade systemic inflammation in DS adults.	N = 40 maels; age: 23.7 ± 3.1 years; DS (IQ: 60–69); randomized groups:	Prospective cohort.	Blood samples—plasma levels of leptin, adiponectin, interleukin-6 and TNF-α (ELISA kits); C-reactive protein—nephelometry; fat-free mass percentage—bio impedance (Tanita TBF521,

		EG: N = 24 | CG: N = 16.		Tanita Corporation of America, Inc., Clearbrook, IL, USA); WC—anthropometric tape; time up-and-go test (Rikli and Jones, 1999).
Rosety-Rodriguez et al. 2021) Spain	Effect of strength training on antioxidant defence system in sedentary DS.	N = 36 males; age: 28.1 ± 3.3 years; DS (mild IDD–IQ: 60–69); randomized groups: EG: N = 18 | CG: N = 18.	Prospective cohort.	8 RM test (exercises: arm curl, leg extension, leg curl, low stroke, triceps extension and leg press); blood samples—puncture of the antecubital vein; maximum force—manual dynamometer JAMAR (Bolingbrook, IL, USA); peak torque of flexion and extension of the of the knees—isokinetic dynamometer at 90°/s -Technogym-REV 9000 (Technogym Spa, Gambettola, Italy); total antioxidant status of plasma—spectrophotometrically, Hitachi 902 Autoanalyzer (Roche, Alameda, CA, USA) by commercial kits (Randox, Crumlin, UK); reduced glutathione level after reaction with DTNB [(5,5-dithio-bis (2-nitrobenzoic acid)]; superoxide dismutase activity—xanthine oxidase-cytochrome c method; glutathione reductase activity; plasma ascorbate and α-tocopherol—reverse phase high-performance liquid chromatography.
Shields and Taylor (2010) Australia	Effects of strength training on the ability to produce muscle strength and physical fitness.	N = 23 (males = 17; females = 6); age: 15.6 ± 1.6 years; DS (mild to moderate IDD); random groups: EG: N = 11 | CG: N = 12.	Prospective cohort.	1 RM test (chest and leg press); timed up and go test (Rikli and Jones, 1999); down stairs test (Zaino et al., 2004); grocery shelving task (Hill et al., 2004).
Shields et al. (2013) Australia	Effects of strength training in adolescents and young DS adults.	N = 68 (males = 38; females = 30); age: 17.9 ± 2.6 years; DS (mild to moderate IDD); random groups: EG: N = 34 | CG: N = 34.	Prospective cohort.	Box stacking test (ACSM, 2013); weighted pail carry test (ACSM, 2013); 1 RM test (chest and leg press).

Note: BMI, body mass index; CG, control group; DS, Down Syndrome; EG, exercise group; IDD, intellectual disability; IQ, intelligence quotient; min, minutes; N, number of participants; s, seconds; RM, maximum repetition.

5.3.3. Origin

From the nine selected studies that were analysed in the systematic review, one is from Asia (Ghaeeni et al., 2015), another from Africa (Kachouri et al., 2016), two are from Oceania (Shields et al., 2013; Shields & Taylor, 2010), two others are from America (Neto et al., 2010; Ortiz-Ortiz et al., 2019) and three are from Europe, with Spain being the country with the largest number of publications about this topic (Fornieles et al., 2014; Rosety-Rodriguez et al., 2013, 2021).

5.3.4. Participants

The total number of participants involved in the selected studies are 280, 150 included in the EG and 130 as part of the CG. The subjects' mean age from all the studies is 18.23 ± 2.86 years, including children, adolescents, and young adults. All the studies used participants with IDD and associated DS, except for the study of Kachouri et al. (Kachouri et al., 2016). There is a shortage of studies in the literature that implemented ST programs in participants with ID without any other associated condition and using a randomized controlled method.

5.3.5. Evaluation Protocols/Instruments/Techniques

Most studies used assessment instruments, such as the agility test, the "box stacking" test, the "supermarket" test, the "bucket transportation" test, or the stairs up/down test (Fornieles et al., 2014; Rosety-Rodriguez et al., 2013; Shields et al., 2013) to evaluate functional capacity. The anthropometric assessment was accomplished using weight, height, WC, and BMI (Neto et al., 2010; Ortiz-Ortiz et al., 2019). Some studies also evaluate fat-free mass and fat mass using the electrical bioimpedance method or subcutaneous adiposity skinfolds (Neto et al., 2010; Ortiz-Ortiz et al., 2019; Rosety-Rodriguez et al., 2013). Although there was a wide dispersion in the evaluation methods used in different studies, the neuromuscular capacity is always assessed either through the exercises prescribed in the training programs or through standard assessments. Maximal and submaximal strength tests were used, such as the 1 RM (Shields et al., 2013; Shields & Taylor, 2010), the 8 RM (Fornieles et al., 2014; Rosety-Rodriguez et al., 2021), the handgrip test measured by manual dynamometer (Ortiz-Ortiz et al., 2019; Rosety-Rodriguez et al., 2021), and different isokinetic strength tests measured by isokinetic dynamometer (Rosety-Rodriguez et al., 2021). It should be noted that Ghaeeni et al. (2015) and Neto et al. (2010) studies did not assess neuromuscular capacity, despite applying strength training programs. Table 23 shows the duration/frequency, type of exercises, intensity, and results of the nine selected studies.

Table 23. Characteristics of the strength training protocols from the nine studies.

Author, Year	Program Duration, Frequency, Session Duration	Exercise Protocol	Results
Fornieles et al. (2014) Spain	12 weeks; 3 x week; session duration ND.	Exercises: arm curl; leg extension; seated row; leg curl; triceps extension; leg press; intensity: 40 a 65% 8 RM; 2 sets; 6 to 10 rep; 90 sec rest.	Increased concentration of salivary immunoglobulin (*p* = 0.0120), testosterone levels (*p* = 0.0088) and job performance (*p* = 0.0141).
Ghaeeni et al. (2015) Iran	8 weeks; 3 × week; 45 a 60 min/session.	Abdominal workout; 3 to 4 exercises per session; 3 to 6 sets; 10 to 20 rep.	Improvement of static balance (*p* = 0.0001).
Kachouri et al. (2016) Tunisia	8 weeks; 3 × week; 45 a 60 min/session.	All exercises were performed in two surfaces, firm and foam; exercises included air squat, squat jumps, straight sit ups, power sit up, flutter kicks, two-foot ankle hop, single-foot side-to side ankle hop, tuck jump with knees up, standing long jump, double leg hops, single leg hops, standing on one-foot, lateral jump with both feet, lateral jump with one foot, running up the stairs with one foot and running up the stairs with both feet. 3 to 5 sets; 15 to 20 rep.	Improves postural balance.
Neto et al. (2010) Brazil	12 weeks; 3 × week; 60 min/session.	Exercises: chest press, squat, shoulders, leg curl, one-sided stroke, heel lift, bicipital curl, tricipital French e abdominal crunch; 3 sets; 8 to 12 rep; 30 to 60 sec rest.	Increased lean mass (*p* = 0.008) and reduced fat percentage (*p* = 0.036).
Ortiz-Ortiz et al. (2019) Mexico	16 weeks; 5 × week; 55 min/session.	Circuit exercises using weight disks, rubber bands, dumbbells, medical balls and shin guards with weights—biceps curl, triceps extension, chest press, and handgrip with different degrees of tension.	Reduction in the BMI (*p* < 0.0001) and the skin fold of the twin (*p* = 0.008); increased isometric strength (*p* < 0.0001).
Rosety-Rodriguez et al. (2013) Spain	12 weeks; 3 × week; session duration ND.	Exercises included arm curl, leg extension, seated row, leg curl, triceps extension, and leg press; 40 to 65% of 8 RM; 2 sets; 6 to 10 rep.	Plasma levels of leptin (*p* < 0.05), TNF-α (*p* < 0.05) and IL-6 (*p* < 0.05) and WC decreased (*p* = 0.0416); increase in fat-free mass (*p* = 0.011); improved response to systemic inflammation.
Rosety-Rodriguez et al. 2021) Spain	12 weeks; 3 × week; Session duration ND.	Exercises included arm curl, leg extension, seated row, leg curl, triceps extension, and leg press; 40 to 50% of 8 RM; 2 sets; 8 to 10 rep; 90s rest.	Improvement of the antioxidant defence system; reduction in markers of oxidative damage.
Shields and Taylor (2010) Australia	10 weeks; 2 × week; session duration ND.	Exercises: lat pull-down, seated chest press, seated row, seated leg press, knee extension, calf raise; 3 sets; 12 rep or until fatigue;	Improvement in muscle strength of the lower limbs (mean difference 36 kg, 95% CI 15 to 58).

		2 min rest between exercises.	
Shields et al. (2013) Australia	10 weeks; 2 × week; 60 min/session.	Exercises: lat pull-down, seated chest press, seated row, seated leg press, knee extension, seated calf raise; 3 sets; 12 rep; 60 to 80% RM; 2 min rest between exercises.	Improvement in muscle strength of the lower 1imbs (mean difference 25 kg, 95% CI 8 to 42) and upper limbs 1 (mean difference 7 kg, 95% CI 3 to 11).

Note: min, minutes; ND, not defined; *p*, significance; rep, repetition; RM, repetition maximum; s, second.

5.3.6. Characteristics of the Strength Training Protocols

Table 23 shows the characteristics of the strength training protocols. The programs' duration varied between 8 and 16 weeks, with half the studies prescribing 12 weeks (Fornieles et al., 2014; Neto et al., 2010; Rosety-Rodriguez et al., 2013, 2021). The weekly frequency varied between two and five times, with a greater number of studies showing a weekly frequency of three sessions (Fornieles et al., 2014; Ghaeeni et al., 2015; Kachouri et al., 2016; Neto et al., 2010; Rosety-Rodriguez et al., 2013, 2021). The training sessions duration varied between 45 and 60 minutes.

The protocols adopted varied from study to study. Six studies applied circuits in strength training machines (Fornieles et al., 2014; Neto et al., 2010; Rosety-Rodriguez et al., 2013, 2021; Shields et al., 2013, 2013), one study included exercise performed in two surfaces conditions (firm and foam) Kachouri et al. (2016), one study applied exercises with free weights (Rosety-Rodriguez et al., 2021), and one study applied an abdominal workout (Ghaeeni et al., 2015).

All studies showed a positive effect from the different strength training protocols, which can be seen in Table 23.

5.4 Discussion

The present systematic review aims to analyse the effects of strength training in individuals with IDD, based on the characterization of several programs implemented, as well as the identification of mean characteristics for strength training prescription programs, namely duration, weekly frequency, appropriate assessment methods, and type of exercises. The following subsections will discuss all main point of the strength training programs applied.

5.4.1 Program Duration

As mentioned in the results section, the programs' durations varied between 8 and 16 weeks, with half the studies prescribing 12 weeks (Fornieles et al., 2014; Neto et al., 2010; Rosety-Rodriguez et al., 2013, 2021). Short-term intervention programs may be a limitation presented in some studies (Fornieles et al., 2014; Shields & Taylor, 2010). Although all studies have shown several positive results (Table 23), further studies with a longer duration are needed to understand the long-term benefits, as well as the type of strength training periodization to be applied in the population with IDD. We consider that the duration of the training programs is critical to outwit if there are individuals who do not experience significant improvements following an exercise training intervention. Such individuals are commonly termed “non-responders”. However, recently, many researchers have taken a sceptical view as to whether exercise non-response either exists or is clinically relevant.

5.4.2 Frequency

The weekly frequency followed the recommendations of the ACSM (2021); once weekly frequency occurred between two and five times. This number of weekly strength training sessions allows adaptations that lead to catabolism and consequent protein anabolism, allowing the maintenance or increase in lean mass (Nogueira et al., 2008). Moreover, except for Ortiz-Ortiz et al. (2019), all the other studies did not report sessions on consecutive days. It is important to reinforce that even the study of Ortiz-Ortiz et al. (2019) improved the BMI ($p<0.0001$) and skin fold of the calf ($p=0.008$), which suggests future studies should confirm such results.

5.4.3 Session Duration

The training sessions duration varied between 45 and 60 minutes and their structure consisted of warm-up, main phase, and a return to calm/cool down, which is in accordance with the ACSM guidelines (2021). However, some studies did not mention the session duration (Fornieles et al., 2014; Rosety-Rodriguez et al., 2013, 2021; Shields & Taylor, 2010), which is a limitation, leaving some doubts about the recovery period that was applied, as well as the replicability of the studies.

5.4.4 Sets

The number of sets per exercise varied between two and six, depending on the progress and training periodization. However, the prescription of two or three sets was more frequent (Fornieles et al., 2014; Neto et al., 2010; Rosety-Rodriguez et al., 2013, 2021; Shields et al., 2013; Shields & Taylor, 2010), in accordance with ACSM (2021). Some authors state that, in untrained individuals, both single set and multiple sets produce similar increases in muscle strength of upper and lower limbs; that is, in the early stages, the strength training, regardless of number of sets, seems to be effective for improving muscle outcomes (Cunha et al., 2020).

5.4.5 Repetitions

The number of repetitions per set varied between 6 and 30; however, most studies prescribed 6 to 12 repetitions (Fornieles et al., 2014; Neto et al., 2010; Rosety-Rodriguez et al., 2013; Shields et al., 2013). This number is influenced by the prescription of one RM methods or the use of a number of repetitions by exercise (not one RM). The number of sets and repetitions per exercise can vary depending on volume and intensity (Iversen et al., 2021). This number follows previous recommendations for healthy people (Duplanty et al., 2014).

5.4.6 Intensity

Strength training programs presented different training intensities according to the different objectives established for the development of strength adaptations (endurance, resistance, power, etc.). The intensity expressed through the percentage of the working load expressed by the number of RM varied between 40 to 65% of 8 RM (Fornieles et al., 2014; Rosety-Rodriguez et al., 2013), from 40 to 50% of 8 RM (Rosety-Rodriguez et al., 2021), and from 60 to 90% of 1 RM (Shields et al., 2013). Different purposes, different available material resources and/or individual characteristics may be some of the reasons to justify such a range of training intensities used in the different studies, not fulfilling the usual recommendations suggested by the ACSM (2021)—75–80% 1 RM. Despite the reported use of different intensities, in general, the ACSM guidelines (2021) were applied and all studies reported a positive effect (see strength training results section).

The application of the training progression general principle was common to several studies (Ghaeeni et al., 2015; Kachouri et al., 2016; Ortiz-Ortiz et al., 2019; Rosety-Rodriguez et al., 2021; Shields et al., 2013; Shields & Taylor, 2010), with an increase in intensity throughout the intervention period, regardless of the type of material/equipment used (whether the programs used weight machines, free weights, rubber bands, or other materials). The progression of the intensity increased gradually, depending on the number of training weeks or individual performance, either by increasing the percentage of the training load (by increasing the weight in the ankle shin guards), or simply by increasing the number of series and/or repetitions to perform during the training session, as recommended by the ACSM (2021).

5.4.7 Exercises

According to the studies evaluated (Ghaeeni et al., 2015; Ortiz-Ortiz et al., 2019; Rosety-Rodriguez et al., 2021; Shields et al., 2013; Shields & Taylor, 2010), most strength training programs included exercises targeting the main muscle groups in each session. Although the studies analysed use different types of equipment (weight training machines, using resistance elastics, and/or ankle weights), all of them show intentionality to use strength training exercises aiming to request the main muscle group (Iversen et al., 2021). It should be noted that only two studies used a period of adaptation and familiarization to the prescribed exercises (Aharoni, 2005; Ayaso-Maneiro et al., 2014), which is important to eliminate the fear of using new materials, movement perception, and to ensure high quality results. The most common exercises used in the strength training programs are the leg flexion and leg extension exercises (hamstrings and quadriceps), the abdominals in their different variants (abdomen muscles), the chest press (pectoral major), the low row or the lat pull down (latissimus dorsi), flexion of the forearm (biceps), an extension of the forearm (triceps), and elevation, abduction, or shoulder press (deltoids). When prescribing six to eight exercises, strength training programs were in accordance with the recommendations provided by ACSM (2021), however, in some studies, this was not the case (Ghaeeni et al., 2015; Neto et al., 2010). In most of studies, selected exercises tended to be simple and easy to be performed, with special attention and reinforcement in the instruction, demonstration, and familiarization (Aharoni, 2005; ACSM, 2021; Ayaso-Maneiro et al., 2014). Some individuals may experience difficulties in controlling movement, particularly in the eccentric phase, and thus it was suggested to use machines that help to better control them (for example, a chest press device rather than the bench press). Additionally, machine exercises are preferable to avoid some type of injury, for presenting a smaller range of motion; however, there were some exceptions such as the biceps curl, seen as working well in participants with IDD (Iversen et al., 2021).

5.4.8 Strength training programs outcomes

Some studies have shown significant positive effects on muscle strength in lower limbs (Shields & Taylor, 2010), in upper and lower limbs (Shields et al., 2013), and in handgrip strength ($p<0.0001$) (Ortiz-Ortiz et al., 2019). These results are very encouraging for further studies with this population and to implement in clinical practice. A greater capacity to generate strength by the muscles (lower and upper limbs) may become an essential tool to insert these patients in professional activities due to the increase in their physical capacities (Shields & Taylor, 2010).

Other studies found an increase in fat-free mass and a reduction in fat mass (Neto et al., 2010; Ortiz-Ortiz et al., 2019; Rosety-Rodriguez et al., 2013). Depending on the aims and evaluation methods used, some studies reported a reduction in the WC (Rosety-Rodriguez et al., 2013) of the BMI (Ortiz-Ortiz et al., 2019) and an improvement in balance (Ghaeeni et al., 2015).

An increase in the concentration of salivary immunoglobulin, testosterone levels, plasma leptin levels, TNF-α, and IL-6 was also found. Specifically, Fornieles et al. (2014) showed thar resistance training program of 12 weeks increased concentration of salivary immunoglobulin (p = 0.0120), testosterone levels (p = 0.0088) and task performance (p = 0.0141). This study highlights the benefits of strength training, as this increase in salivary IgA levels can prevent respiratory tract infections in individuals with DS (Chaushu et al., 2002). This study also shows an improvement in the anabolic status of DS patients after the strength training program, as cortisol levels remain unchanged and there was an increase in salivary testosterone. It was also found that the improvement of task performance is of great interest to this population. Having improved levels of muscle strength may allow this population to perform a greater number of activities and continue to exercise, thus reducing the risk of secondary consequences for their health (Lotan, 2007; Shields et al., 2010). Additionally, improvements in the response to systemic inflammation, in the antioxidant defense system, and a reduction in oxidative damage were also reported (Fornieles et al., 2014; Rosety-Rodriguez et al., 2013, 2021).

Dynamic balance as a parameter of functional capacity is also limited in individuals with IDD. Even so, two studies reported improvements with strength training, particularly in exercises focused to improve strength and power of the lower limbs (Ghaeeni et al., 2015; Shields & Taylor, 2010). These improvements were also associated with improvements in gait speed and balance (Shields & Taylor, 2010). Other non-randomized controlled studies have shown interesting results through the implementation of strength training programs in individuals with IDD, namely, cognitive effects such as positive changes in working memory, short-term memory, vocabulary knowledge, and reasoning ability (Zenebe et al., 2020), and improved flexibility (Jeon & Son, 2017) and performance in daily life activities (Raulino et al., 2014). There is an urgent need for randomized procedures to assess the benefits of these variables and aerobic capacity. Several studies have found significant differences in body composition parameters after the strength training program, namely a reduction in the BMI ($p<0.001$) and the skin fold of the calf ($p=0.008$) (Ortiz-Ortiz et al., 2019); a decreased in WC ($p=0.0416$) and increase in the fat-free mass ($p=0.011$) (Rosety-Rodriguez et al., 2013); and an increased in the lean mass ($p=0.008$) and reduction in the fat percentage ($p=0.036$) (Ortiz-Ortiz et al., 2019). Since being overweight and obesity are associated with poor health and QoL, these results show that strength training is a good intervention to reduce these values.

With the implementation of strength training programs, despite the different prescriptions, positive results were verified in terms of the aims defined in all studies, which shows how training variables, techniques, and methods (for example, training frequency and exercise selection volume, training load and repetitions, and others), can be manipulated to optimize training response. The different results presented in Table 23 and of the non-randomized controlled studies (Jeon & Son, 2017; Raulino et al., 2014; Zenebe et al., 2020) are demonstrated due to the different aims and evaluation methods used in each study, being an added value the application of ST, since it can have this wide range of benefits. All these results are important in terms of promoting the QoL of individuals with IDD, related to the conceptual model of Schalock and Verdugo (2002), a construct divided into three dimensions: (i) independence; (ii) social participation; (iii) well-being.

Some studies included in the systematic review have some limitations, which may limit the magnitude of the results. Future studies should take them into account when implementing strength training programs: (i) short-term studies (Fornieles et al., 2014; Rosety-Rodriguez et al., 2013; Shields et al., 2013); (ii) no follow up to determine whether the positive effects were maintained (Fornieles et al., 2014; Rosety-Rodriguez et al., 2013, 2021; Shields et al., 2013); (iii) small sample size (Kachouri et al., 2016); (iv) sample size only boys (Kachouri et al., 2016); (v) exclusion of children with severe and profound IDD (Kachouri et al., 2016); (vi) a small number of professionals to supervise the exercises produced in the experimental protocol (Neto et al., 2010); (vii) lack of more accurate measurements to evaluate; and (viii) a small number of outcomes (Shields et al., 2013).

At the same time, future studies are suggested to apply the assessment of body composition variables by electrical bioimpedance, such as the phase angle, since it has been considered a relevant marker of health status (Martins et al., 2021). Moreover, a higher phase angle value is positively associated with a higher quality of cell membranes (Sardinha, 2018), while a lower value is associated with deterioration, which can compromise all cell functions (Sardinha, 2018). Thus, phase angle assessment would be helpful to understand if there are adaptations with strength training in this variable that has a strong correlation with cell health and integrity, being an excellent indicator of the capacity of the cell membrane to retain liquids, fluids, and nutrients in the population with ID.

The fact that IDD is a multisystem and complex disorder characterized by the presence of delays or deficits in the development of adaptive behaviour comprising conceptual, social, and motor skills may support a possible explanation why results could differ between studies and studies without the RCT method. The effects of the interventions in the various studies appear similar to those that have been reported following resistance training in the average healthy and intellectually disabled population (Dairo et al., 2016; Hawke & Garry, 2001; Pereira et al., 2012; Ratamess et al., 2009; St. John et al., 2020). However, some variability has also been reported in other resistance training studies and those examining other exercise modalities (Bloomer & Goldfarb, 2004; Cowley et al., 2011; Shields et al., 2013; Shields & Taylor, 2010; Zenebe et al., 2020). Inherent within any measurement are both technical error and random within-subject variation (Hecksteden et al., 2015). Studies included in this systematic review have shown that, although using different training intensities, it was possible to identify improvements in the variables under study; however, it is noted that, before starting the training program, it is necessary to carry out strength assessments, either through RM tests, using devices, or isokinetic, as recommended by ACSM (2021), to determine the correct intensity to be used. During this strength assessment process, as during training, RM tests using free weights, push-ups, and pull-ups should be avoided ACSM (2021) to prevent any type of injury. Moreover, familiarization with the assessment procedures, a practical demonstration of execution, simple instructions, constant supervision, and verbal and visual reinforcement are necessary (ACSM, 2021; Ayaso-Maneiro et al., 2014) for greater success in the didactic-pedagogical process.

This systematic review analysed the effects of strength training in individuals with intellectual disability, aiming to be a reference guidelines tool for researchers and professionals of physical exercise. The analysed studies show characteristics and recommendations that professionals can follow when implementing a strength training program to promote benefits and positive outcomes, namely, the maintenance of/increase in physical fitness, QoL, and health, thus decreasing the risk of developing chronic diseases, being the strong aspect of this systematic review. Therefore, it is essential to implement this type of strength training program, incorporated into the weekly routine of this population, which, when associated with an appropriate lifestyle, causes a set of adaptations and benefits and, ultimately, can promote a decrease in clinical expenses, an increase in healthy aging, and better health.

It is recommended to increase the implementation of strength training programs in the target population, expanding the knowledge in terms of the methods, structure, and duration used, so that professionals can prescribe adapted and effective strength training programs. At the same time, it is important that the exercise professionals have an in-depth knowledge of the individual, their comorbidities, limitations, and preferences, before prescribing and starting a physical exercise program (Iversen et al., 2021).

Despite the relevance of the selected clinical trials for the preparation of this systematic review, some limitations can be observed: (1) the diversified intervention methodology, involving different strengths, intensities, volumes, and weekly training exercise programs; (2) unclear descriptions of the process of randomization and allocation of people with IDD in the groups; (3) loss of follow-up; (4) different evaluation methodologies, as well as the results, not allowing a further discussion as well as a meta-analysis about the effects produced by the several strength training programs applied; (5) the level of IDD was not mentioned in all studies included, which limits the generalization of the results and suggests that future studies should mention such specificity.

5.5 Conclusion

According to the studies included in this systematic review, it can be concluded that the strength training program interventions (particularly when not combined with other exercises) for individuals with IDD are effective in positive muscle strength and present positive outcomes that contribute to the improvement of functional capacity. However, the limited number of studies and the low study quality scores indicate the potential risk of bias, which limits the interpretation of the findings and warrants further investigation. Further studies on strength training are needed to better analyse the training program characteristics and their effects on individuals with IDD.

From the analysed studies, the following aspects were considered transversal in the strength training prescription:

a) Duration of 12 weeks for mesocycles;
b) Most are applied at least three times per week;
c) Duration of 45 to 60 minutes per session;
d) Six to seven exercises recruiting the main muscle groups, avoiding free weights, such as chest press, low row or lat pull-down, elevation, abduction or shoulder press, and abdominals due to their different variants, flexion of the forearm, the extension of the forearm, and leg extension/leg curl/leg press;
e) For each exercise: two or three sets with 6 to 12 repetitions per exercise or maximum. The review of the intensity is essential for the overload process, which can be carried out in the ways mentioned above.
f) Testing and assessment protocols used in strength training programs should be individualized for adults with IDD to accommodate their characteristics and should be implemented under conditions like those experienced during the training regimen.
g) It is important to implement familiarization sessions before carrying out muscular strength testing or initiating a strength training program to ensure safety, accuracy, and effectiveness of the program for adults with IDD.

There are several benefits of strength training in the individual with IDD: (i) increase in the strength of the lower and upper limbs, of the fat-free mass, balance, concentration of salivary immunoglobulin, testosterone levels, plasma leptin levels, factors of tumour necrosis alpha, and interleukins 6; (ii) reduction in WC, BMI, fat mass and oxidative damage; (iii) improved response to systemic inflammation and antioxidant defence system.

We hope this systematic review will be a reference tool for researchers and exercise professionals when prescribing and implementing strength training programs.

Chapter 6 – Assessment of isokinetic strength of the lower limbs of individuals with Intellectual and Developmental Disabilities – systematic review with protocol proposal (study 5)

Assessment of isokinetic strength of the lower limbs of individuals with Intellectual and Developmental Disabilities – systematic review with protocol proposal. Under review in Strength and Conditioning Journal (JCR; IF: 2.5; Q2) since August 11, 2023.

6. Abstract

Strength capacity is associated with positive performance in activities of daily living in individual with IDD and lower levels are directly related to dependence. One of the methods of assessing strength is through the isokinetic dynamometer, a reliable method for this population. This paper describes the design of a method to be adopted for the assessment of isokinetic strength of the lower limbs in individuals with IDD. Using systematic review methodology, electronic searches were conducted in PubMed, Scopus, SPORTDiscus and Web of Science databases and included articles published between January 1990 and September 2022. The key terms used were combined with the Boolean operator "AND" or "OR". After the methodological process, twenty-three studies were included for analysis. The protocol proposal consists of 9 phases, covering previous considerations, warm-up, adjustment of the equipment, the choice of limb and exercise to be evaluated, sets, repetitions, rest, as well as the angular velocity to be tested and the variables. It is intended that this paper provides insights into the development of a useful tool for the various stakeholders interested in assessing the isokinetic strength of the lower limbs of individuals with IDD.

Key words: Concentric, Dynamometer; Eccentric, Intellectual Disability; Neuromuscular capacity.

6.1. Introduction

Muscle strength has been defined as "the ability of a muscle group to produce maximal contractile force against a resistance in a single contraction, and is associated to the ability to perform activities that require high levels of muscular force" (ACSM, 2021). Measuring muscle function using the isokinetic dynamometer is a common method for the general population (Drouin et al., 2004). This test is based on measuring the torque developed during isolated joint exercise, in which resistance is provided during constant angular velocity (Sapega, 1990). It relates agonist and antagonist muscle groups (ex. hamstrings/quadriceps) (Sapega, 1990), allowing the characterization of muscle performance and the risk of injury through opposing muscle groups (Tam et al., 2017).

Dynamometry has been a recognized viable method for assessing muscle performance in healthy and symptomatic populations (Frisiello et al., 1994; Griffin, 1987), which involves constant angular velocity. Isokinetic muscle action can be defined as the tension produced by the muscle to overcome resistance. In turn, resistance is electronically controlled by a computer connected to the equipment, which exerts a resistance proportional to the force developed by the individual and allows the assessment of muscle strength in static or dynamic conditions (Baltzopoulos & Brodie, 1989). This method has been used to study different phases of an exercise (Beckham et al., 2012), determine differences in force production between various sports (McMaster et al., 2014) or the effect of a physical exercise program (Bazyler et al., 2015) and is the most common method of measuring muscles strength (McMaster et al., 2014).

In individuals with IDD, characterized by the deficits in general mental abilities and impairment in everyday adaptive functioning, with onset during the developmental period (American Psychiatric Association, 2013), measuring isokinetic strength using a dynamometer proved to be a reliable method (Pitetti, 1990) and currently constitutes an innovative method in this population to measure physical fitness, essential in activities, tasks and/or daily life routines, such as dressing, personal hygiene, among others (Smail & Horvat, 2006). On the other hand, isokinetic equipment is safety equipment, since it allows you to work with very low loads, control the progressive increase and easily isolate a certain muscle group.

Flexion and extension strength of the lower limbs plays an important role in supporting body weight and in supporting, aiding and absorbing impact in various motor activities (walking, running, among others) and, therefore, can help predicting the functional ability (Frontera et al., 1988; Garcia et al., 2015; Masuda et al., 2005). In turn, the functional capacity of individuals with IDD is fundamental for performing activities of daily living (Raulino et al., 2014), such as climbing stairs, getting up/sitting or in locomotion capacity and, consequently, improving their QoL (Bartlo & Klein, 2011). It is also associated with increased autonomy/functionally and less dependence on others.

Assuming that the isokinetic strength test is reliable for individuals with IDD (Pitetti, 1990) and is recommended by the (ACSM, 2021), this study aims to conduct a discussion of the manuscripts that have used this methodology in recent years and to present a suggested method to be adopted to assess lower limb isokinetic strength in this population.

6.2. Methodology

This systematic review was prepared following the items of the PRISMA guidelines (Page et al., 2021). The PICOS strategy (Methley et al., 2014; Nang et al., 2015) was defined as follows: i) “P” corresponded to participants with IDD (included DS), of any age, gender, ethnicity or race; ii) “I” non applicable; iii) “C” non applicable; iv) “O” corresponded to isokinetic strength as a primary or secondary variable in study; v) “S” corresponded to intervention studies, RCT’s or non RCT’s, pilot study or cross-sectional studies. The protocol was registered in the PROSPERO, with the number CRD42022307164.

6.2.1. Sources of information and research strategies

The research was carried out until the 6th of September 2022, in English, by searching the databases PubMed (title and abstract), Web of Science, Scopus and SPORTDiscus (title, abstract and keywords), considering the period of retreat until 1990. The following descriptors were used: “dynamometer”, “peak torque”, “knee extensors”, “knee flexors”, “Intellectual Developmental Disorder”, “intellectual disability”, “intellectual disabilities”, “mental retardation”, “Down Syndrome” and “Down's syndrome”, combined with the Boolean operator “AND” or “OR”, as shown in table 24.

Table 24. Research strategy.

Research number	Research terms
1	("dynamometer" OR “peak torque” OR “knee extensors” OR “knee flexors”) AND (“Intellectual Developmental Disorder” OR "intellectual disability" OR "intellectual disabilities" OR “mental retardation” OR "Down Syndrome" OR “Down's syndrome”)

6.2.2. Data extraction process

The research was carried out by two investigators independently. After the process was concluded, duplicate articles and those that did not meet the eligibility criteria were eliminated. After reading the full text of the articles, in accordance with the eligibility criteria previously defined, the study sample was constituted with 23 articles. One of the researchers downloaded the relevant information from the articles and entered them in a table (author, year of publication, country, aims, participants and assessment instruments).

6.2.3. Eligibility criteria

For the selection of studies, the following inclusion criteria were considered: a) intervention studies, RCT's or non RCT's, pilot and cross-sectional studies; b) individuals with IDD, including DS; c) Studies with individuals of any age group, gender, race or ethnicity; d) studies that evaluated the strength of the lower limbs through the isokinetic dynamometer. Likewise, the following exclusion criteria were considered: a) studies that have not been published in English or Portuguese; b) studies with participants with other pathologies and/or other disabilities; c) study that do not describe the evaluation protocol.

6.2.4. Methodological Quality Assessment

The methodological quality assessment process of the included articles was carried out independently by two authors and any disagreement were resolved by debate or by consulting a third evaluator. The instrument used was the STROBE checklist, which includes 22 criteria to measuring methodological quality of studies (von Elm et al., 2008). The procedure for using STROBE was according to the following parameter: for each item, scores were given from 0 (answer was "no") or 1 (answer was "yes"). At the end of the classification, a score was generated for each study based on the scores for each item. The quality of the studies was classified as high (final score ≥ 70%), moderate (final score ≥ 60%), and low (final score <60%). *Cohen's kappa* (1988) coefficient of inter-rater agreement, shows substantial agreement (*k*=0.628).

6.3. Results

Through our systematic search, 169 studies were extracted, 37 of which refer to the Pubmed database, 62 from the Scopus database, 48 from the Web of Science and 22 from the SportDiscus. Considering the inclusion and exclusion criteria for this study and the complete reading of the articles, a sample of 23 articles constituted for full analysis. Figure 11 represents the flow chart of this systematic review.

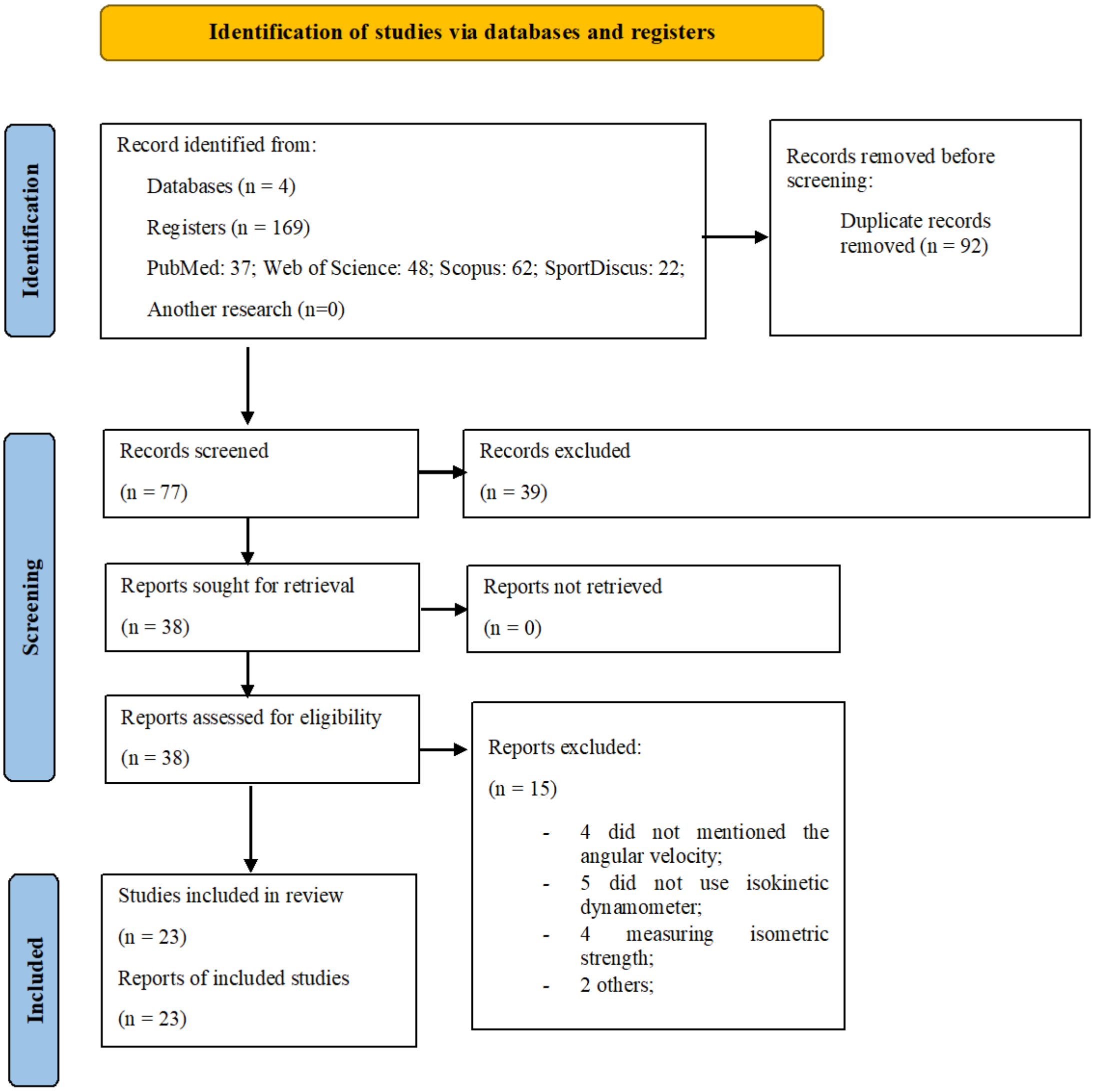

Figure 11. PRISMA flow diagram illustrating each phase of the search and selecting process.

Table 25. Characteristics and protocol of the studies included in review.

Author, year, Country	Aims	Participants	Assessment instruments/angular velocity/other observations	
Angelopoulou et al. (1999)	Assess differences in isokinetic muscle torque in the knee among IDD individuals with DS, IDD individuals without DS, and sedentary subjects without IDD.	N = 27; 24.9 ± 4.9y; Mild to moderate IDD (DS inclusive).	Knee extension and flexion of the right lower extremity - Cybex II isokinetic dynamometer (Lumex Inc., Ronkonkoma, NY 11779) - 60, 120, and 300º/s; Testing was performed on two separate days; Warm-up on a cycle ergometer (6-min); Adjustment of the equipment and participant according to the manual or/and protocol; Test was performed only once, with 5 min. of preliminary testing - Three test repetitions – 30s rest period between each trial and 60s each velocity measurement. Instruction to maximally exert each contraction, during every trial (verbal encouragement).	High methodological quality
Angelopoulou et al. (2000)	Compare the bone mineral density of men with DS to otherwise IDD men and to investigate whether leg muscle strength.	N = 16; 23.7 ± 3.9y; Mild to moderate IDD (DS inclusive).	Right quadriceps femoris and hamstrings muscles - Cybex II isokinetic dynamometer (Lumex Inc, Ronkonkoma NY) - PT at angular velocities at 60, 120, and 300º/s; 6-min warm up - bicycle ergometer; Adjustment of the equipment and participant according to the manual or/and protocol; Three test repetitions - 30s rest period between each trial and 60s each velocity measurement. Instruction to maximally exert each contraction, during every trial (verbal encouragement).	High methodological quality
Carmeli et al. (2002c)	Compared isokinetic leg strength of aged individuals with IDD with and without DS.	N = 25; 61.92 ± 2y; Mild IDD (DS inclusive).	Biodex dynamometer, Medical Systems, Shirley, NY - Knee extension and flexion strength was measured bilaterally; warm-up consisting of a 3-minute velocity walk; Adjustment of the equipment and participant according to the manual or/and protocol; 10-minute practice session (5 repetitions of knee extension and flexion) at a velocity of 60º/s;	High methodological quality

			Following this practice, the subjects then performed 3 maximal voluntary contractions at a velocity of 60º/s;	
Carmeli et al. (2002b)	Compare lower limb isokinetic muscle power, locomotor performance and flexibility of aged adult IDD individuals with and without DS.	N=20; 57-65y; Mild IDD (DS inclusive).	Knee extension and flexion power - isokinetic system (Biodex dynamometer, Medical Systems, Shirley, NY, USA) - dynamic torque, dynamic torque percent body weight and average power; 3 min warm-up walking at a comfortable velocity; Adjustment of the equipment and participant according to the manual or/and protocol; Five practice repetitions for knee extension and flexion at a velocity of 90º/s; Three maximal voluntary contractions at a velocity of 90º/s;	High methodological quality
Carmeli et al. (2002a)	Effects of physical exercise on isokinetic leg strength and dynamic balance.	N=26; 57-6y; Mild IDD (DS inclusive).	Knee extension and flexion strength - isokinetic system (Biodex dynamometer; Medical Systems, Shirley, NY) – PT, PT percent body weight, and average power; 3 min warm-up walking at a comfortable velocity; Adjustment of the equipment and participant according to the manual or/and protocol; Familiarization with the equipment; Five practice repetitions for knee extension and flexion at a velocity of 60º/s and 120º/s; Three maximal voluntary contractions at a velocity of 60º/s and 120º/s.	High methodological quality
Carmeli et al. (2005)	Investigate the effect of physical training on balance, strength, and general well-being in adult people with IDD.	N=22; 54-66y. Mild IDD.	Knee flexion and extension strength, 60º/s - (Biodex, Medical Systems, Shirley, NY, USA); Warm-up; Three maximal repetitions of knee flexion extension at velocitys of 60º/s.	Moderate methodological quality

Cowley et al. (2011)	Examine the effect of progressive resistance training on leg strength, aerobic capacity and physical function in persons with DS.	N = 30; 28 ± 8y. DS and mild IDD.	Knee extensor and flexor PT - Biodex System 3 dynamometer (Biodex Medical Systems, Shirley, NY); Adjustment of the equipment and participant according to the manual or/and protocol; Three sets of five maximal contractions with the knee extensors and flexors at 60º/s with 3 min between set.	High methodological quality
Croce et al. (1996)	Compare isokinetic hamstring and quadriceps peak torque (Nm), average power (watts), and corresponding hamstring/quadriceps ratios of adult with DS.	N = 22; 25 ± 395y; IDD (DS inclusive).	Dominant side - The dominant leg was defined as the leg the subject used or would use to kick a ball; PT and average - 60°/s and 90°/s (Cybex 340 isokinetic dynamometer); Testing was performed on two different days, with 48 to 96 hours between test days; Warm-up (6 to 10 min on either a Schwinn Air-Dyne ergometer or a treadmill); Adjustment of the equipment and participant according to the manual or/and protocol; Ten practice repetitions, beginning at a low effort and gradually increasing to efforts of high intensity, for leg extension and flexion at a velocity of 60°/s; Two sets of three maximal efforts at 60°/s; Following a 1-min rest, subjects performed two sets of three maximal efforts at 90°/s.	High methodological quality
Eid et al. (2017)	Investigate the effects of isokinetic training on muscle strength and postural balance in children with DS.	N = 31; 9 to 12y; DS;	PT of the knee flexors and extensors of both sides 120°/s Biodex System 3 dynamometer (Biodex Medical System, Shirley, New York, USA); Adjustment of the equipment and participant according to the manual or/and protocol; 10 concentric contractions at 120°/s (flexion and extension) and the measurement test were repeated three times.	High methodological quality
Frey et al. (1999)	Compare physical fitness levels of trained runners with mild IDD.	N =9; 28.7 ± 7.4y; Mild IDD.	Dominant knee extensors and flexors - isokinetic dynamometry (KINCOM 500-H, Chattecx); Familiarization and practice; Five trials were conducted at 60º/s.	Moderate methodological quality

Horvat et al. (1999)	Compare isokinetic knee strength of nondisabled youth and youths with IDD.	N = 30; 10 to 16y; Mild to moderate IDD.	PT, time to PT, angle of PT, total work, and PT hamstrings/quadriceps ratio - of 60°/s; Stretching exercises (10 min) and practice extension/flexion with the dynamometer; Adjustment of the equipment and participant according to the manual or/and protocol; 3-5 submaximal repetitions – test; The subject performed a max-effort knee extension followed by a max-effort knee flexion throughout the range of motion. This procedure was repeated for six continuous extension-flexion repetitions. No rest was allowed between the extension-flexion repetitions - Kin-Con isokinetic dynamometer; Adjustment of the equipment according to the manual.	High methodological quality
Ko et al. (2012)	Investigate the effects of physical activity on the muscular strength of the lower extremities of IDD adults	N = 10; 47.5 ± 2.75y; IDD.	Isokinetic device (Cybex 770, USA) - flexors and the extensors of the knee joint; Rehearsed the procedure 3 times in advance before the actual measurement; Muscular strength was measured 5 times at a loading rate of 60°/s, which was focused on the knee joint.	High methodological quality
Pitetti et al. (1992)	Compared isokinetic arm and leg strength of individuals with DS, with IDD without DS and sedentary young adults with no IDD.	N = 36; 25.6 ± 4y; IDD (DS inclusive).	Knee extension and flexion (Cybex 340 dynamometer); Dominant side - the dominant leg was defined as the leg the subject used or would use to kick a soccer ball; PT, PT percent body weight, average power, and average power % body weight; Testing was performed on two different days, with 48 to 96 hours between test days; Warm-up submaximal exercise (either a Schwinn Air-Dyneb ergometer) at a workload ranging between 25 and 100 watts (6 min); Ten practice repetitions for leg extension and flexion at a velocity of 60º/ s; Four repetitions, two at moderate velocity and the final two at maximal velocity. Within ten seconds after the four repetitions, subjects performed two sets of three maximal efforts. with 30s between sets.	High methodological quality

Pitetti & Boneh (1995)	Compare cardiovascular fitness to leg strength of young adults with MR with and without DS and to determine whether a relationship exists.	N = 30; 27.2 ± 4y; DS.	Two sets of three maximal efforts, with 30s between sets a velocity of 60º/s; PT, average power and expressed relative to body weight – knee extension and knee flexion of the dominant leg; The dominant arm was defined as the limb the subject used or would use to throw a ball;	High methodological quality
Pitetti and Fernhall (1997)	Evaluate the relationship between aerobic capacity and leg strength of youths with IDD.	N = 29; 14.2 ± 2.1y; Mild to moderate IDD.	Knee flexion and extension - dominant side (the leg used to kick a soccer ball) - Kin-Com M500 H dynamometer, a velocity of 60°/s (Chattex Corporation, Chattanooga Group, Inc.); PT, peak force and average force; Adjustment of the equipment and participant according to the manual or/and protocol; Stretching exercises of the quadriceps and hamstrings before performing the test; Practiced the knee extension/flexion movement until the they demonstrated proper testing procedure; 5 min following the practice session, subjects performed two sets of six repetitions, with a 3-min rest period between sets; Subjects were verbally encouraged to perform as vigorously as possible.	High methodological quality
Raulino et al. (2014)	Measure muscle strength (isokinetic) and activities of daily living in individuals with IDD.	N = 40; 21.6 ± 4.8y; Mild to severe IDD.	PT - Biodex System 3 Pró (Biodex Medical, Shirley, New York); Warm up 5 minutes on a 25-watt calibrated exercise bike and stretching of lower limbs; Adjustment of the equipment and participant according to the manual or/and protocol; Familiarization - 4 submaximal repetitions; After 1 minute the individual performed 2 sets with 4 maximum repetitions of knee flexion and extension in concentric-concentric 60°/s.	High methodological quality
Rosety-Rodriguez et al. (2021)	Effect of strength training on antioxidant defence	N = 36; 28.1 ± 3.3y; DS (mild	PT of flexion and extension of the of the knees - isokinetic dynamometer at 90°/s -Technogym-REV 9000 (Technogym Spa, Gambettola, Italy);	High methodological quality

	system in sedentary DS.	IDD);	Warm-up - stationary bicycle at a comfortable pace and light stretching leg exercises; Adjustment of the equipment and participant according to the manual or/and protocol; Participants were asked to exert the maximal force over the full range of motion.	
Suomi et al. (1993)	Determine the reliability of isokinetic and isometric measurement of strength for tests of knee extension and hip abduction on individuals with mental retardation.	N = 22; Mean age: 30.3y. Mild to moderate IDD.	Isokinetic knee extension on both limbs; 5-minute warm-up period - pedalling a bicycle ergometer at a submaximal level; Initial warm-up of 10 repetitions of knee extension at 60º/s; After a l-minute rest. the subjects performed four maxima1 repetitions at either 60º/s (knee extension); A 2-minute rest was then provided. followed by three sets of four maxima1 contractions at 60º/s for knee extension; Peak torque – Total work;	High methodological quality
Suomi et al. (1995)	Effects of hydraulic resistance training on total work and PT measures on men with IDD.	N = 22; 30.1 ± 5.8y; Mild to moderate IDD.	Musculoskeletal Evaluation, Rehabilitation and Conditioning (MERAC) Systems Dynamometer (Universal Gym Equipment, Cedar Rapids, IN; Total work and PT - knee extension for each limb; All subjects were tested under comparable conditions by the same tester who was a certified athletic trainer; One day before the test session, each subject attended an orientation session to ensure their understanding of the test protocol; Previous research has indicated that at least two test sessions are required to obtain reliable isokinetic test results from subjects with MR; 5-minute warm-up - pedalled a bicycle ergometer; Adjustment of the equipment and participant according to the manual or/and protocol; Initial warm-up of 10 repetitions of knee extension (KE) at 60°/s;	High methodological quality

			After a 1-min rest, four maximal repetitions of the knee extension test at 60°/s; 2-min rest period was followed by the actual test session which consisted of three sets of four maximal contractions conducted at a velocity of 60°/s with a 1-min rest period between sets; No verbal prompting (feedback) was provided.	
Suomi (1998)	Compare isokinetic measures of PT and total work in men with IDD.	N = 12; 27 ± 6.1y; mild to moderate IDD.	Isokinetic knee extension test at a velocity of 60°/s - Musculoskeletal Evaluation, Rehabilitation, and Conditioning (MERAC) Systems Dynamometer; Total work and PT - Knee extension for each limb; All subjects were tested under comparable conditions by the same tester who was a certified athletic trainer; One day before the test session, each subject attended an orientation session to ensure their understanding of the test protocol; Previous research has indicated that at least two test sessions are required to obtain reliable isokinetic test results from subjects with MR; 5-min warm-up period in which they pedalled a bicycle ergometer; Adjustment of the equipment and participant according to the manual or/and protocol; Warm-up of 10 repetitions of knee extension at 60°/s; After a 1-min rest, the subjects performed four maximal repetitions of the knee extension test at 60°/s; 2-minute rest period was followed by the actual test session which consisted of three sets of four maximal contractions conducted at a velocity of 60°/s with a 1-min rest period between sets; No verbal prompting (feedback) was provided.	High methodological quality

Tsimaras & Fotiadou (2004)	Evaluate the effect of training on the muscle strength and dynamic balance ability of adults with DS.	N=25; Mean age: 24.5y; DS.	PT of knee extension and flexion - Cybex II isokinetic dynamometer (Lumex Inc., Ronconkoma, NY) The research protocol took place during 2 separate days of testing spaced 48–72 hours apart; 25 repeated maximum efforts at an angular velocity of 180º/s.	High methodological quality
Tsimaras et al. (2009)	Evaluate the effect of basketball training on the muscle strength of adults.	N=16; Mean age: 25.9y; IDD.	Knee extensor and flexor muscle groups - maximal isometric and isokinetic concentric and eccentric torque - Cybex Norm isokinetic dynamometer; Warm-up - 5 min of cycling on a Monark ergometer (Monark Exercise AB, Vansbro, Sweden) - cadence at which they felt comfortable; Adjustment of the equipment and participant according to the manual or/and protocol; A series of submaximal isometric, concentric, and eccentric contractions at 60º/s; 3 reciprocal maximal concentric and eccentric contractions and 3 maximal isometric contractions of knee extensors and flexors, with a 3-min interval between them.	High methodological quality
Zafeiridis et al. (2010)	Examined fatigue profile during intermittent exercise in 10 men.	N = 10; 24 ± 3.3y; mild to moderate IDD.	4 sets of 30s (18 maximal flexions and extensions of the knee joint – 120ºs-1), with a 60s rest interval between sets (isokinetic dynamometer (Chatanooga Group Inc., USA); 5-min warm up on a bicycle ergometer at a heart rate of 120–130 bpm, and 5 min of stretching exercises; Adjustment of the equipment and participant according to the manual or/and protocol; Only the leg of preference was tested.	High methodological quality

Note: Bpm, beats per minute; DS, Down Syndrome; IDD, Intellectual Developmental Disabilities; Min, minute/s; N, participants; PT, peak torque; S, second; Y, years.

6.3.1. Quality of studies

All studies showed moderate to high methodological quality, which is indicative of the quantity of information provided by the authors of the primary studies. No study was excluded due to low quality scores. On the other hand, although the studies had different methodological goals, the analysis focused mainly on the isokinetic assessment protocol.

6.3.2. Protocol proposal

Overall, studies showed that participants had to be guided and controlled so that no moderate or high-intensity physical activity was performed in the 48 hours prior to the assessments, thus avoiding the interference of variables that could compromise the test results. Some authors stated that the assessments should take place on two separate days, with an interval of 48-96 hours, and an analysis should be made of whether there are significant differences between both moments, to obtain reliable results from individuals with IDD. However, this situation was not observed in all studies. Familiarization or training with the equipment should be considered in future studies, as it is essential for the individual to understand the assessment protocol and the intended movement, as well as diminish the learning effect impact on results.

The assessment protocol should include several phases, which are describe below.

6.3.2.1. Warm-up

An evident aspect of most studies is the warm-up before the implementation of the isokinetic strength assessment protocol. This warm-up lasted from 3 to 10 minutes, in which a cycle ergometer was used (Angelopoulou et al., 1999), namely a static bike (Angelopoulou et al., 2000; Raulino et al., 2014; Suomi, 1998; Suomi et al., 1995; Tsimaras et al., 2009), a Schwinn Air-Dyne (Croce et al., 1996; Pitetti et al., 1992), a treadmill (Croce et al., 1996) or through a simple walk at a comfortable intensity (Carmeli et al., 2002a; Carmeli et al., 2002b; Carmeli et al., 2002c). At the same time, some studies performed stretching as a way of warming up (Horvat et al., 1999; Pitetti & Fernhall, 1997). The study of Rosety-Rodriguez et al. (2021) and Zafeiridis et al. (2010) combined the two methodologies, that is, prescribed a warm-up through a cycle ergometer and performing after it stretching. Although considered an important phase, other studies did not mention if a warm-up was performed before the isokinetic strength assessment (Carmeli et al., 2005; Cowley et al., 2011; Eid et al., 2017; Frey et al., 1999; Ko et al., 2012; Pitetti & Boneh, 1995; Tsimaras & Fotiadou, 2004).

6.3.2.2. Adjustment of the equipment and participant according to the manual or/and protocol

A correct calibration in accordance with the manufacturer's specifications of the equipment before the evaluations is essential (Carmeli et al., 2002a; Carmeli et al., 2002b; Carmeli et al., 2002c; Raulino et al., 2014), as well as a correct vertical and horizontal adjustment of the dynamometer according to the participant (Angelopoulou et al., 1999, 2000; Carmeli et al., 2002a; Carmeli et al., 2002b; Carmeli et al., 2002c; Cowley et al., 2011; Croce et al., 1996; Eid et al., 2017; Horvat et al., 1999; Pitetti & Fernhall, 1997; Raulino et al., 2014; Rosety-Rodriguez et al., 2021; Suomi, 1998; Suomi et al., 1995; Tsimaras et al., 2009; Zafeiridis et al., 2010). Although manuals may differ from model to model, it is important to describe the main procedures to be taken into account: a) seated in the chair with a solid back support (85º hip flexion); b) stabilization straps (velcro straps) at the trunk, thigh, pelvis, and tibia to prevent extraneous joint movement; c) tested knee positioned at 90º flexion (0º = fully extended knee); d) parallel alignment of the limb to be evaluated with the lever arm of the dynamometer; e) alignment of the anatomical axis of rotation of the joint with the rotational axis of the dynamometer, considering the distal point of the lateral condyle of the femur (the fixing strip of the pad was adjusted 2 centimetres above the upper edge of the fibular malleolus); e) lever pad placed on the distal anterior tibia 3 to 5 centimetres above the lateral malleolus; f) arms comfortably across the chest.

6.3.2.3. Knee extensors and/or flexors and both limbs or only dominant limb

Only the study by Suomi (1998) did not evaluate the two movements, extension and flexion of the lower limb, having only evaluated the knee extension. The evaluation of the agonist and antagonist muscles (concentric or eccentric movement) allows us to assess the imbalance and/or weakness between them, namely in the stabilization of the knee joint (Muñoz-Bermejo et al., 2019), since disparate values are considered a sign of injury (Ruivo et al., 2012; Tam et al., 2017). In healthy adults, the average peak torque ratio, of flexors and extensors, ranges from 50 to 80%, according to different angular velocities (Calmels et al., 1997; Rosene et al., 2001).

Some studies assessed only the dominant limb (Croce et al., 1996; Frey et al., 1999; Pitetti et al., 1992; Pitetti & Boneh, 1995; Pitetti & Fernhall, 1997; Zafeiridis et al., 2010). Of these studies, some specified how the dominant limb of these individuals was defined (Croce et al., 1996; Pitetti et al., 1992; Pitetti & Boneh, 1995; Pitetti & Fernhall, 1997). The studies of Angelopoulou et al. (1999, 2000) only evaluated the right lower limb, independently of being the dominant one or not. A considerable number of studies have evaluated both lower limbs (47% of the studies extracted) (Carmeli et al., 2002a; Carmeli et al., 2002b; Carmeli et al., 2005; Carmeli et al., 2002c; Cowley et al., 2011; Eid et al., 2017; Ko et al., 2012; Raulino et al., 2014; Suomi, 1998; Suomi et al., 1995; Tsimaras et al., 2009). A small number of studies did not specified which member was evaluate (Horvat et al., 1999; Rosety-Rodriguez et al., 2021; Tsimaras & Fotiadou, 2004). It is important to evaluate both lower limbs to assess strength imbalances between dominant and non-dominant muscle groups (Croisier et al., 2007).

In addition to being fundamental for competence and motor skills for the practice of physical exercise, games and sports activities (Eliakim et al., 2019; Santos et al., 2013), muscle strength is crucial for success in activities of daily living (Eliakim et al., 2019; Raulino et al., 2014). This physical capacity must be recognized as a pre requisite of global health (Eliakim et al., 2019) and evaluated as comprehensively as possible, in order to better plan physical exercise and analyse its impact, promoting physical fitness and QoL.

6.3.2.4. Repetitions/Sets /Rest

In relation to number of repetitions/sets and rest duration, it was found a great heterogeneity of protocols. It can be observe studies that evaluate only one set (Carmeli et al., 2002a; Horvat et al., 1999; Ko et al., 2012; Tsimaras & Fotiadou, 2004) two sets (Croce et al., 1996; Pitetti et al., 1992; Pitetti & Boneh, 1995; Pitetti & Fernhall, 1997; Raulino et al., 2014), three sets (Angelopoulou et al., 1999, 2000; Cowley et al., 2011; Eid et al., 2017; Suomi, 1998; Suomi et al., 1995; Tsimaras et al., 2009) or four sets (Zafeiridis et al., 2010) in each angular velocity. Resuming, the number of sets to assess isokinetic strength varied from 1 to 4, with most prescribing 3 sets.

With regard to repetitions per sets, it can be observe studies that tested one repetition (Angelopoulou et al., 1999, 2000; Tsimaras et al., 2009), three (Carmeli et al., 2002b; Carmeli et al., 2005; Carmeli et al., 2002c; Croce et al., 1996; Pitetti et al., 1992; Pitetti & Boneh, 1995; Tsimaras et al., 2009), four (Suomi, 1998; Suomi et al., 1995), five (Cowley et al., 2011; Frey et al., 1999; Ko et al., 2012), five (Raulino et al., 2014), six (Horvat et al., 1999; Pitetti & Fernhall, 1997), ten (Eid et al., 2017), eighteen (Zafeiridis et al., 2010), twenty-five (Tsimaras & Fotiadou, 2004), being the higher number of repetitions associated with other aims such as the analysis of muscle fatigue (Zafeiridis et al., 2010). Most studies tested isokinetic strength using 3 repetitions per set of angular velocity.

Some studies presented 30 seconds of rest between each sets (Angelopoulou et al., 1999, 2000; Pitetti et al., 1992; Pitetti & Boneh, 1995), others 60 seconds (Suomi, 1998; Suomi et al., 1995; Tsimaras et al., 2009; Zafeiridis et al., 2010) or 3 minutes (Cowley et al., 2011; Pitetti & Fernhall, 1997; Tsimaras et al., 2009). Some studies combined 60 seconds of rest between each angular velocity (Angelopoulou et al., 1999, 2000).

6.3.2.5. Angular velocities

Most studies, namely 73%, only assess isokinetic strength of individuals with IDD at a single angular velocity (Carmeli et al., 2002b; Carmeli et al., 2005; Cowley et al., 2011; Eid et al., 2017; Frey et al., 1999; Horvat et al., 1999; Ko et al., 2012; Pitetti et al., 1992; Pitetti & Boneh, 1995; Pitetti & Fernhall, 1997; Raulino et al., 2014; Rosety-Rodriguez et al., 2021; Suomi, 1998; Suomi et al., 1995; Tsimaras et al., 2009; Tsimaras & Fotiadou, 2004; Zafeiridis et al., 2010). The study of Carmeli et al. (2002) and Croce et al. (1996) evaluate at two angular velocities and the studies of (Angelopoulou et al., 1999, 2000) used three angular velocities.

The evaluated angular velocities tested were: 60, 90, 120, 180 and 300º/s, however, 73% of the studies only tested the angular velocity of 60º/s (Angelopoulou et al., 1999, 2000; Carmeli et al., 2002a; Carmeli et al., 2005; Carmeli, et al., 2002c; Cowley et al., 2011; Croce et al., 1996; Frey et al., 1999; Horvat et al., 1999; Ko et al., 2012; Pitetti et al., 1992; Pitetti & Boneh, 1995; Pitetti & Fernhall, 1997; Raulino et al., 2014; Suomi, 1998; Suomi et al., 1995; Tsimaras et al., 2009).

Some studies indicate that the test-retest reliability of the isokinetic strength test at fast velocities, namely above 180º/s, in individuals with IDD, is not as reliable as tests performed at slower velocities (Horvat et al., 1997; Pitetti, 1990). Therefore, it is recommended that the assessments carried out would be performed with an angular velocity of 180º/s or less.

6.3.2.6. Evaluated variables

Variables considered for analysis were: 1) absolute dynamic torque and in percentage of body weight, 2) absolute peak torque and in percentage of body weight, 3) time to peak torque, 4) angle of peak torque, 5) total work, 6) peak torque ratio hamstrings/quadriceps, 7) absolute average power and in percentage body weight, 8) peak force and average force. However, peak torque was the most common variable evaluated in all studies. Peak torque is the highest torque value output reached by the joint due to muscle contraction as the knee moves, in flexion or extension, through the range of motion.

6.4. Discussion

The present review intends to suggest method to be adopted for the assessment of isokinetic strength of the lower limbs in individuals with IDD, being an analysis that allows the assessment of the neuromuscular function, functional capacity and, consequently, perceive QoL (Bartlo & Klein, 2011; Pitetti, 1990; Raulino et al., 2014). The paper presents the entire process preceding and during the isokinetic evaluation of the studies found in the literature, suggesting a protocol to adopt.

Isokinetic strength assessment is a reliable method to measure the strength of individual with IDD, namely to assess the work performed for clinical, rehabilitation or performance purposes (Pitetti, 1990). In more recent years some researchers have established their own protocol and presented some recommendations and practical implications, regarding the isokinetic assessment process, which was shown to be different among the studies. This fact is due to the evolution of science and greater research in this area, lacking recent studies that provide guidelines that encompass and discuss all the information.

Knowing that the QoL of individuals with IDD is of interest to more researchers, the conclusions of this study are important as they provide a useful tool on which future researchers/clinicians or exercise professionals can support their methodological decisions. Also, knowing that physical fitness (namely neuromuscular capacity) is related to the survival of individuals with IDD and that these individuals tend to adopt sedentary lifestyles and physical inactivity, physical exercise should be seen as an integral part of the daily life of this population (Oppewal & Hilgenkamp, 2019). Recent publications have drawn consideration to the high frequency of physical inactivity (Kohl et al., 2012). These articles highlight the harmful effects that physical inactivity and sedentary behaviour can have on the individual’s environment and the health. The necessity for investigate which focuses on increasing physical activity levels in specific population groups has been emphasized as an important step towards resolution this problem (Bauman et al., 2012). On the other hand, isokinetic assessment allows a complete knowledge of the neuromuscular capacity, essential for planning exercise programs for recreational and social purposes, as well as for the development of motor skills and fitness in rehabilitation, exercise, and sport (Zafeiridis et al., 2010).

Considering that this is only a descriptive study, these results should be interpreted with caution, in the sense that future studies should test their reproducibility and reliability. Such procedure is essential for the protocol to be reliable and to ensure that the observed changes in performance over the various assessment times reflect real data and are not merely artifacts of the measurements or procedures, minimizing the amount of measurement error and deviation between the true and observed score (Frontera et al., 1993).

6.5. Conclusion

Through the present systematic review, some guidelines are provided for an assessment protocol when evaluating the isokinetic strength of the lower limbs of individuals with IDD. Aspects to be considered: a) avoiding physical activity at moderate or vigorous intensities in the 48 hours before the assessments; b) if possible, replicate the assessments on two different days, two to four days separately, maintaining the assessment at the same hour of the day.

Our proposal for an isokinetic strength assessment consists of a nine phases protocol: i) 3 to 10 minutes of warm-up using cycle ergometers or a simple walk; ii) familiarization or training with the equipment before the isokinetic strength assessment; iii) adjustment of the equipment according to the manual or/and protocol; iv) assessment of extension and flexion of both lower limbs (concentric or eccentric movement); v) 1-4 sets, preferably 3 sets; vi) 3 repetitions per sets; 30-60 seconds rest between sets, vii) 20 seconds rest between each exercise; 60 seconds rest between each angular velocity; viii) 60º/s angular velocity (in addition to this angular velocity, if another is to be performed, it must be ≤180º/s); ix) evaluation of at least the peak torque (concentric or eccentric movement).

Is intended that this protocol can serve as framework or model for assessing the isokinetic strength of individuals with IDD, in a safe and adapted way.

Chapter 7 – Effects of physical exercise program in adults with Intellectual and Developmental Disabilities – a study protocol (study 6)

Ferreira, J.P., Monteiro, D., Matos, R., Campos, M., Antunes, R., Jacinto, M. (2022). Effects of physical exercise program in adults with Intellectual and Developmental Disabilities – A study protocol. *Journal of Clinical Medicine, 11*(24), 7485. https://doi.org/10.3390/jcm11247485.

7. Abstract

We developed a physical exercise program for people with IDD, aiming to determine the effects on physical fitness, health, cognitive ability, and QoL. Using experimental methodology, this intervention study recruited 21 adults (18 to 65 years old), institutionalized and with no other associated pathology, who will be allocated to one of the different groups: (i) IG (using weight machines), (ii) OG (using low-cost materials), or (iii) CG (without specific intervention, who continue with their normal daily activities). Both intervention groups will engage in 45 minutes of training per session, twice a week, for 24 weeks. Assessments will be conducted at baseline (initial assessment), 3 months (mid-term assessment), and 6 months (final assessment). Variables assessed include anthropometrics, body composition, functional capacity, muscle strength, general health, cognitive ability, and QoL. The results of this study will assist in the development of more effective strategies, recommendations, and interventions to ensure better and greater adherence to physical exercise by institutionalized individuals with IDD, namely, recommendations for assessment, prescription, and implementation of physical exercise for this population. Additionally, we intend to make available two physical exercise programs if they are adapted and promote positive effects.

Keywords: physical fitness; cognitive capacity; intellectual disability; physical exercise; quality of life.

7.1. Introduction

Individuals with IDD (new designation according to International Classification of Diseases 11th Revision - ICD-11) (WHO, 2022) are characterized by a deficit of intellectual and adaptive functioning in the conceptual, social, and practical domains. This individual can be identified with mild, moderate, severe, and profound degrees and are a type of disability that develops before age 22 (Schalock et al., 2021).

In this population, several studies show improvements in physical fitness through the implementation of physical exercise programs, increasing the success in performing activities of daily living (Jacinto et al., 2021b; Raulino et al., 2014). Performed in a regular way, physical exercise is also associated with brain development, particularly the frontal and temporal region, due to the cortical activity it stimulates (Vogt et al., 2012), affecting brain plasticity and improving cognitive ability (Fernandes et al., 2017; Weinberg & Gould, 2015). In individuals with IDD, a simple 20 minutes treadmill walking training provides significant improvements in choice response time and processing speed, attention, and inhibition (Chen & Ringenbach, 2016; Chen et al., 2015). In the same sense, the improvements found are not only in terms of physical fitness and cognitive ability variables, but also in QoL (Pestana et al., 2018). The QoL of this population is a construct consisting of a set of factors that determine their well-being, or their perception of their social position, including individual needs, experiences, and sociocultural values and preferences (Schalock et al., 2002, 2011). In the Pérez-Cruzado and Cuesta-Vargas (2016) study, an 8-week physical exercise intervention program promoted physical fitness and QoL in 40 individuals. In addition, a previous study with a sample of 529 individuals with IDD, despite being an intervention with physical activity, identifies benefits in each of the domains of the aforementioned model (Carbó-Carreté et al., 2016).

Despite the importance of physical activity and/or exercise benefits, this population has high rates of sedentarism and low levels of physical activity engagement (Dairo et al., 2016; Harris et al., 2017), not meeting the recommendations (ACSM, 2021; Bull et al., 2020), which puts them at greater risk of developing chronic diseases (de Winter et al., 2012a) and consequent premature death (O'Leary et al., 2018; Trollor et al., 2017). The risks of physical inactivity in people with disabilities increase when compared to the general population: higher prevalence of hypertension (25 to 41% compared to 29% in the general population); obesity (30.8 to 36.6% compared to 18.2 to 18.5%); and metabolic syndrome (21 to 29.3% compared to 13.5% to 17.9%) (Brooker et al., 2015; Foley et al., 2017). In addition, as the degree of disability increases, physical activity levels decrease more significantly (Peterson et al., 2008), affecting their physical fitness, capacity to perform activities of daily living, and independence (Oppewal et al., 2014). To promote their life conditions, people with IDD should be integrated into physical activity and exercise practice, according to recent recommendations (ACSM, 2021; Bull et al., 2020).

One of the possible reasons for these low levels of practice is the existence of barriers that hinder their practice. Among them, we can find factors such as financial cost and lack of adapted physical exercise (Jacinto et al., 2021c; van Schijndel-Speet et al., 2014). To reduce the impact of these barriers, it is important to develop physical exercise programs. Besides being adapted to the individuals, they must be accessible to any type of context and financial availability, both for the individuals and the support institutions. In addition, the development of these physical exercise may contribute to the reduction in the risk of the onset of metabolic and cardiovascular diseases, which decreases healthcare costs and promotes physical fitness, functionality, and QoL. Therefore, the main objective of the present study is to evaluate and compare the effectiveness of two different 24-week physical exercise programs on levels of physical fitness, general health, dementia/cognitive function and QoL in individuals with IDD.

Therefore, the following hypotheses will be operationalized: (i) individual with IDD increased physical fitness after 12 and/or 24 weeks of physical exercise program; (ii) individual with IDD increased general health after 12 and/or 24 weeks of physical exercise program; (iii) individual with IDD increased dementia/cognitive function after 12 and/or 24 weeks of physical exercise program; (iv) individual with IDD increased QoL decline after 12 and/or 24 weeks of physical exercise program; (v) there was a difference between groups on levels of physical fitness after 12 and/or 24 weeks of physical exercise program; (vi) there was a difference between groups on levels of general health after 12 and/or 24 weeks of physical exercise program; (vii) there was a difference between groups on levels of dementia/cognitive function after 12 and/or 24 weeks of physical exercise program; and (viii) there was a difference between groups on levels of QoL after 12 and/or 24 weeks of physical exercise program.

7.2. Materials and Methods

7.2.1. Study Design

The present study protocol describes a non-randomized experimental study, consisting of three groups (1:1 allocation), to assess and compare the effectiveness of two different combined physical exercise program (strength + aerobic capacity) for individuals with IDD.

Participants will be allocated to one of the three groups: (i) IG with sessions carried out in a gym, using weight machines; (ii) OG with sessions using low-cost materials; and (iii) CG with participants continuing to do their normal activities (participation in one of the exercise interventions will not be allowed), based on their interests and availability to be involved with physical exercise program programs.

Participants from both EG will participate twice a week, in a 24-week supervised physical exercise program, with sessions lasting 45 minutes per session. All outcome measures will be collected at three different time moments, at baseline (time 0, baseline assessment, or week 0), at mid-term (time 1, intermediate assessment, week 12), and at the end of the intervention program time 2, final assessment, week 24). The measurements will be performed after 48 h, after the last workout in both groups, and always in the morning. Figure 12 shows the participant flow for this trial.

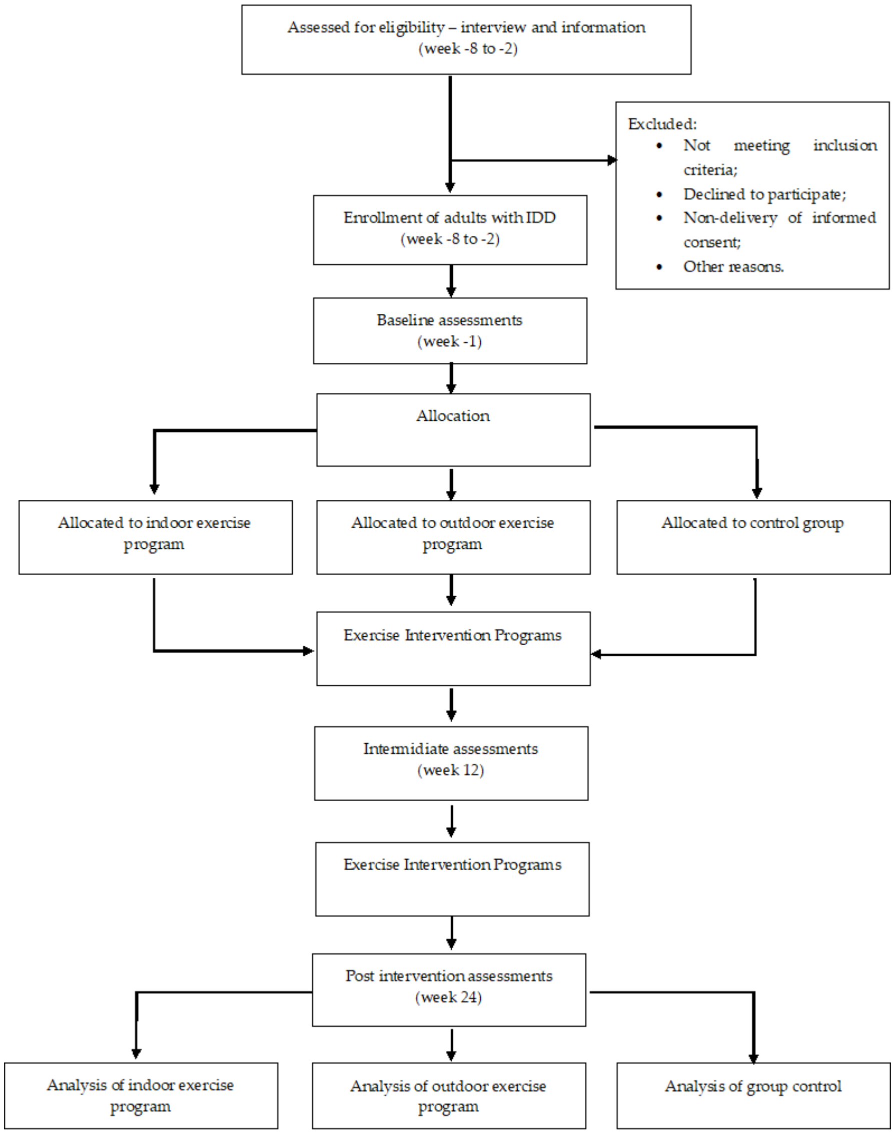

Figure 12. Timeline for the study design.

7.2.2. Participants

Adult volunteers, institutionalized in a support institution, located in Leiria, Portugal, recruited by the non-probabilistic convenience method will participate in the program.

In the first step, an individual explanation will be held about the procedures and objectives of the study, as well as the potential benefits, risks, and the time needed for the development of the project.

In a second moment, the participants/family members/tutors will sign a free consent form. Inclusion criteria will be defined: (1) adults with IDD, diagnosed with mild, moderate, or severe IDD; (2) age over 18 years) success in performing movements such as pulling/pushing; (3) capacity to perform the assessments. Exclusion criteria will be defined: (1) individuals who cannot commit themselves for 6 months; (2) individuals with other associated pathologies; (3) contraindications to physical exercise program (e.g., high blood pressure); (4) inability to walk unaided; (5) profound IDD; (6) inability to communicate; (7) non-delivery of signed informed consent.

Due to the characteristics of this special population and logistical constraints intrinsic to the development of intervention studies, the sample will consist of the first 21 individuals who agree to participate in the program, aged between 18 and 65. After that, participants will be allocated to one of the three groups. A power analysis (calculated using *G*Power*, version 3.1.9.7 (Faul et al., 2007) showed that a sample of at least 15 was required to detect a medium effect size (*ES*) of 0.5 ($\alpha = 0.05$, $1 - \beta = 0.95$) using a repeated-measures analysis of variance (*ANOVA*), in agreement with some previous studies (Cicone et al., 2018; Fujita et al., 2021). The effect size of 0.5 was chosen given that this value was verified from studies investigated the effects of exercise on the variables of interest in our study (Bartlo & Klein, 2011; Obrusnikova et al., 2021; St. John et al., 2020).

7.2.3. Informed Consent

A comprehensive explanation of the study (material and methods inclusive) by the research leader and the host institution will be conducted to allow participants/family members/tutors to be fully informed. The subject group will be given adequate time to decide on their participation; however, the first 21 individuals who agree to participate in the study will be part of the sample. To do this, participants/family members/tutors must sign and deliver the informed consent form.

7.2.4. Protocols

The development of 2 training programs, one Indoor (table 26) and one Outdoor (table 27), occurred taking into account one of the barriers identified by individuals with IDD and their caregivers and/or family members/tutors to physical inactivity: lack of adapted physical exercise and the financial cost of the practice (Jacinto et al., 2021b).

Table 26. Indoor training program

Exercise Prescription	Weight Machines	Breathing: Continuous, Not Forced					
	Main Muscle Group/Critical Components	**Duration**	**Speed**	**Intensity**	**Rep's**	**Series**	**Volume**
"Caterpillar game" or shuttle run	Practitioners dispersed throughout the space, an element is defined to start catching, then, who is caught, joins the colleague forming a "caterpillar" (holding hands) or "back and forth" race, which consists of executing the maximum number of exercises. routes performed at a predetermined distance and cadence.	5 to 7 min					40 min
Treadmill		10 min	Walk	40–80% of HR_{max}			
Leg press	Seated; back completely against the bench; feet resting on the press at shoulder width; legs in flexion forming a 90° angle between leg and thigh; the toes in line with knee height. Perform this way the extension of the leg, without any sudden movement—Quadriceps Activation.		Max. concentric eccentric 3 s	40–80% 3RM	8–15	2–3	
Chest press	Seated; back against the bench; arms in pronation, flexed, and elbows in line with the shoulders. Carry out the extension of the same until the level of the chest. Looking forward—Activation of the Big Chest.						
Leg extension	Sitting, completely leaning against the bench; knees bent; ankles positioned on the supports. Perform the extension of the knees, until forming a parallel line between the lower limbs and the ground—Quadricipital Activation						
Lat Pull Down	Sitting in front of the machine; look ahead; slight flexion of the legs, supported on the quadriceps support; grab the handle. Perform the pull-up to the chest area—Latissimus dorsi activation						
Leg curl	Sitting and leaning against the bench; legs in extension; heels positioned on the supports. Perform knee flexion—Activation of the hamstrings						
Shoulder press	Sitting and leaning against the bench; look ahead; hands in pronation, hold the handles. Perform adduction and abduction of the shoulders, or extension and flexion of the upper limbs—Shoulder Activation						

Note**:** the rest interval between exercises or sets is 30 s.

Flexibility: dynamic active method (stretching).				
Exercise	Duration (second)	**Series**	**Recovery**	**Volume**
4 static stretches	30 s	1	Does not exist	2 min
Note: stretching performed unilaterally, must last 15 s per limb (not in the case of this 1st micro cycle).				

Table 27. Outdoor training program

Exercise Prescription	Resistance Elastic and 1–2 kg Shin Guards	Breathing: Continuous, Not Forced					
	Main Muscle Group/Critical Components	Duration	Speed	Intensity	Rep's	Series	Volume
"Caterpillar game" or shuttle run	Practitioners dispersed throughout the space, an element is defined to start catching, then, who is caught, joins the colleague forming a "caterpillar" (holding hands) or "back and forth" race, which consists of executing the maximum number of exercises routes performed at a predetermined distance and cadence.	5 to 7 min					40 min
Walk		10 min	March	40% to 80% of the HR_{max}			
Stand up/sit down from chair + elastic bands	Sitting, with legs bent, forming a 90° angle between leg and thigh, feet flat on the floor at shoulder width, lift. Perform full trunk extension. The elastic must always be attached under the feet and held with the hands—Quadriceps's Activation.		Max. concentric eccentric 3 s	6–9 OMNI-RES scale	15	3	
Low row + elastic bands	Seated; arms outstretched in order to grip the elastic. Pull your elbows toward your torso, keeping your back straight and your chest high—Back Activation						
Unilateral knee extension + shin guards	Seated; straight back; knees bent; feet resting on the ground. Carry out the extension of the same, until forming a parallel line between the lower limbs and the ground—Quadricep Activation						
Chest press + elastics	Sitting or standing; arms in pronation, flexed, and elbows in line with the shoulders. Carry out the extension of the same until the level of the chest. Look ahead. The elastic band can be on the dorsal area or on a post/pillar—Activation of the Big Pectoral.						
Single leg curl + shin guards	Standing. Flex your knees until you form a 90° angle between the thigh and the leg—Activation of the hamstrings						
High row + elastic	Standing; upper limbs extended at shoulder level and parallel to the ground; grab the elastic. Flex your upper limbs in order to pull the elastic towards your chest.						
Note: the rest interval between exercises or sets is 30 s.							

Flexibility: dynamic active method (stretching).				
Exercise	Duration (second)	Series	Recovery	Volume
4 static stretches	30 s	1	Does not exist	2 min
Note: stretching performed unilaterally, must last 15 s per limb (not in the case of this 1st micro cycle).				

The indoor training program should be performed in the context of a gym/health club/association, using the available materials. The outdoor training program should be performed with low-cost materials, allowing its application in any economic context. The use of some low-cost equipment is suggested, such as elastic bands and shin guards of different weights. However, if this is not possible, the outdoor physical exercise can be performed with bodyweight only or with water/sand bottles. These programs were as close as possible to the recommendations suggested by ACSM (2021), as well as to the scientific evidence (Jacinto et al., 2021b).

Strength training was combined with aerobic training in the same session, performed twice a week, for 45 minutes, always at the same time, namely, in the morning. Each training session was divided into 4 phases (warm-up, cardio, resistance, and flexibility training). Considering the initial assessment and physical fitness of each participant, the intensity is progressive throughout the program, and the stimulus and load will be continuously adjusted in order to promote the consequent adaptation processes in the body, considering the principle of progressive overload. Although a set of exercises are suggested, the planning is not fixed and may be adjusted to the characteristics of individuals. First, the required movement will be practiced without any kind of material. All participants will have familiarization sessions with the training materials, prescribed movements, and with the space and with all the routines that an exercise session involves. Occasionally, if individuals mention/evidence any kind of mental/psychological or physical problem, the training intensity is adjusted to allow participation in the exercise session.

The programs will be supervised by two physical exercise technicians, trained in a standardized manner, with recovery periods of at least 48 h. The control of training intensity will be carried out using heart rate monitors (Polar M400, Kempele, Finland), through the formula used to calculate the HR_{max} (Karvonen et al., 1957) and also the equation for individuals with DS (ACSM, 2021) to calculate the target heart rates. If any subject exceeds the target intensity, they will be instructed to decrease or even rest.

7.2.4.1. Indoor Training Program

The indoor physical exercise program was carried out in a gym with weight machines. Seven heart rate monitors and seven gym towels will be required. The physical exercise program was divided into four parts. Part I: playful game or shuttle run (5 to 7 minutes). Part II: aerobic training; Part III: strength training; Part IV: 4 static stretches/cool down. Table 26 shows the training program in detail.

7.2.4.2. Outdoor Training Program

The program will be conducted in an outdoor space with elements of nature, where resistance elastic bands and shin guards for the ankles will be needed. The outdoor physical exercise program was carried out in a natural environment near the institution. Natural environments, which, for this experimental study, are defined as "any outdoor spaces with elements of nature, from pure or semi-natural areas to urban green or blue spaces, including green infrastructure" (Silva et al., 2018). The physical exercise program was divided into four parts. Part I: playful or shuttle run; Part II: aerobic training; Part III: strength training; Part IV: 4 static stretches/cool down. Progression of exercises with changing the resistance of the TheraBand's and shin guards. Table 27 shows the outdoor physical exercise program in detail.

7.2.4.3. Control Group

Subjects in the CG will be encouraged to keep their usual lifestyle and their attendance at exercise sessions corresponding to the two exercise programs will not be allowed.

7.2.5. Assignment of intervention and Blindness

After obtaining informed consent and finishing the initial assessments, the volunteers will be distributed to the three groups, according to their intention to participate in the study. Due to the nature of the intervention, after the initial assessment, it will not be possible to randomize the sample by groups, nor will it be possible to "blind" the participants and lead investigator belonging to the group. Upon delivery of the informed consent, a code will be assigned to each participant, ensuring the anonymity of the subjects. The researchers responsible for the evaluations will have no knowledge of which group each subject belong to, except for the principal researcher. To minimize differences in procedures, the same team will perform the assessments at different moments.

7.3. Outcomes

The assessments will be carried out in the laboratory of the FCDEF-UC. The space is ample and isolated, the temperature controlled, and each step of the assessment should be organized to provide maximum comfort and privacy to each participant. The research team will provide information on the procedures and aims. The researchers will answer any questions that may arise. All assessments will be performed in a controlled environment, during the morning period, with only the ingestion of breakfast due to the characteristics of the participants and the taking of medications.

7.4. Instruments/Procedures

7.4.1 Anthropometry

For the measurement of body mass and height, a scale with a portable stadiometer model seca (model 870, Hamburg, Germany) will be used. The participant will stand barefoot on top of the stadiometer platform, leaning against the pole of the device, looking forward, and with arms along the body. Subsequently, the BMI of the formula, weight (kg)/height (m^2) will be calculated and the WC will be measured, measured halfway between the iliac crest and tenth rib, directly on the skin, using a flexible tape measure; the methods being viable, reliable, and accurate for the population (Wouters et al., 2017).

7.4.2 Body composition

For the evaluation of body composition, bio-impedance equipment (InBody770) will be used, being a viable, reliable, and non-invasive method (Havinga-Top et al., 2015). The participant must climb to the platform of the device with bare feet, to contact the four electrodes of the feet, measure the weight, and hold the bar with the four electrodes of the hands.

7.4.3 Neuromuscular Capacity

Lower limb strength will be assessed using an isokinetic dynamometer (BIODEX Multijoint System 3 Pro, Shirley, NY, USA), which is reliable for the target population (Pitetti, 1990), through leg flexion and extension, using maximal concentric contractions. Equipment calibration was performed before the evaluation session according to the manufacturer's instructions (Biodex Medical Systems, Inc., 2000, Shirley, NY, USA). Participants will sit in the equipment chair (chair inclined backward at 85° of hip flexion), according to the manual's recommendations, and stabilize using crossed belts close to the chest, hip, and thigh of the member to be evaluated, in order to avoid compensation. The axis of rotation of the dynamometer was aligned with the external femoral condyle of the knee. The fixing strip of the pad was adjusted 2 cm above the upper edge of the fibular malleolus. The global range of motion was defined as between 85 and 90°. The individual gravity calibration was corrected before each test in the position of 30 degrees of knee flexion (Osternig, 1986). To familiarize the participants, before starting the test, 3 repetitions were performed for each velocity and action (De Ste Croix et al., 2009). During the test, participants were instructed to keep their arms crossed with their hands on the opposite shoulder. The computer screen connected to the dynamometer provided consistent visual feedback in real time (Baltzopoulos et al., 1991). The warm-up protocol consists of 5 minutes of walking at a comfortable intensity. Concentric and eccentric reciprocal muscle actions will be tested considering 3 repetitions for each movement 60 º/s and 120 º/s. A 60 s interval was established between the 3 rep familiarization and the test, as well as between angular velocities (Perrin, 1993). Values will be obtained such as peak torque, Peak TQ/BW, Maximum Repetition Total Work, Coeff of Var., Average Power, Total Work, Acceleration Time, Deceleration Time, ROM, Average Peak TQ, and Agonist/antagonist ratio.

To measure upper limb strength, a handgrip test will be used, using a manual dynamometer, the reliability and validity of which have been confirmed by Cabeza-Ruiz et al. (2019) and Oppewal and Hilgenkamp (2020) and the procedures recommended by the Brockport Fitness Test Manual will be used (Winnick & Short, 2001). The "3 kg medicine ball throw test" will also be applied (Harris et al., 2011), valid and reliable for people with IDD (Wouters et al., 2017), in order to assess the muscular power of the upper limbs. The participant will be seated in a chair with the ball close to the chest. At the start signal, throw the ball, and raise the chest pass from as far as possible.

The test of 3 maximum repetitions, for the prescribed actions/movements, will also be applied to the participants of the indoor physical exercise program. To perform the test of 3 maximum repetitions for the participants of the IG, a small warm-up is performed, and a load is placed on the equipment, depending on the experience of the physical exercise technician who supervises the test, so that the individual cannot perform more than 3 repetitions. If you exceed 3 repetitions, the load is gradually increased (2–5 kg) and a rest period is given between the new set (3–5 minutes).

7.4.4 Functional Capacity

Fullerton battery of functional tests (Rikli & Jones, 1999) will be used to assess physical fitness, namely, the tests: 30 seconds chair stand, evaluating the strength and resistance of the lower limbs, a viable and reliable test for people with IDD (Hilgenkamp et al., 2012; Wouters et al., 2017). The purpose of the test is to assess the strength and resistance of the lower limbs (number of executions in 30 seconds without using the upper limbs). The test begins with the participant sitting in the middle of the chair, with the back straight and feet shoulder-width apart and fully supported on the floor. At the "start" signal, the participant rises to maximum extension (vertical position) and returns to the initial sitting position. The participant is encouraged to complete as many repetitions as possible within a 30 second time interval.

The "agility" test to assess physical mobility, validity, and reliability will be used as assessed by Cabeza-Ruiz et al. (2019), in which the objective is to assess physical mobility, namely, speed, agility, and dynamic balance. The participant must be seated in the chair, with hands on thighs and feet flat on the floor. At the starting signal, he gets up from the chair and walks as fast as possible (without running), around a cone (located at 2.44 m) and returns to the chair. The participant must be informed that the test is evaluated by the time it takes to perform the exercise.

The 6-minutes' walk test, to assess aerobic resistance, is also valid and reliable for the study population (Nasuti et al., 2013). The objective of the 6-minutes' walk test is to assess aerobic resistance by covering the greatest distance in 6 minutes. At the starting signal, the participant is instructed to walk as quickly as possible (without running) the distance marked around the cones. If necessary, participants can stop and rest, being able to sit down and resume the course.

7.4.5 General Health Status

For the evaluation of the general state of health, blood samples will be collected by professionals accredited for this purpose, through the venipuncture technique (WHO, 2010). The results will be analysed by the certified laboratory to which the professional belongs and will be sent via email to the principal investigator of the study.

A digital sphygmomanometer Omron Digital Blood Pressure Monitor HEM-907 (Omron Healthcare Europe BV, Matsusaka, Japan) will be used to obtain hemodynamic parameters, such as resting blood pressure (systolic and diastolic) and resting heart rate, as well as an oximeter. Participants, before data collection, will remain at complete rest for five minutes, with legs uncrossed, and back and arm supported without speaking/or moving (Muntner et al., 2019). Two readings will be taken, with an interval of 1–2 minutes between them and the average of these readings will be recorded. If the values deviate ≥ 5 mmHg, a third measurement will be taken (Muntner et al., 2019). Measurements will be taken in the morning, with only one meal and participants will be instructed to avoid caffeine, exercise, and smoking for at least 30 minutes before measurements (Muntner et al., 2019).

The Heart Rate Variability (HRV) will also be evaluated, according to the procedures of Proietti et al. (2017) and the guidelines Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology (1996), using a Polar ProTrainer (Kempele, Finland). Participants will place the sensor on their chest, below the pectoralis major. Afterward, the participants will be instructed to sit comfortably in a chair, with their eyes open, with a calm breath, and to avoid any movement during the data acquisition period. The test will last 10 minutes, in a calm, silent, and low-light environment. After the test is performed, the data will be downloaded via the Polar Flow Web Service as ".txt" files and exported for analysis using the Kubios HRV software package (Kubios HRV, Biomedical Signal Analysis Group, Department of Applied Physics, University of Kuopio, Finland) (Tarvainen et al., 2014). The RR intervals corresponding to the first two minutes will be discarded (stabilization period) and the data from the following five minutes will be used to calculate the HRV. In the time domain, the following items will be calculated: (i) mean RR (mean of the RR intervals in ms); (ii) SDNN (standard deviation of RR intervals in ms); (iii) RMSSD (root mean square of successive RR interval differences in ms); (iv) pNN50 (percentage of successive RR intervals that differ by more than 50 ms). In the frequency domain, the following items will be calculated: (i) LF (absolute power of the low-frequency band, 0.04–0.15 Hz, in ms2); (ii) HF (absolute power of the high-frequency band, 0.15–0.4 Hz, in ms2; (iii) ratio of LF-to-HF power (LF/HF).

7.4.6 Quality of Life

For the evaluation of QoL in people with IDD, the Personal Outcomes Scale (Claes et al., 2010; Loon et al., 2010), in the Portuguese version (Simões et al., 2016) based on the model of Schalock et al. (2002), developed at the *Arduin Foundation and Ghent University*, will be applied by technicians with specific training for this purpose.

The Personal Outcomes Scale includes eight domains, each containing five questions, which can be answered through self-report or the report of caregivers, who may be family members or professionals, making a total of forty questions, presented with three response options, through the Likert format, as, for example, often, sometimes, or never, thus making it possible to (1) measure the results of service interventions; (2) reorient public policies to improve these results; (3) improve support management and the service financing mechanism; (4) compare to QoL of citizens; (5) monitoring the application of human and legal rights, provides crucial information so that it can be used to improve the quality of intervention and credible and sustainable practices, important to implement strategies that align at different levels of systems (Simões et al., 2016).

7.4.7 Cognitive Function

The Mini-Mental State Examination (MMSE) is a simple test, using a sheet of paper and pencil, with an easy and quick application (about 5 to 10 minutes) (Folstein et al., 1975) and is a dementia/cognitive function screening test. This test is adapted to the Portuguese population (Guerreiro, Silva, Botelho, et al., 1994), has been applied by some authors to the population with IDD (Paiva et al., 2020), and consists of thirty items (scored with a value of 0—when the person gives an incorrect answer or simply does not answer or 1—when the person answers correctly) organized by six domains: Orientation (which assesses recent memory, attention, and the temporal–spatial orientation); Retention (assess attention and short-term or primary memory); Attention and Calculation (assesses calculation ability, attention, and immediate and working memory); Evocation (assesses recent or secondary memory); Language (assesses spontaneous speech, listening, repetition, naming, reading, and writing). The maximum test score is thirty points, with higher scores indicating better results.

To assess cognitive ability through the MMSE, you will need a sheet of paper and pencil. The test will take about 5 to 10 minutes and will be conducted by a technician with specific training for this purpose, following the protocol. As with the Personal Outcomes Scale, the application of the MMSE scale will be carried out in a room without isolation from noise and possible distractions, in a 1:1 aspect (one specialist for one participant).

For the evaluation of QoL in people with IDD, the Personal Outcomes Scale will be applied to the self and to the reference technicians/caregivers, by specialists with specific training for this purpose, following the protocol. The application of the scale will be carried out in a room without isolation from noise and possible distractions, in a 1:1 aspect (one specialist for one participant).

7.5. Procedures

Intervention study that involves several phases: (a) design of physical exercise programs; (b) promotion of the program (information pamphlets will be distributed to the target people with IDD/guardians/tutors/caregivers about the study procedures and aims); (c) sample recruitment (participants/parents/tutors will sign an informed consent form and all project will be carried out in accordance with the Declaration of Helsinki; (d) division according to their intention to participate in the study: (i) IG/ (using weight machines), (ii) OG (low cost), or (iii) CG (no specific intervention; continue with normal daily activities); (e) initial evaluation of the groups by an evaluator blinded to the group belonging; (f) intermediate evaluation of the groups by an evaluator blinded to the group belonging; (g) final evaluation of the groups by an evaluator blinded to the group belonging; (h) data analysis: descriptive, comparison between groups and conditions, comparison before and after, correlations, among others (subjects who do not perform at least 75% of the sessions will be excluded from data processing).

7.6. Adverse Events

Despite all safety procedures adopted/provided, participants may, at some moment, experience some adverse effects, as well as be aware of some unlikely risks, during the assessment protocols or even during the interventions. When starting a physical exercise program, people who, as a rule, adopt a sedentary lifestyle, run the risk of experiencing some type of discomfort, fatigue, or muscle pain. Given that the intensity will be gradually increased, it is expected that muscle pain will be light and brief, mitigating with the muscle's habit of exertion. Therefore, the leader will be available for any dialogue throughout the project, to help and advise the participants.

Likewise, participants who develop any type of physical injury or other health problem during the interventions will be referred to the institutional physiotherapy office or family doctor and their continuation in the project will depend on the consideration of all related parties. All adverse physical and psychological outcomes will be recorded, described, and reported in future publications.

7.7. Participation Attendance/Adherence

Individual participation in each physical exercise session will be scored with 0 (zero) if the participant does not attend or 1 (one) if the participant is present at the physical exercise session and participates in it. At the end of the interventions, the participants who do not perform at least 75% of the sessions will be excluded from data processing.

7.8. Statistical Analysis

In the statistical analysis, descriptive parameters will be used (mean ± standard deviation or percentage) normality and homogeneity will be verified through the *Shapiro–Wilk* test and the *Levene* tests, respectively. The existence of significant differences between groups will be analysed using the *Kruskal–Wallis* test and between times using *Wilcoxon* or *Friedman* test. The non-parametric statistic was defined according to the "Central Limit Theorem" (Fischer, 2011), in the sense that it will require 30 participants in the sample to have a normal distribution. The magnitudes of the differences will be examined using the *Cohen's d* effect size (Cohen, 1988). Likewise, associations across studies variables will be verified through the *Spearman* coefficient of bivariate correlations (r = 0.10 to 0.29—small; r = 0.30 to 0.49—moderate; r = 0.50 to 1—strong) (Cohen et al., 2002). The significance level adopted for all analyses will be $p<0.05$. For data processing, the computer program Statistical Package for Social Sciences (SPSS Science, Chicago, IL, USA), version 28 will be used.

7.9. Discussion

This study will allow us to investigate and compare the effectiveness of two different 24-week exercise programs, in different environments, on the levels of the physical fitness, general health, cognitive ability, and QoL of individuals with IDD. We intend to evaluate a set of quantitative variables at the same time, with the expectation that participants in the EG will show positive changes, taking into consideration previous studies (Bartlo & Klein, 2011; Jacinto et al., 2021b). In the CG, no changes in the variables analysed are expected. It is believed that the expected results can be attributed to the physical and physiological effects of the environment associated with the different exercise protocols proposed, as there is evidence that finds disparate results in physical exercise programs performed in different contexts (Brito et al., 2022). The results will be published at the conclusion of the study.

The pilot study that will follow is essential to understand if these two physical exercise programs are effective tools to reduce barriers that hinder/impede their practice (Jacinto et al., 2021c; van Schijndel-Speet et al., 2014), and their effectiveness in promoting the variables assessed, taking into account the low levels of physical fitness and QoL of this population. Likewise, we intend to contribute with implications for the practice with new interventions with physical exercise, prescription, and effective strategies, which we believe can contribute, at all levels, to individuals with IDD.

The expected physiological benefits are based on the hypothesis that regular physical exercise practice leads to adaptations in both the cardiovascular and musculoskeletal systems that support an overall increase in exercise capacity and performance (Brito et al., 2022). It is considered an ideal tool in the prevention and treatment of various types of cardiometabolic diseases, a promoter of physical fitness, performance activities of daily living, and in reducing/mitigating sarcopenia and cognition decline. In addition, neuromuscular mechanisms, namely, the increased expression of neurotrophic factors (i.e., BDNF), the increase in serotonin and norepinephrine, the regulation of the hypothalamic-pituitary-adrenal axis activity, and decreased systemic inflammatory signalling (Brooks, 2012; Garza et al., 2004; Lin &

Kuo, 2013; Lopresti et al., 2013; Mathur & Pedersen, 2008), may be associated with cognitive decline and QoL.

This study has also a multidisciplinary approach, as it is prudent to investigate the combined effects of some independent variables. In addition, we will also examine the hypothetical premise that some objective measures have strong associations with subjective perception measures.

Although there is a clear need to carry out more research on healthy lifestyle interventions for people with more severe levels of IDD (profound IDD), our current intervention is limited to participants with mild to severe IDD, so future studies should take this level of IDD into account.

Finally, as with all studies, our study has some limitations, among which we highlight: (1) due to logistical constraints, the groups will not be randomized; (2) it is impossible to control activities outside the physical exercise program, which may affect negatively or positively the variables under study; and (3) the physical exercise program is not adapted to individuals with profound IDD.

7.10. Ethics and Dissemination

Any changes to the protocol will be agreed upon by the research team and formally reported to the FCDEF-UC ethics committee prior to application. Written informed consent will be obtained from participants (who will be provided a copy) after the study has been fully explained (i.e., study procedures, objectives, potential risks, and expected outcomes). Each participant will receive a single coded identification number to maintain their confidentiality, and all experimental data will be recorded using these codes.

All data evaluated will be collected and stored strictly for research purposes. The evaluation data will be stored on a laboratory computer, in a folder with a password, to which only the principal investigator will have access and will be kept for a period of 5 years after the end of the investigation. After this period, all data will be irreversibly deleted.

The results of this study will be reported and published regardless of the magnitude or direction of effect, at the intended target of 3 to 6 months after the end date of the intervention (or an earlier date if conditions permit). Communication of the results to the public will begin with study participants, their families, and to the collaborators of the institution. Communication to the scientific community will be carried out through participation in conferences/congresses. Authorship of manuscripts resulting from this research will be based on the following criteria: significant contributions to the conceptualization or design of the research project, formal analysis and/or interpretations of the data, and critical writing and/or review and editing of the manuscript.

Chapter 8 – Quality of life in individuals with Intellectual and Developmental Disabilities: the congruency effects between reports (study 7)

Jacinto, M., Rodrigues, F., Monteiro, D., Antunes, R., Ferreira, J.P., Matos, R., Campos, M.J. (2023). Quality of Life in Individuals with Intellectual and Developmental Disabilities: The Congruency Effect between Reports. *Healthcare*, *11*(12),1748. https://doi.org/10.3390/healthcare11121748.

8. Abstract

Assessing QoL is important to provide personalized and individualized support plans, with the purpose of improving personal outcomes. Based on the conceptual model of QoL, the aim of this study was to assess the congruence between the perceptions of QoL of institutionalized individuals with IDD and the perception of third party. Forty-two individuals participated in this study, including 21 with mild to severe IDD and their family members/caregiver/reference technician, who responded to the Personal Outcomes Scale (Portuguese version). Significant differences ($p<0.05$) were found between reports in the personal development ($t=-2.26$; $p=0.024$), emotional well-being ($t=-2.263$; $p=0.024$), physical well-being ($t=-2.491$; $p=0.013$) and total QoL ($t=-2.331$; $p=0.02$). The results further show that most third-party reports tend to undervalue the Qol of the individual with IDD and that there is no congruence in any of the QoL domains. The inclusion of self-reports in the QoL assessment is important, in addition to the assessment of third-party reports, in the process of making decisions appropriate to the context and individual characteristics. On the other hand, the inclusion of third-party reports is an opportunity to promote communication among all stakeholders, recognize and discuss differences, and promote QoL, not only of individuals with IDD, but also of families.

Keywords: caregivers/family members; intellectual disability; *Escala Pessoal de Resultados*; Personal Outcomes Scale; self-reports.

8.1. Introduction

QoL, for (Barbosa, 1998) is expressed by the relationship between man, nature and the environment that surrounds him, forming a whole.

(Minayo et al., 2000) states that QoL is a personal concept, related to the degree of satisfaction in family, love, social, environmental, and existential aesthetics. For this author, the QoL concept expresses knowledge, individual values, and experiences, as well as the associations and cultures belonging to certain moments, spaces, times, and histories.

For (Vilarta, 2004) QoL is the way in which subjects live, feel and understand their daily lives, encompassing aspects such as housing, health, education, transport, work and participation in decision-making about them. This notion delimits the conditions in which human beings live, resulting from a set of individual, environmental and social factors (Nahas et al., 2000). It can also be defined as the distance between individual expectation and reality, given that the greater the distance, the worse the QoL (Martin & Stockler, 1998).

On the other hand, for the WHO (WHOQOL, 1998; WHOQOL GROUP, 1994), QoL concerns the individual's perceptions of their position in life, in the context, culture and value system to which they are inserted, taking into account the relationship with their goals, expectations, standards and concerns. The WHOQOL is multidimensional instrument that has been validated assuming seven domains, namely: i) physical health; ii) psychological domain; iii) level of independence; iv) social relationships; v) environment; vi) spirituality; vii) personal domain.

There are different definitions of QoL (as we have shown above) and, although they diverge in the construct, they converge as to the existence of multidimensional domains and respective indicators (Cummins, 2005). For this study, we considered the construct presented by Schalock and Verdugo (2002), because this concept is one of the most cited, used, and has critical impact on research or in practice involving individuals with the characteristics of the participants in this study. Schalock and Verdugo (2002) refers to QoL as set of factors that address individual well-being or the perception of their social position, in the context and culture to which they are inserted, assuming sociocultural values, needs, expectations and individual preferences. It is a multidimensional phenomenon composed of factors and domains (Table 1), influenced by personal characteristics and environmental contexts (Schalock et al., 2011).

Independence factor comprises the domains of "Personal Development" and "Self-determination", which reflect the degree of autonomy of the individual. The domains of "Interpersonal Relations", "Social Inclusion" and "Rights" reflect the Social Participation factor. Last, the domains of “Emotional Well-Being”, “Physical Well-Being” and “Material Well-Being” correspond to the Well-Being factor. The domain of "Personal Development" is related to individual lifelong learning, including education, as well as the ability to acquire skills and/or abilities and to demonstrate them in the community. The domain of "Self-Determination" relates to personal objectives, goals, and desires, and the ability to make decisions and to make one's own choices. The domain of "Interpersonal Relationships" is related to relationships with others, with respect to family, friends, and/or social networks. It is also related to the support and help you receive from others. Regarding the "Social Inclusion" domain, as the name implies, it is related to inclusion and participation in the community, as well as the roles one plays in it and also the support one receives from society. Contained in the "Rights" domain are aspects such as respect, dignity, equality, citizenship, access, and fair treatment. The "Emotional Well-Being" domain is related to perceived life satisfaction, self-concept, and absence of stress. The "Physical Well-Being" domain is related to overall health, namely health care, ability to take care of oneself, mobility, and recreation/leisure. Ending with the domain of "Material Well-Being" which contains questions that address financial status, employment, as well as living conditions and material possessions that one has (Simões et al., 2017).

The concept and study of QoL in individuals with Intellectual Developmental Disabilities - IDD (i.e., Intellectual Disability) has been arousing the interest of various stakeholders having practical implications for interventions performed for and with this population (Schalock & Verdugo, 2002), to drive progress towards equity, empowerment, and self-determination (Verdugo et al., 2012). In individuals with IDD, characterized by a deficit of intellectual and adaptive functioning in the conceptual, social and practical domains, identified with mild, moderate, severe and profound degrees and developed before 22 years old (Schalock et al., 2021), measuring QoL allows: i) to understand their degree of satisfaction; ii) understand personal perceptions; iii) support decision-making; iv) evaluate the intervention; v) evaluate theoretical models. This measurement allows researchers to direct the individual to the life he likes and values (Schalock et al., 2002). On the other hand, measuring QoL in individuals with IDD aims to address challenges and overcome barriers that people with IDD have been facing, as well as to improve public policies or service practices to meet their needs and choices.

QoL scales for people with IDD should assess each indicator by two methods: subjectively, involving the person him/herself as primary respondent (self-reports); and objectively, based on proxy reports of the person's experiences and circumstances. Self-report measures are widely accepted for assessing your QoL. However, it is also important to consider the views of people who know a person well (measures of others' reports). Self-report measures for people with IDD have become essential in this field of research because they actively participate in taking on their role as individual citizens (Simões et al., 2016). On the other hand, the reporting of others allows us to observe potential differences between people with IDD and support staff or family members

(Claes, Vandevelde, et al., 2012; Claes, Van Hove, et al., 2012). The combination of the two measures, provides an estimate of the accuracy of people with IDD reporting, enriching information for informing decision-making, an important step in increasing the ongoing understanding of how to assess and improve the QoL of people with IDD.

In the present investigation, we aimed to align these trends and discuss the relationship between self-report and proxy-report measures. The aim of the study was to explore different perceptions in QoL assessments by examining the effect of congruency between the perceived QoL of 21 individuals with IDD, institutionalized in a supportive care organization and the 21 family members/caregiver/reference technician perceptions. Knowing that individuals with IDD demonstrate low levels of QoL and therefore their relatives and/or reference technician (caregiver) (Ali et al., 2021), analyzing the different responses is an opportunity to promote communication between all stakeholders, recognize and discuss differences, and promote QoL, not only for individuals with IDD, but also for families.

8.2. Materials and Methods

This study was carried out in accordance with the Declaration of Helsinki for human studies (World Medical Association, 2013) and was approved by the ethics committee of the University of Coimbra – Faculty of Sport Sciences and Physical Education with an approval code: CE/FCDEF-UC/00872021.

8.2.1. Participants

Twenty-one individuals volunteer (42.81 ± 10.99 years; 10 females and 11 males), institutionalized in a support institution, located in Leiria, Portugal, recruited by the non-probabilistic convenience method. Their family members/caregiver/reference technician also participated in the study. The following inclusion criteria were defined: (1) aged ≥18 years; (2) adults with mild, moderate, or severe IDD and their family members/caregiver/reference technician; (3) capacity to complete individually the questionnaires. Exclusion criteria were defined: (1) individuals with other associated pathologies; (2) profound IDD; (3) inability to communicate; (4) non-delivery of signed informed consent.

8.2.2. Quality of life assessment/instrument

For a correct assessment of personal outcomes, it is necessary to have measures with satisfactory psychometric properties, based on an empirically validated model. As stated in the principles of QoL measurement, the assessment involves the combination of the subjective measure of well-being (including individual preferences) and the objective circumstances and life experiences.: The Personal Outcomes Scale (Claes et al., 2010; Schalock et al., 2011; van Loon, 2014; van Loon et al., 2009) is a measure developed according to several studies encompassing the conceptualization and validation of the different QoL domains. This measure allows to: i) understand their degree of individual satisfaction; ii) understand personal perceptions; iii) support decision-making; iv) evaluate the intervention; v) evaluate theoretical models. This measure allows us to direct the individual to the life he likes and values and is designed to assess, firstly, people with IDD (self-reports) and, secondly, the perspectives of people close to them (professional or family - third party report) (Schalock et al., 2002).

Personal Outcomes Scale Portuguese version (Simões et al., 2016) was applied by technicians with specific training for this purpose. As in the original version (Claes et al., 2010; van Loon et al., 2009), the scale has two parts: a) questions to be answered by the individual with IDD (self-report); b) questions to be answered by a family members/caregiver/reference technician (third-party report). The scale is composed of a total of 48 questions in each part (6 questions per domain). Each item is rated on a 3-point Likert scale, and a higher score indicates better QoL (e.g., 3 = always; 2 = sometimes; 1 = seldom or never).

For self-report measure, all composite reliability coefficients were within standards for acceptable internal consistency ranging from .75 to .91. For report of others measure, the scores ranged from .72 to .92.

8.2.3. Procedure

The same procedures of previous study (Ferreira et al., 2022) was applied, which should be consulted for a more detailed knowledge of the procedure used in the present study. All assessments were performed in the support institution, by the same researchers to minimize possible measurement errors. Instructions were given to ensure the safety and comfort of the participants. The application of the scale will be carried out in a room with isolation from noise and possible distractions, in a 1:1 aspect (one specialist for one participant) for individuals with IDD and their family members/caregiver/reference technician. For each individual with IDD, we collected two responses: i) self-reports; 2) third-party reports.

8.2.4. Statistical analysis

Descriptive statistics were used to characterize the sample, including mean, standard deviation, median, and minimum and maximum. The *Shapiro-Wilk* and *Levene* test were used to test the normality of the results. The level of agreement, underreporting, and overreporting between the ratings of the individuals with IDD themselves and their family members/caregiver/reference technician were calculated to see if they agreed or disagreed (i.e., underreporting and overreporting). The minimum level was set at 10% discrepancy, as suggested in previous studies (Fleenor et al., 1996). Then, the IDD individuals' own scores were subtracted from the scores of their family members/caregiver/reference technician, since individual perceptions may be the most meaningful measure (Atwater et al., 1998). The following calculations were then performed: i) the percentage of agreeing behaviors, defined as less than half the standard deviation (-.5 / .5) between both scores; ii) the percentage of over-reported behaviors, explained by the mean scores of the family members/caregiver/reference technician who were .5 standard deviation above the self-perception of individuals with IDD; and iii) the percentage of under-reported QoL, defined as the mean scores are below half the standard deviation. The middle deviation criterion was based on previous assumptions (Fleenor et al., 2010) and the cut-off are considered a reliable source of group characterization. In the final step, the mean scores for all domains of the interpersonal QoL were compared with the categorization of the three groups. The existence of significant differences between groups will be analysed using the *Wilcoxon* test. All data were analyzed using IBM SPSS Statistics (version 28, IBM Corporation (SPSS Inc., Chicago, IL, USA) and the significance level adopted was $p < 0.05$.

8.3. Results

The mean rates of discrepancies and agreement are presented in Table 28. The results seem support a rather unbalanced distribution, where disagreement seems exist in all QoL domains, with participants perceive higher values compared to those reported by family members/caregiver/reference technician. After performing the statistical test that compares the reports, the differences between responses are only significant for the personal development (t=-2.26; p=0.024), emotional well-being (t=-2.263; p=0.024), physical well-being (t=-2.491; p=0.013) and total QoL (t=-2.331; p=0.02).

Table 28. Frequencies of predictor discrepancies and agreement

QoL domains	Third party report: Mean ± SD	Third party report: Median	Third party report: Min-max	Self-report: Mean ± SD	Self-report: Median	Self-report: Min-max	Congruence effects: Differences between reports	%	Comparison between reports
Personal development	8.71 ± 1.45	8.85	6-11	9.57 ± 1.91	9.78	7-14	Under-report answers family members/caregiver/reference technician > self-reports	14.3	$t=-2.26$; $p=0.024$
							Agreement = answers family members/caregiver/reference technician = self-reports	23.8	
							Over-report answers family members/caregiver/reference technician < self-reports	61.9	
Self-determination	10.14 ± 2.55	10.57	5-15	11.14 ± 2.10	11.07	7-15	Under-report answers family members/caregiver/reference technician > self-reports	23.8	$t=-1.667$; $p>0.05$
							Agreement = answers family members/caregiver/reference technician = self-reports	19	
							Over-report answers family members/caregiver/reference technician < self-reports	57.1	
Interpersonal relations	10.43 ± 1.85	9.71	8-15	11.38 ± 2.2	9.19	7-15	Under-report answers family members/caregiver/reference technician > self-reports	28.6	$t=-1.749$; $p>0.05$
							Agreement = answers family members/caregiver/reference technician = self-reports	23.8	
							Over-report answers family members/caregiver/reference technician < self-reports	47.6	
Social inclusion	9.71 ± 1.97	8.85	6-13	10.71 ± 2.39	9.35	6-15	Under-report answers family members/caregiver/reference technician > self-reports	28.6	$t=-1.094$; $p>0.05$
							Agreement = answers family members/caregiver/reference technician = self-reports	14.3	
							Over-report answers family members/caregiver/reference technician < self-reports	57.1	
Rights	9 ± 2.23	10	5-14	9.43 ± 1.77	9.71	6-13	Under-report answers family members/caregiver/reference technician > self-reports	33.3	$t=-0.962$; $p>0.05$
							Agreement = answers caregiver/reference technician = self-reports	28.6	

							Over-report answers family members/caregiver/reference technician < self-reports	38.1	
Emotional Well-being	12.38 ± 1.65	12.19	8-14	13.62 ± 1.56	11.8	10-15	Under-report answers family members/caregiver/reference technician > self-reports	23.8	*t*=-2.263; *p*=0.024
							Agreement = answers family members/caregiver/reference technician = self-reports	14.3	
							Over-report answers family members/caregiver/reference technician < self-reports	61.9	
Physical Well-being	11.95 ± 2.01	12.47	7-15	13 ± 1.44	12.5	10-15	Under-report answers family members/caregiver/reference technician > self-reports	19	*t*=-2.491; *p*=0.013
							Agreement = answers family members/caregiver/reference technician = self-reports	28.6	
							Over-report answers family members/caregiver/reference technician < self-reports	52.4	
Material Well-being	7.48 ± 1.53	6.73	5-10	7.76 ± 2.04	2.04	5-12	Under-report answers family members/caregiver/reference technician > self-reports	23.8	*t*=-1.667; *p*>0.05
							Agreement = answers family members/caregiver/reference technician = self-reports	28.6	
							Over-report answers family members/caregiver/reference technician < self-reports	47.6	
Total QoL	79.81 ± 8.04	79.4	63-91	86.62 ± 8.31	7.38	71-101	Under-report answers family members/caregiver/reference technician > self-reports	33.3	*t*=-2.331; *p*=0.02
							Agreement = answers family members/caregiver/reference technician = self-reports	0	
							Over-report answers family members/caregiver/reference technician < self-reports	66.7	

Note: QoL, quality of life; *p*, p value between reports; *t*, test value; SD, standard deviation; %, percentage.

8.4. Discussion

The objective of this study was to compare the agreement and discrepancies between self-report and third-party answers on the perceived QoL of individuals with IDD.

In cases of disagreed about the level of perception of QoL, the results supported that individual with IDD perceived higher values than their family members/caregiver/reference technician. This fact seemed to be true for all domains of the QoL scale, however, only significant for personal development, emotional well-being, physical well-being and total QoL.

The literature evidences a high agreement between self-reports and other reports, highlighting the fact that the information complements each other (Claes et al., 2010; McVilly et al., 2000), results that were not found in our study. The severity of the disability may predict a higher disagreement between answers (Schmidt et al., 2010), or the intelligence quotient level with the discrepancy in some domains (Llario et al., 2016), which may be the justification for our results. On the other hand, there is evidence that the degree of agreement may depend on whether the reporter is a family member or a professional, and professionals' reports were closer to self-reports than to family reports (Simões & Santos, 2016). This level of agreement seems to depend more on the degree of closeness and relationship in everyday life than the professional nature or family relationship (McVilly et al., 2000; Schmidt et al., 2010). On the other hand, caring is also associated with a burden and can be stressful and can have an effect on the caregiver's own QoL (Pinquart & Sörensen, 2003; Sjolander et al., 2012), which can, in turn, influence the perception of the individual with IDD. Our study is in agreement with other studies, in other contexts/populations, where the answers of family members/caregiver/reference technician tend to underestimate the QoL scores, which may be associated with a less concrete and visible perception of certain domains of QoL, or that the level of agreement decreases as the disability/illness becomes more severe (Fayers & Machin, 2000; Magaziner et al., 1988; Milne et al., 2006; Sneeuw et al., 1997). On the other hand, according to Milne et al. (Milne et al., 2006) these discrepancies may not be justified by a lack of agreement, but rather by methodological weaknesses, such as differences in interpretations of response categories, and may be influenced by other factors, such as caregiver anxieties and patient stoicism.

This discrepancy between reports cannot be seen as a question of unreliability and a discussion about who is "right" or "wrong", but rather an opportunity to combine both perceptions for a more correct adjustment and response to the needs of all stakeholders (Sandercock et al., 2020). In addition, it is an opportunity to promote communication between all stakeholders, recognize and discuss differences, and promote the QoL, not only of individuals with IDD, but also of families.

Although we could not examine more specifically whether the results could be replicated for different peers due to sampling limitations, our results are consistent with some of the previous studies (Burke et al., 2022; Carbó-Carreté et al., 2019). These results further highlight the importance of self-report measures of QoL and the integration of proxy reports to give more importance to and go beyond one-way perspectives by considering both self-report and family member/reference technician perspectives, as these responses do not always agree.

However, family members do not always undervalue the QoL of individuals with IDD. In the study by Berástegui et al. (2021) individuals with IDD scored lower in the domains (physical well-being, material well-being, and rights). On the other hand, individuals with IDD perceived higher levels of QoL in the Emotional Well-being and Physical well-being domains, in agreement with previous studies (Golubović & Skrbić, 2013), indicating that support strategies should focus on maintaining these values and increasing the remaining domains.

Despite some studies showing the existence of barriers in self-reports, namely the difficulty that some people with disabilities have in understanding the questionnaire or communicating their perspectives, needs and feelings, the difficulty of data collection, namely the collection of informed consent and the bias that the response may have (Balboni et al., 2020; Emerson et al., 2013; Finlay & Lyons, 2001; Nieuwenhuijse et al., 2019), there is a growing interest and commitment to consider the report of individuals with IDD in the assessment of their QoL (Balboni et al., 2020; Claes et al., 2010; Emerson et al., 2013). For all domains of QoL, responses include an interaction between objective circumstances and subjective perceptions, evaluations, and feelings about them, and self-reports play an essential role in accurately assessing their QoL. An assessment of QoL without considering self-reports translates into a contradiction, in the sense that decision-making is focused on Person-centred planning (McCausland et al., 2022).

Considering that there are 200 million individuals with IDD worldwide (more or less 2.6% of the world population) (WHO, 2011), that individuals with IDD have lower

QoL values compared to non-disabled individuals (Golubović & Skrbić, 2013; Sasinthar et al., 2022) and that QoL decreases with advancing disability and age (Thurston et al., 2010), a continued commitment to specialized support, assistance, and services is needed. On the other hand, the growing increase of individuals with IDD in support institutions makes the study of QoL relevant.

The cross-sectional nature of the study does not allow inferences about the degree of fluctuation of the results over time. At the same time, Due to the small number of participants in this study, the results should be considered with caution. On the other hand, the QoL of people with IDD is significantly affected by micro, meso, and macro factors and should be the focus of future research. According to Bronfenbrenner's Ecological Systems model (Bronfenbrenner, 1979), each of these systems contains functions, norms, and rules that can influence an individual's development, which must be seen as an integral part of the process. Individual, organizational, and systemic factors simultaneously impact people with IDD experiences and lives, and the timing of their survey may have affected the results.

To obtain a more complete picture of the QoL of individuals with IDD, further research is needed to determine the effects of various factors on QoL, monitor the success of the interventions applied and determine effective and adapted guidelines/strategies in the intervention with this population. These strategies for improving QoL among the population with IDD should be transversal to all institutions and their respective professionals, as well as to family members, with the aim of improving personal outcomes.

8.5. Conclusions

Assessing the QoL of individuals with IDD is essential to detect, monitor, and report their support needs and to carry out effective and adapted individual, institutional, and policy planning.

Our sample with IDD seems perceives higher values for all domains of Qol. However, the significant differences between responses are only significant for the personal development, emotional well-being, physical well-being and total QoL.

In addition, the results of this study deepen the understanding of the complexity of the QoL assessment process of individuals with IDD. They highlight that it is important not only to measure the perceptions of QoL of individuals with IDD through the perceptions of their family members, but also through self-reports, both accounts being complementary. Could negatively impact QoL of people with ID, if their self-report views are not considered when planning strategies.

Chapter 9 – Physical fitness variables, general health, dementia and quality of life in individuals with Intellectual and Developmental Disabilities: a cross-sectional study (study 8)

Jacinto, M., Matos, R., Gomes, B., Caseiro, A., Antunes, R., Monteiro, D., Ferreira, J. P., & Campos, M. J. (2023). Physical Fitness Variables, General Health, Dementia and Quality of Life in Individuals with Intellectual and Developmental Disabilities: A Cross-Sectional Study. *Healthcare*, *11*(19). https://doi.org/10.3390/healthcare11192688.

9. Abstract

The average life expectancy of individuals with IDD is increasing. However, living more years does not mean living better, leading to the need for research on comorbidities associated with the aging process. Associated with this process are the physical characteristics most prevalent in an individual with IDD: low levels of all physical capacities, the accumulation of central fat, hyperglycemia, dyslipidemia, and hypertension, variables considered to be one of the main risk factors for the onset of metabolic and cardiovascular diseases, variables that can negatively impact the QoL. Therefore, the aim of this study is to describe and characterize a sample of 21 individuals with IDD (42.81 ± 10.99 years old) in relation to anthropometric characteristics, body composition, general health status, functional capacity, neuromuscular capacity, and dementia/cognitive function, performing an anamnesis to analyse possible health risk factors and possible associations with QoL. Several validated tests were applied to evaluate each of the variables presented. Overall, participants present worrisome results (namely low levels of physical fitness and metabolic and cardiovascular markets). On the other hand, functional and neuromuscular ability seems to be associated with QoL ($p \leq 0.05$). This study highlights the importance of primary and secondary care providers in diagnosing, treating, and supporting individuals with IDD to promote QoL.

Keywords: anamneses; assessment; cardiovascular disease; intellectual disability; metabolic disease.

9.1. Introduction

The accumulation of central fat, hyperglycemia, dyslipidemia and hypertension are one of the main risk factors for the onset of metabolic diseases and cardiovascular diseases (Alberti et al., 2009; Mottillo et al., 2010), considered one of the main causes of death in individuals with IDD. When analysing the population with disabilities (motor, intellectual, or sensory), the prevalence of these factors triples compared to the general population (Froehlich-Grobe et al., 2013; Rimmer et al., 2010).

Greater longevity is associated with a higher prevalence of cardiovascular and metabolic diseases and other comorbidities (Baumbusch et al., 2017). Between 1996-2001 the age of death for individuals with IDD was 45 years old (similar for men and women) (Lavin et al., 2006). From 2003 to 2012 the average age of death increased to 55 years old (McCarron et al., 2015). Therefore, there has been an increase in the average life expectancy of this population over the years (Dieckmann et al., 2015), justifying the greater need to study the effects of intervention strategies that promote health improvement and reduce the impact of comorbidities associated with aging (de Winter et al., 2011). The most common symptoms of aging in individuals with intellectual disabilities include confusion, difficulty with problem resolution, communication, and socialization. It is important that individuals receive appropriate services (educational support, behavioural intervention, vocational training, family education, government resources and psychopharmacologic interventions), reducing the risk of adverse health conditions, in order to maintain/promote their independence and QoL as they age (Lee et al., 2022).

Despite having different health needs from the population without disabilities, these individuals face inequalities in access to health care (Emerson et al., 2016; Melville et al., 2007). Individuals with IDD may have significantly different medical, social, emotional, and educational needs compared to them without disabilities matches. Similarly, they may often lack the capacity to perceive, report, or address symptoms of disease, which can delay detection and intervention (Draheim, 2006; Evenhuis, 1997). On the other hand, any of the health problems are associated with the premature aging of individuals with IDD that begins around the fifth decade of life (Janicki & Dalton, 2000).

These health problems are also attributed to their sedentary lifestyle, and physical inactivity, associated with various factors such as possible lack of motivation, barriers to physical activity, and unhealthy diet (Jacinto, et al., 2021b; McKeon et al., 2013). These factors are associated with low physical fitness and health problems such as osteoporosis, musculoskeletal disorders, dementia, and metabolic and cardiovascular disease (de Winter et al., 2012a; de Winter & Evenhuis, 2014). On the other hand, a sedentary lifestyle (Melville et al., 2018), physical inactivity (de Winter et al., 2015), and a higher incidence of obesity (de Winter et al., 2011; Rimmer et al., 2010) lead to a major decrease in physical fitness (de Winter et al., 2009; Vohra et al., 2017). In addition, sedentary lifestyles and low adherence to physical activity also leads these individuals to have low levels of physical abilities.

Considering that the population with IDD can present all the aforementioned comorbidities and, therefore, negatively influence the activities of daily living and QoL (Cowley et al., 2010; Downs et al., 2019; Williams et al., 2021), constant monitoring and the definition of strategies that can promote these variables become urgent. Primary and secondary care agents should be able to diagnose, treat, and support individuals with IDD in the promotion of QoL. Detecting individuals with risk factors and developing specific interventions is urgent. It is hoped that early detection and appropriate treatment/promotion of problems by primary and secondary care will help individuals with IDD to maximize their potential and integration into society and promote their QoL.

Therefore, the aims of our study are describing and characterize participants with IDD (and to understand if there are differences between them and between sexes) in the following parameters: anthropometric characteristics, body composition, general health status, functional capacity, neuromuscular capacity, and dementia/cognitive function. This evaluation will allow us to perform an anamnesis and detect possible for the screening of some type of disease (ACSM, 2021). The secondary objective is to analyze the influence of these variables on the QoL of individuals with IDD. It is important to study the association of these variables with their QoL, to study and develop effective strategies to promote these variables.

9.2. Materials and Methods

The study was approved by the ethics committee of the University of Coimbra – Faculty of Sport Sciences and Physical Education, under the code: CE/FCDEF-UC/00872021 and was carried out in accordance with the Declaration of Helsinki for human studies (World Medical Association, 2013). It is an original part of a previously published study (Ferreira et al., 2022).

9.2.1. Participants

Participants were 21 individuals with IDD, 11 males (52%; 42.18 ± 10.15 years old) and 10 females (48%; 43.5 ± 12.376 years old) with a mean age of 42.81 ± 10.99 years old. All individuals are institutionalized in a support institution, located in Leiria (Portugal) and are diagnosed with IDD (mild to severe).

The following inclusion criteria were defined: (1) age over 18 years; (2) adults with mild, moderate, or severe IDD (DS inclusive); (3) success in performing movements, namely pulling/pushing; 4) capacity to perform the assessments. Exclusion included: (1) contraindications to exercise (e.g., high blood pressure) (2) individuals with other associated pathologies; (3) inability to walk unaided; (4) profound IDD; (5) inability to communicate; (6) non-delivery of signed informed consent.

9.2.2. Procedure

All assessments were performed in the morning period, in the laboratory of the FCDEF-UC, by the same researchers, to minimize possible measurement errors. All pre-test instructions were given to ensure the safety and comfort of the participants. The procedures used in the present study are described in more detail in a previously published protocol (Ferreira et al., 2022).

9.2.3. Anthropometric and body composition assessment

The first assessment included measuring weight and height using a scale and stadiometer (SECA 870, Hamburg, Germany). To perform this assessment, participants were asked to wear light clothing, without shoes, and stand in the Frankfurt horizontal position. BMI was calculated using the standard formula (body mass (kg)/height $(m)^2$). The WHO classification was used to classify participants into "underweight," "normal weight," "overweight," and "obesity" (WHO Consultation on Obesity (1999: Geneva & Organization, 2000). Then, body composition assessment was applied with a tetrapolar multifrequency InBody 770 instrument following the manufacturer's instructions and comprehensive guidelines described (Havinga-Top et al., 2015). The following variables were assessed: BMI, WC, total body water (L), proteins (kg), minerals (kg), fat mass (kg), muscle mass (kg), lean mass right and left arm (kg), lean trunk mass (kg), lean mass right and left leg (kg), fat right and left arm (kg), trunk fat (kg), fat right and left leg (kg) intracellular water (L), extracellular water (L) and phase angle. For anthropometric and body composition assessments, participants were encouraged not to drink caffeine or alcohol within 12h prior to the assessments.

9.2.4. General health status assessment

A digital sphygmomanometer Omron Digital Blood Pressure Monitor HEM-907 (Omron Healthcare Europe BV, Matsusaka, Japan) was used to obtain hemodynamic parameters, such as resting blood pressure (systolic and diastolic) and resting heart rate. HRmax was also calculated using the standard formulas (ACSM, 2021). Measurements were taken in the morning and participants were instructed to avoid caffeine, exercise, and smoking for at least 30 minutes before measurements (Muntner et al., 2019).

The HRV was also assessed following to the procedures of Proietti et al. (2017) and Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology (1996), using a Polar ProTrainer (Kempele, Finland). In the time domain, the following items were calculated: (i) mean RR; (ii) SDNN; (iii) RMSSD; (iv) pNN50. In the frequency domain, the following items were calculated: (i) LF; (ii) HF; (iii) LF/HF.

Blood samples were collected by accredited professionals using the venipuncture technique (WHO, 2010b). The results of Glycemia, Total Cholesterol and Triglycerides were analysed by the certified laboratory to which the professional belongs.

9.2.5. Functional capacity assessment

Functional capacity was assessed using three standardized tests from the Fullerton battery (Rikli & Jones, 1999), which included the 30 s chair test (number of executions in 30 s without using the upper limbs; more repetitions means more strength and endurance of the participant's lower limbs) (Hilgenkamp et al., 2012; Wouters et al., 2017); the timed up and go test (time that the participant take to walk 2.4 meter, around a cone and sit down again; the less time, the greater the speed, agility and dynamic balance of the participant) (Cabeza-Ruiz et al., 2019); and the 6 min walk test (distance performed when walking as fast as possible without running for 6 min; more meters walked means more aerobic endurance of the participant) (Nasuti et al., 2013).

9.2.6. Neuromuscular capacity assessment

Lower limb strength was assessed using an isokinetic dynamometer (BIODEX Multijoint System 3 Pro, Shirley, NY, USA), which is reliable for the target population (Pitetti, 1990), by knee flexion and extension, using maximal concentric contractions. Equipment calibration was performed prior to the evaluation session according to the manufacturer’s instructions (Biodex Medical Systems, Inc., 2000, Shirley, NY, USA). Concentric actions were tested considering 3 repetitions for each movement 60 º/s and 120 º/s. A 60 s interval was established between the 3 repetitions familiarization and the test, as well as between angular velocities.

To measure upper limb strength, a handgrip test was used, using a manual dynamometer. The reliability and validity have been confirmed by Cabeza-Ruiz et al. (2019) and Oppewal & Hilgenkamp (2020) and the procedures recommended by the Brockport Fitness Test Manual (Winnick & Short, 2001) were used. The “3 kg medicine ball throw test” were also be applied, a protocol valid and reliable for people with IDD (Wouters et al., 2017), in order to assess the muscular strength of the upper limbs.

9.2.7. Dementia/cognitive function assessment

The MMSE, Portuguese version (Guerreiro, Silva, & Botelho, 1994; Paiva et al., 2020), was also used in the present study. The instrument is composed of 30 questions, evaluating the cognitive profile through the assessment of six areas of cognition: orientation, immediate recall, attention, calculation, delayed recall, and language. Its score ranges from 0 to 30 points, and the cut-off values that classify individuals into cognitive profiles are: a) severe cognitive impairment (1 to 9 pts); b) moderate cognitive impairment (10 to 18 pts); c) mild cognitive impairment (19 to 24 pts); d) normal cognitive status (25 pts and above).

9.2.8. Quality of life assessment

The Personal Outcomes Scale (Claes et al., 2010; Loon et al., 2010), in the Portuguese version (Simões et al., 2016), was applied by technicians with specific training for this purpose. The Personal Outcomes Scale includes eight domains, each containing five questions, making a total of forty questions, presented with three response options, through the Likert format and answered by self-report. The overall QoL score was used for this study.

9.2.9. Statistical analysis

Descriptive statistics were used to characterize the sample, including mean, standard deviation, median, and minimum and maximum. The Shapiro-Wilk and Levene test were used to test the normality of the results. The Kruskal-Wallis H was used to assess differences between sexes and Wilcoxon between different limbs. The relationship between variables was verified using Spearman's correlation test, allowing the magnitudes of the associations to be determined ($r = 0.10$ to 0.29 - small; $r = 0.30$ to 0.49

- moderate; r = 0.50 for 1-strong) (Cohen et al., 2002). All data were analysed using IBM SPSS Statistics (version 28, IBM Corporation (SPSS Inc., Chicago, IL, USA) and the significance level adopted was $p<0.05$.

9.3. Results

Demographic data on the characteristics of the participants can be found in Table 29.

Table 29. Demographics and participant characteristics.

21 participants	**Mean ± SD**	**Median**	**Min-max**
Age (years)	42.81 ± 11.18	10.99	23.00-58.00
Height (cm)	160.05 ± 7.93	160.40	138.00-171.00
Weight (kg)	74.11 ± 16.11	75.50	48.60-105.30
Women	Mean ± SD	Median	Min-max
Age (years)	43.50 ± 12.37	46.50	23.00-58.00
Height (cm)	157.36 ± 9.45	160.00	138.00-165.50
Weight (kg)	79.42 ± 15.67	79.75	52.10-105.30
Men	Mean ± SD	Median	Min-max
Age (years)	42.18 ± 10.15	45.00	27.00-56.00
Height (cm)	162.50 ± 5.63	160.80	155.40-171.00
Weight (kg)	69.30 ± 15.64	72.00	48.60-93.30

Note: Max, maximum; Min, minimum; SD, standard deviation.

Table 30 showed the results of the body composition assessment, performed using the InBody 770 instrument.

Table 30. Body composition results.

	Mean ± SD	**Median**	**Min-max**	**Differences between limbs**
BMI (kg/m^2)	29.13 ± 6.86	29.20*	19.10-40.90	
WC (cm)	92.90 ± 15.45	93.60*	64.07-115.00	
Total body water (L)	31.58 ± 4.18	31.05*	25.40-38.90	
Proteins (kg)	8.37 ± 1.16	8.15*	6.70-10.50	
Minerals (kg)	2.83 ± 0.43	2.86	2.11-3.64	
Fat mass (kg)	36.64 ± 12.70	40.20*	14.80-56.90	
Muscle mass (kg)	23.30 ± 3.51	22.75*	18.20-29.50	
Lean mass right arm (kg)	2.57 ± 0.85	2.34	1.75-4.69	$p>0.05$
Lean mass left arm (kg)	2.36 ± 0.40	2.33	1.82-3.11	
Lean trunk mass (kg)	20.76 ± 3.36	20.25	16.50-26.60	
Lean mass right leg (kg)	6.22 ± 0.93	6.17	4.80-7.67	$p>0.05$

Lean mass left leg (kg)	6.17 ± 0.94	6.05*	4.46-7.48	
Fat right arm (kg)	3.29 ± 1.77	3.70*	0.90-6.60	*p*>0.05
Fat Left arm (kg)	3.46 ± 1.62	3.75*	1-60.60	
Trunk fat (kg)	18.38 ± 5.68	20.00*	7.60-25.20	
Fat right leg (kg)	4.96 ± 1.83	5.45*	2.10-8.20	*p*>0.05
Fat left leg (kg)	4.96 ± 1.81	5.45*	2.10-8.20	
Intracellular water (L)	19.38 ± 2.67	18.95*	15.50-24.10	
Extracellular water (L)	12.20 ± 1.53	12.25	9.90-14.80	
Phase angle	5.20 ± 1.33	4.70*	3.50-8.50	

Note: BMI, body mass index; Max, maximum; Min, minimum; SD, standard deviation; WC, waist circumference; * Difference between sexes.

Table 30 shows that all 21 participants are in the overweight range. When analysing by sex, females are in the obese range and, in turn, males are at the lower threshold of the overweight range (WHO, 2000). In addition, females have high WC values ($p \leq 0.05$) (Klein et al., 2007).

On the other hand, there are significant differences between sex in the BMI values (females: 32.6 ± 7.2; males: 25.99 ± 4.95), WC (females: 96.56 ± 13.26; males: 25.99 ± 4.95), total body water (females: 31.58 ± 4.18; males: 35.83 ± 4.97), fat mass (females: 36.64 ± 12.70; males: 20.41 ± 10.42), muscle mass (females: 23.3 ± 3.51; males: 27 ± 4.17), lean mass left leg (females: 6.17 ± 0.94; males: 2.76 ± 0.57), fat right and left arm (respective: females: 3.29 ± 1.77; males: 1.4 ± 0.92; females: 33.46 ± 1.62; males: 1.42 ± 0.91), intracellular water (females: 19.38 ± 2.67; males: 22.33 ± 3.3) and phase angle (females: 5.2 ± 1.33; males: 5.83 ± 0.77).

Then, in Table 31, the results of the health variables are presented.

Table 31. General Health Status results.

	Mean ± SD	**Median**	**Min-max**
Systolic blood pressure (mm Hg)	124.42 ± 18.75	121.00	101.00-168.00
Diastolic blood pressure (mm Hg)	79.95 ± 11.85	80.00	63.00-108.00
HR_{max} (mm Hg)	176.99 ± 9.79	176.50	149.80-191.90
Resting heart rate (mm Hg)	74.28 ± 14.13	72.00	52.00-113.00
SDNN (ms)	35.72 ± 19.68	32.18	2.95-77.44
Mean RR (ms)	811.13 ± 161.78	794.34	516.42-1174.20
RMSSD (ms)	25.71 ± 15.85	23.99	5.86-66.62
pNN50 (%)	6.81 ± 8.77	1.03	0.00-27.14
LF (log)	5.56 ± 1.20	5.52	3.03-7.63
HF (log)	5.10 ± 1.45	5.32	2.50-7.61
LF (n.u.)	58.77 ± 23.24	62.95	15.48-94.51
HF (n.u.)	41.13 ± 21.28	36.58	9.76-71.75
LF/HF ratio	3.07 ± 4.05	1.69	0.18-17.26
Glycemia (mg/dL)	96.23 ± 24.75	93.00	61.00-154.00
Total Cholesterol (mg/dL)	190.19 ± 43.70	192.00	107.00-261.00
Triglycerides (mg/dL)	137.19 ± 69.32	114.00	37.00-337.00

HF, absolute power of the high-frequency band, 0.15–0.4 Hz, in ms^2; HRmax, maximum heart rate; LF, absolute power of the low-frequency band, 0.04–0.15 Hz, in ms^2; LF/HF, ratio of LF-to-HF power; Max: maximum; Mean RR, mean of the RR intervals in ms, Min: minimum; pNN50, percentage of successive RR intervals that differ by more than 50 ms; RMSSD, standard deviation of RR intervals in ms; SD: standard deviation; SDNN, standard deviation of RR intervals in ms.

For all the variables presented in Table 31, there are no differences between sexs. On the other hand, the sample presents high levels of systolic blood pressure and cholesterol.

The results of the three functional tests performed are presented in Table 32.

Table 32. Functional capacity results.

	Mean ± SD	**Median**	**Min-max**
30 seconds chair stand (s)	13.52 ± 3.90	13.00	4.00-20.00
Timed up and go (s)	8.82 ± 4.06	7.08	4.75-17.75
6-minute walk (m)	474.19 ± 69.68	456.00	326.00-592.00

Max: maximum; Min: minimum; SD: standard deviation.

For the 3 functional tests performed, there are no differences between sexes ($p \geq 0.05$). However, the males show better values for all variables (mean females ± Standard Deviation (SD) vs mean males ± SD: 30 seconds chair stand: 12.7 ± 2.58 seconds vs 14.27 ± 4.81 seconds; Timed up and go: 9.43 ± 4.09 seconds vs 8.27 ± 4.15 seconds; 6-minute walk test: 460.3 ± 74.76 meters vs 486.81 ± 65.66 meters).

The following table (33) presents the results of the evaluation of the neuromuscular capacity, through the knee flexion and extension concentric test, on the isokinetic dynamometer.

Table 33. Neuromuscular results (dynamometer isokinetic).

	Extension 60 º/s		Flexion 60 º/s		Extension 120 º/s		Flexion 120 º/s	
Peak Torque	**right**	**left**	**right**	**left**	**right**	**left**	**right**	**left**
Mean	59.00±40.11	68.18±44.17	28.38±23.59	31.08±23.58	47.37±35.02	51.06±37.09	23.15±21.95	23.44±21.94
Median	55.20	62.20	20.05	27.40	38.20	41.40	40.00	41.50
Min-max	6.90-182.70	5.10-211.10	0.40-90.40	0.50-90.20	0.00-161.30	0.00-171.00	0.00-88.90	1.50-87.00

Note: Max, maximum; Min, minimum.

There were no significant differences between sex. However, there are differences between limbs for the extension at 60 º/s (p=0.019) and at 120 º/s (p=0.04) tests.

The results of the manual dynamometer and 3kg throw ball test are presented below, in table 34.

Table 34. Neuromuscular results (manual dynamometer and 3kg throw ball test).

	Mean ± SD	**Median**	**Min-max**
Manual dynamometer (kg)	20.06 ± 7.56	19.80	8.70-40.20
3kg throw ball test (m)	2.27 ± 0.85	2.20*	1.19-4.33

Note: Max: maximum; Min: minimum; SD: standard deviation, * Difference between sexes.

For manual dynamometer test there were differences between sexes on the 3kg throw ball test (p=0.035; females: 1.83±0.57; males: 2.67±0.88).

Similarly, the results of the MMSE presented on table 35.

Table 35. Mini-Mental State Examination results

	Mean ± SD	**Median**	**Min-max**
MMSE (score)	21.42 ± 5.61	22.00	7.00-30.00

Note: Max, maximum; Min, minimum; MMSE, Mini-Mental State Examination; SD, standard deviation.

No significant differences between sexes were found for all variables (p≥0.05). Considering the values of the test and the corresponding score, the participants presented mild cognitive impairment (Guerreiro, Silva, & Botelho, 1994; Paiva et al., 2020). Similarly, in the sample, there were individuals with severe cognitive impairment (Guerreiro, Silva, & Botelho, 1994; Paiva et al., 2020).

Finally, the results of the QoL are presented on table 36.

Table 36. Quality of life results

	Mean ± SD	**Median**	**Min-max**
QoL (score)	86.61 ± 8.31	85	71-101

No significant differences between sexes were found (p≥0.05). No significant differences for body composition and General Health Status variables. In turn, QoL was associated with the functional 30 s chair test (r=0.441; p=0.045) and negatively with the timed up and go test (r=-0.596; p=0.004). As for the neuromuscular capacity variables, there were some associations, namely between Flexion 60 º/s left (r=0.549; p=0.01), Flexion 120 º/s left (r=0.44; p=0.046) and manual dynamometer (r=0.57; p=0.007).

9.4. Discussion

The effects of physical inactivity and a sedentary lifestyle, result in an increased onset of cardiovascular and metabolic disease in adults with IDD (de Winter et al., 2012b). Associated with this is the aging process, with higher rates of multimorbidity and frailty at younger ages than in the population without disabilities (Evenhuis et al., 2012). Therefore, the aim of this study was to characterize a sample of 21 institutionalized adults with IDD (42.81 ± 10.99 years) at the anthropometric level, body composition, physical fitness, general health, cognitive function and QoL, for a subsequent prescription of physical exercise.

9.4.1. Anthropometric and body composition assessment

Participants are in the overweight range, which increases the probability of having other obesity-related health problems such as type 2 diabetes, hypertension, and obesity-related cardiovascular diseases (de Winter et al., 2011; Rimmer et al., 2010). When analysed our participants by sex, females are in the obese range and, in turn, males are at the lower threshold of the overweight range (WHO, C., n.d.). In addition, females have high WC values (Klein et al., 2007).

On the other hand, there are significant differences between sex BMI values, waist circumference, total body water, fat mass, muscle mass, lean mass left leg, fat right and left arm, intracellular water and phase angle, with the women showing more unfavourable values, with the causes remaining unclear.

According to the literature, the participants in this study had unfavourable body composition values (Hsieh et al., 2014; Segal et al., 2016). This fact may be caused by several factors, such as environmental, behavioural, genetic and/or medical (Pronk et al., 2004), namely eating unhealthy foods, limited access to health care (Cooper et al., 2015; Emerson et al., 2016), some prescribed medications (Doody & Doody, 2012), variables that should be assessed and controlled in future studies. Associated with these variables, individuals with IDD are less likely to have opportunities to engage in physical activity (reasons for barriers to practice), which also contributed to these body composition results (Jacinto, et al., 2021b).

Monitoring of body composition of individuals with IDD, along with the implementation of strategies to promote a healthy lifestyle, namely through physical activity and healthy eating, should be studied. It is also important that this literacy in healthy practices be directed and adapted to both the person with IDD and their support network.

9.4.2. General Health Status

The results of our study do not indicate elevated blood pressure values. The literature has shown that individuals with IDD have high blood pressure values, even reaching hypertension values. Some prescribed medications for this population, sedentary and inactive lifestyle, poor diet, overweight, and obesity may justify these results (Doody & Doody, 2012; Jacinto et al., 2021c).

Considering the resting heart rate, the participants in this study as shown to have high values. There are several factors that can explain these results, namely communication difficulties (individuals with ID who do not communicate, acute pain or distress may be reflected in high resting heart rate values), executive/cognitive functioning, social skills, lack of physical activity, and physical and mental stress and anxiety may be behind these high resting heart rate values (Kildal et al., 2021; Reimers et al., 2018), as well as an autonomic response to pain and acute distress (Ledowski et al., 2011), happiness, excitability (Waldstein et al., 2000) or postural changes and muscle work at the time of assessment. Future studies that assess the resting heart rate or that want to promote the decrease of the values, should also look at these mentioned variables.

Another variable that is associated with chronic diseases, namely cardiovascular diseases in individuals with IDD, is HRV. Research has shown that individuals with IDD have a lower HRV than individuals without IDD (Meule et al., 2013; Nunan et al., 2010), which is confirmed in most of our results. For example, all participants in this study had SDNN values lower than 50 ms, which is related to a higher risk of cardiovascular diseases (Kleiger et al., 2005) and QoL (Meule et al., 2013).

With regard to blood test variables, individuals with IDD may be at higher risk of elevated triglyceride cholesterol and blood glucose values than those without IDD (Axmon et al., 2017; Gazizova et al., 2012). Once again, lifestyle factors such as an unhealthy diet and lack of physical activity could explain these elevated values. In addition, some prescribed medications can increase the values, such as antipsychotics and antidepressive (Axmon et al., 2017; Gazizova et al., 2012), and that future ones should take this variable into consideration.

9.4.3. Functional capacity assessment

There were no differences between sexes in the three functional tests performed, although men presented best performances for all variables. Most literature reports that there are significant differences between sexes in functional capacity, particularly in tests associated with physical capacity, strength, balance, and cardiorespiratory capacity (Graham & Reid, 2000; Skowroński et al., 2009), indicating that men show more favourable values (Camargo Rojas et al., 2020). These results may be influenced by the level of IDD (Golubović et al., 2012; Hartman et al., 2015) and age (Graham & Reid, 2000; Lahtinen et al., 2007).

Poor functional capacity (due to poor physical fitness, that may be the result of low levels of physical activity practice), along with high rates of overweight and obesity, increases the risk of developing cardiovascular and metabolic diseases (Izquierdo-Gomez et al., 2013; Secchi et al., 2014; Wouters et al., 2020). In addition, low levels of all physical capacities are predictive of a decline in performance of activities of daily living, decline in mobility, and an increased risk of early mortality in adults with IDD (Oppewal et al., 2014; Oppewal & Hilgenkamp, 2019), so that the promotion of physical capacity should be taken into consideration in future studies.

9.4.4. Neuromuscular assessment

Although there were no significant differences between sexes in the evaluation of peak torque, the literature shows that males tend to show higher levels of strength (Lahtinen et al., 2007; Skowroński et al., 2009), which may be justified by the influence of testosterone (Cadore et al., 2008). On the other hand, the differences between limbs for the test of concentric Extension at 60 º/s (p=0.019) and at 120 º/s (p=0.04) may be influenced by the values of females, since no significant differences were found in males. Both sexes showed asymmetries in the peak torque of both lower limbs, although these differences are only significant in females. These asymmetries may be a consequence of laterality, explained by the inequality of the cerebral hemispheres, or they may be related to the dominant limb, leading to biomechanical and postural changes (Barut et al., 2007; Reiss & Reiss, 2000).

On the other hand, compared to the reference values for the general population (20 to 80 years old), as defined by Neder et al. (1999), both sexes in the present study show lower endurance values, in all tests. In the same sense, comparing our results with those of the study by Raulino et al. (2014), namely the initial evaluation carried out, our participants present lower values in both tests performed.

For the manual dynamometer test there were no significant differences between sexes, contrary to the information found in the literature. Bofosa et al. (2019), assessed the explosive, resistant and isometric strength through a horizontal jump, maximum crunches in 30 seconds and hand grip strength of individuals with IDD. He found that males presented higher values when compared to females. However, and despite presenting handgrip strength levels within the normative values for the population with IDD, the females presents relatively low values when compared to the population without disabilities (Cuesta-Vargas & Hilgenkamp, 2015). In turn, despite presenting higher grip strength levels than females, males present grip strength levels below the reference values for the population with IDD and compared to the population without IDD (Y.-C. Wang et al., 2018).

For individuals with IDD, muscle strength is a differential variable of physical fitness, essential in activities, tasks and/or routines of daily living, such as dressing, personal hygiene, among others (Smail & Horvat, 2006). In turn, hand strength is considered a useful indicator of sarcopenia, nutritional status, frailty, and muscle strength (Sousa-Santos & Amaral, 2017), so it may be important to introduce this measure in the population with IDD. However, the results of the present study demonstrate that the participants have lower levels of strength. These low levels of strength can be explained by peripheral and central factors, in the activation of motor units and some abnormal intrinsic muscle properties (Borji et al., 2019; Golubović et al., 2012). Finally, it is important to monitor muscle strength in adults with IDD, define strategies for decreasing barriers to activity (Jacinto et al., 2021c) and prescribe adapted exercise to their needs (Ferreira et al., 2022; Jacinto et al., 2021b; Jacinto et al., 2022).

9.4.5. Dementia/cognitive function

The participants in the present study have mild cognitive deterioration. In our sample, there are also individuals with severe cognitive deterioration. One potential explanation is reduced brain reserve (i.e., smaller brain size, fewer neurons or synapse count) (Stern, 2002), in the sense that people with IDD may be less resilient to developing symptoms when age is related to neuropathology (Sheehan et al., 2014).

On the other hand, studies have shown that dementia is associated with poor physical health outcomes and accounts for 30% of deaths in individuals with IDD (Englund et al., 2013; Evenhuis et al., 2012). Exercise has been associated not only with improved physical fitness, but also with improved cognitive function and reduced risk of dementia (Alty et al., 2020; Heyn et al., 2004). One possible justification for this relationship is the increased blood flow that occurs in the brain, providing it with essential nutrients and oxygen (SWang et al., 2021), during exercise.

9.4.6. Quality of life

A higher functional and neuromuscular capacity seems to be associated with a higher perceived QoL. However, more studies with a larger sample size are needed to reach more robust conclusions. In the same vein, future research should analyze this relationship longitudinally.

Since individuals with IDD have sedentary lifestyles and low adherence to physical activity (justified by the existence of barriers to physical activity (Jacinto et al., 2021c), strategies to promote QoL may include the prescription of adapted exercise.

Several authors have shown that functional and neuromuscular capacity may affect the QoL of individuals with IDD (Jacinto et al., 2022; Williams et al., 2021) and our results are in accordance with these results.

Although there are barriers to physical exercise practice (Jacinto, et al., 2021c), it is considered a promoter of all physical capacities (Pestana et al., 2018) and, according to the results of our study, may further promote a higher perception of QoL, requiring intervention studies in the study population (Ferreira et al., 2022). In the same sense, physical exercise can act as a predictor of improved QoL (Carbó-Carreté et al., 2016). In Pérez-Cruzado and Cuesta-Vargas study (2016), an 8-week physical activity intervention program increased the physical fitness and QoL of 40 individuals with IDD. The relevance of this kind of research becomes more important when we analyze some preliminary results.

9.4.7. Conclusions

According to our results, in addition to low levels of physical fitness, these individuals are at risk of developing metabolic and cardiovascular diseases, highlighting the significance of an intervention with physical exercise. This initial assessment is important, not only for an initial anamnesis, but also for the development of an adapted, effective and safe prescription of physical exercise programs, according to the participants characteristics. On the other hand, functional and neuromuscular capacity seems to be associated with a greater perception of QoL. This should be the process/approach to be carried out before implementing strategies to promote exercise programs and consequently QoL in individuals with IDD, as well as active aging.

Chapter 10 – Effects of 24-week exercise program on functional capacity, dementia and quality of life in individuals with Intellectual and Developmental Disabilities (study 9)

Effects of 24-week exercise program on functional capacity, dementia and quality of life in individuals with Intellectual and Developmental Disabilities. Under review in Journal of Sports Sciences (JCR; IF: 3.943; Q2) since February 17, 2023.

10. Abstract

This study aims to investigate the effects of two exercise programs for adults with IDD, using an experimental study. Twenty-one adults with IDD (Mean age = 43.04; SD=11.18 years) were assigned to IG (N=7; 24-weeks gym intervention), OG (N=7; 24-weeks outdoor intervention) or CG. The assessment included QoL, dementia/cognitive function and functional capacity. *Kruskal-Walli* test was used to verify differences between groups and *Wilcoxon* signed-rank test and *Friedman* test to verify differences between moments. The IG significantly improved Physical Well-being, when compared to the CG (t=2.762; p=0.017; η^2=0.545). There were no significant differences in dementia/cognitive function score between groups and moments. There were differences between groups post intervention for 30 seconds chair stand between IG and CG (t=2.572; p=0.03; η^2=0.47), Timed up and go test (t=-3.253; p=0.003; η^2=0.756) and 6-minute walk test (t=2.541; p=0.033; η^2=0.461) and between moments in IG for 30 seconds chair stand (pre≠post; t=-3.031; p=0.007; W=0.65) and 6-minute walk test (pre≠post; t=3.03; p=0.007; η^2=0.656). An outdoor, in contact with nature seems to be effective in improving Physical Well-Being. An indoor intervention using weight-training machines seems to be a good method for promoting functional capacity.

Keywords: cardiorespiratory training, indoor training, outdoor training, physical fitness, resistance training.

10.1. Introduction

For WHO, QoL concerns the individual's perceptions of their position in life, in the context, culture and value system to which they are inserted, considering the relationship with their goals, expectations, standards and concerns. The multidimensional construct was validated assuming seven domains: i) physical health; ii) psychological domain; iii) level of independence; iv) social relationships; v) environment; vi) spirituality; vii) personal domain (WHOQOL, 1998). On the other hand, for Schalock and Verdugo (2002), QoL refers to a set of factors that address the individual's well-being, or the perception of their social position, in the context and culture to which they are inserted, assuming sociocultural values, needs, expectations and individual preferences. It is a multidimensional phenomenon composed of factors: i) Independence; ii) Social Participation; iii) Well-being and domains: i) Personal Development; ii) Self-determination; iii) Interpersonal Relations; iv) Social Inclusion; v) Rights; vi) Emotional; vii) Physical; viii) Material, influenced by personal characteristics and environmental contexts (Schalock et al., 2011).

The concept and study of QoL in individual with IDD has been the topic of interest of various stakeholders with practical implications for interventions conducted with this population (Schalock & Verdugo, 2002). In individuals with IDD, characterized by a deficit of intellectual and adaptive functioning in the conceptual, social and practical domains, identified with mild, moderate, severe and profound degrees and developed before 18 or 22 years old (Schalock et al., 2021), measuring QoL allows: i) to understand their degree of satisfaction; ii) understand personal perceptions; iii) support decision-making; iv) evaluate the intervention; v) evaluate theoretical models. This measurement allows us to direct the individual to the life he likes and values[3].

In this population early aging process starting at age 40 (Tse et al., 2018), leading to early onset of physical health problems, functional disability, visual and hearing problems, dementia, chronic diseases. In addition, this early aging affects the successful performance of their activities of daily living and consequently their perceived QoL (Lifshitz et al., 2008). Improved medical care, health care and more targeted interventions for the individual have gradually increased the life expectancy of people with IDD. On the other hand, this increase in life expectancy ha also increased the rate of individuals with IDD and dementia. The incidence of dementia in this group was found to be up to five times higher than in the general population, being the most important cause of morbidity, QoL and mortality in this population (Janicki, 2011). People with pre-existing cognitive compromise seems to be less resilient to developing symptoms when age-related neuropathological damage occurs.

At the same time, in this population, physical inactivity and sedentary lifestyles prevail (Dairo et al., 2016), not meeting the WHO physical activity guidelines (WHO, 2020). Due to their physical inactivity and sedentary lifestyles, individuals with IDD have low levels of physical fitness (decreasing their functional capacity and success in performing activities of daily living), with increased risk of acquiring other comorbidities such as type II diabetes, hypertension, cholesterol and metabolic syndrome (de Winter et al., 2012a), affecting their QoL.

One of the reasons found in the literature for physical inactivity and sedentary lifestyles in individuals with IDD is the existence of barriers that prevent/hinder their practice namely lack of adapted physical exercise programs, limited financial resources and lack of places to practice (Jacinto et al., 2021c). Therefore, there is a scarcity of research, including little clarity in intervention protocols used and a variety of methodologies addressing the applicability of non-pharmacological, psychological and psychosocial interventions, as is the case of physical exercise programs, for the promotion of the several variables.

One of the most studied relationships is between exercise and the promotion of physical fitness, confirming its direct impact on functional capacity. Taking into account, studies about dementia and cognitive function only assess a few number of variables that may be associated but that alone do not represent it, such as attention (Ptomey et al., 2018), memory (Ptomey et al., 2018) and language fluency (Ringenbach et al., 2016). Regarding QoL, a 8-weeks multidisciplinary exercise intervention program aiming to improve muscle strength, flexibility, balance, aerobic fitness, and educational advice to increase physical activity found significant differences [F=4,18 (p=0,04)], however the physical exercise program is not clarified (Pérez-Cruzado & Cuesta-Vargas, 2016). On the other hand, a previous systematic review associated the effects of physical exercise on variables that are related to QoL, namely pain, general health and anxiety (Bartlo & Klein, 2011). In studies that focus on physical activity, this variable has been found to be a predictor of QoL (Carbó-Carreté et al., 2016), however, studies with physical exercise programs are still care or unclear.

Therefore, alternative, and innovative solutions to promote/maintain physical function, reduce the risk of onset of dementia early in life, and promote/maintain QoL of individuals with IDD should include physical exercise. Taking this introductory approach into consideration, the present non-RCT aimed to assess the effects of two 24-week exercise program (indoor and outdoor) on functional capacity, dementia/cognitive function, and QoL in institutionalized individuals with IDD.

10.2. Methods

This study followed a non-randomized experimental methodology, following the assumptions of the Helsinki Declaration (World Medical Association, 2013) and was approved by the Ethics Committee of the FCDEF-UC. All participants and family members were informed about the purpose of the study, potential implications and methodological procedures, and signed an informed consent form before participating in the study. This study followed a pre-determined published protocol (Ferreira et al., 2022) using exercise as a major intervention tool to improve functionality, cognitive function and QoL in individuals with IDD.

10.2.1. Participants

Adult institutionalized volunteers from Leiria region (Centre Portugal) participated in the exercise intervention program. Participants were selected using the following inclusion criteria: 1) adults with IDD; 2) without medical contraindications; 3) age over 18 years; 4) with mild, moderate or severe IDD diagnosis (DS inclusive); 5) success in performing movements such as pulling/pushing; 6) ability to carry out the intended assessments. Additionally, we also used the following exclusion criteria: 1) individuals who cannot commit for 6 months; 2) individuals with other associated pathologies; 3) contraindications to physical exercise; 4) inability to walk unassisted; 5) profound IDD; 6) inability to communicate; 7) non-delivery of the duly signed informed consent.

Due to the special characteristics of IDD population and to the logistic intrinsic constraints related with the development of intervention studies, the sample size included 21 participants aged between 18 and 65 years (10 women, 11 men, mean age = 43.04±11.18 years) who agreed to participate in the intervention program. A power analysis (calculated using *G*Power*, version 3.1.9.7 showed that a sample of at least 15 was required to detect a medium effect size (*ES*) of 0.5 (α = .05, 1 − β = 0.95) using a repeated-measures analysis of variance (*ANOVA*), in agreement with some previous studies (Cicone et al., 2018; Fujita et al., 2021). Effect size of 0.5 was chosen given that this value was verified from studies investigating the effects of exercise on the variables of interest in our study (Bartlo & Klein, 2011; St. John et al., 2020).

10.2.2. Instruments

10.2.2.1. Quality of life

The Portuguese version of the Personal Outcomes Scale (Simões et al., 2016) was used. The instrument was applied by technicians with specific training aiming to evaluate QoL in people with IDD. The Personal Outcomes Scale includes eight domains, each containing five questions, making a total of forty questions, presented with three response options, through the Likert format.

10.2.2.2. Dementia/Cognitive function

The MMSE is a simple paper and pencil test with an easy and quick application (about 5 to 10 minutes) aiming to screen dementia/cognitive function. MMSE test was adapted to the Portuguese population by Guerreiro et al. (1994) and used with IDD population (Paiva et al., 2020). The thirty items questionnaire (scored 0 value - when the person gives an incorrect answer or simply does not answer or scored 1value - when the person answers correctly), is organized in six domains: Orientation (which assesses recent memory, attention and the temporal-spatial orientation); Retention (assess attention and short-term or primary memory); Attention and Calculation (assesses calculation ability, attention and immediate and working memory); Evocation (assesses recent or secondary memory); Language (assesses spontaneous speech, listening, repetition, naming, reading and writing). The maximum test score is thirty points, with higher scores indicating better results. Its score ranges from 0 to 30 points, and the cut-off values that classify individuals into cognitive profiles are: a) severe cognitive impairment (1-9 pts); b) moderate cognitive impairment (10-18 pts) mild cognitive impairment (19-24 pts), d) normal cognitive status (25 pts and above).

10.2.2.3. Functional Capacity

Fullerton battery of functional tests (Rikli & Jones, 1999) was used to assess physical fitness, namely:

i) the 30 seconds chair stand, validated for the IDD population (Cabeza-Ruiz et al., 2019) evaluated the strength and resistance of the lower limbs. The purpose of the test is to assess the strength and the resistance of the lower limbs (number of executions in 30 seconds without using the upper limbs). The test begins with the participant sitting in the middle of the chair, with the back straight and feet shoulder-width apart and fully supported on the floor;

ii) the Timed up and go test, validated for the IDD population (Cabeza-Ruiz et al., 2019) aimed to assess physical mobility, namely speed, agility and dynamic balance;

iii) the 6-minute walk test validated for IDD population (Cabeza-Ruiz et al., 2019) aimed to assess aerobic resistance by covering the greatest distance in 6 minutes.

10.2.3. Procedures

Participants were taken to a laboratory environment (FCDEF-UC) where the evaluations were carried out. The space was large and isolated, the temperature was controlled (with exception the 6-minute walk test which was performed abroad) and each step of the evaluation was organized to provide maximum comfort and privacy for the participants. The team of researchers provided all the information on the procedures and objectives and answered all the participant´s questions.

Three moments of evaluations were carried out during the physical exercise program (initial, week -1; intermediate, week 12; final, week 24. To minimize differences in procedures, the same team carried out the assessments at different times. All assessments were carried out in a controlled environment, during the morning, with only breakfast, due to the characteristics of the participants themselves and the taking of medications. The researchers responsible for the evaluations did not have any knowledge of the group belonging to each participant, except for the principal researcher.

Participants were allocated to one of the three groups: i) IG with sessions carried out in a gym, using weight machines; ii) OG with sessions using low-cost materials; and iii) CG with participants continuing to do their normal activities, based on their interests and availability to get involved with physical exercise programs. The training groups underwent a 24-week combined exercise intervention twice a week for approximately 45 minutes. CG participants were encouraged to maintain their usual lifestyle. Throughout the 24 weeks, participant´s attendance sessions were recorded with an IG attending average of 78% and an OG attending average of 76%.

10.2.4. Intervention

10.2.4.1. Indoor training program

The indoor physical exercise program was carried out in a gym with weight machines. The physical exercise program was divided into four parts. Part I: playful game or shuttle run (5 to 7 minutes). Part II: aerobic training (treadmill; 10 minutes; 40% to 80% of Heart Rate Reserve (HRR); between 12 to 17 according to the Borg RPE Scale

(Borg, 1982); between 5 to 8 according to the Borg CR-10 Scale (Borg, 1998). Part III: strength training (more or less 25 minutes; Leg Press + Chest Press + Leg Extension + Lat Pull Down + Leg Curl + Shoulder Press; 40-80% of 3RM; 10-15 reps; 2-3 sets). Part IV: 4 static stretches (30 to 60 seconds each).

10.2.4.2. Indoor training program

The outdoor physical exercise program was carried out in a natural environment near the institution. Natural environments, which for the purpose of this experimental study are defined as "any outdoor spaces with elements of nature, from pure or semi-natural areas to urban green or blue spaces, including green infrastructure" (Silva et al., 2018). The physical exercise program was divided into four parts. Part I: playful or shuttle run (5 to 7 minutes). Part II: aerobic training (walking; 10 minutes; 40% to 80% of Heart Rate Reserve (HRR); between 12 to 17 according to the *Borg RPE Scale* (Borg, 1982); between 5 to 8 according to the *Borg CR-10 Scale* (Borg, 1998). Part III: strength training (more or less 25 minutes; Sit to stand from the chair + TheraBand's; Low row + TheraBand's; Low row + TheraBand's; Sitting unilateral knee extension + shin guards; Chest press + TheraBand's; Standing unilateral knee flexion + shin guards; High row or seated shoulder press + TheraBand's; ≥15 reps depending on the *OMNI-RES* scale (Robertson et al., 2003); 3 sets). Part IV: 4 static stretches (30 to 60 seconds each). Progression of exercises with changing the resistance of the TheraBand's and shin guards.

10.2.5. Statistical Analysis

Descriptive statistics including mean and standard deviation were calculated for studied variables. The *Shapiro-Wilk* ($n<50$) and *Levene* test were used to verify data normality and homoscedasticity, respectively. Thus, to understand if there were differences between groups, a *Kruskal–Wallis* test was performed. For comparison and identification of possible differences in each group, the *Wilcoxon* signed-rank test and *Friedman's* test were used. Both these tests are non-parametric *ANOVA's* correspondence and adjusted for small samples testing. The multiple comparison test used the *Bonferroni* correction (i.e., alpha level/ number of tests) to avoid error Type I (Ho, 2014). The effect size η^2 (appropriate for the *Wilcoxon* test, which allows two paired groups to be compared) was calculated and the assumed reference values were as follows: "small" effect ≥ 0.01, "medium" effect ≥ 0.3, and "large" effect ≥ 0.5 (Cohen, 1988; Fritz et al., 2012). In turn, *Kendal's W* effect size (suitable for *Friedman's* test, which allows comparing two paired groups) was calculated and the assumed reference values were as follows: "small" effect ≥ 0.01, "medium" effect ≥ 0.3 and "large" effect ≥ 0.5 (Cohen, 1988; Fritz et al., 2012). The significance level to reject the null hypothesis was set at 5% and analyses were performed in IBM SPSS Statistics.

10.3. Results

The table 37 presents descriptive statistics, namely mean and standard deviation of the groups regarding QoL assessment. The results of the initial and final moment are presented for each domain of the questionnaire.

Table 37. Global sample descriptive of the Quality of Life Scale

	IG		**OG**		**CG**	
	Mean ± SD					
	pre	**post**	**Pre**	**Post**	**Pre**	**post**
Personal Development (5-15)	9 ± 1.63	8.71 ± 2.13	10.42 ± 2.37	9.42 ± 2.14	9.28 ± 1.6	8.85 ± 1.34
Self-Determination (5-15)	10 ± 2	10.83 ± 1.83	12.57 ± 2.37	12.57 ± 1.9	10.85 ± 1.06	12 ± 2.16
Interpersonal Relations (5-15)	12 ± 1.82	12.5 ± 1.87	11.42 ± 1.71	13.14 ± 1.95	10.71 ± 2.98	11.28 ± 1.6
Social Inclusion (5-15)	12.57 ± 2.14	12 ± 2.09	9.42 ± 2.5	10.85 ± 2.85	10.14 ± 1.34	10.14 ± 1.34
Rights (5-15)	10.14 ± 1.67	10.66 ± 2.42	10 ± 1.15	9.71 ± 0.48	8.14 ± 1.86	8.71 ± 1.88
Emotional Well-being (5-15)	14.28 ± 0.95	13 ± 2.28	13.57 ± 1.39	14.28 ± 1.11	13 ± 2.08	14.57 ± 0.78
Physical Well-being (5-15)	13.14 ± 1.34	13.5 ± 0.95	13.42 ± 2.07	14.42 ± 0.78	12.57 ± 0.53	12.57 ± 1.27
Material Well-being (5-15)	8.57 ± 2.93	7.16 ± 2.13	7 ± 0.81	6.71 ± 1.79	7.71 ± 1.79	6.85 ± 2.11

Note: CG, control group; IG, indoor group; OG, outdoor group; SD, standard deviation.

The descriptive statistics of the MMSE scale results are presented in table 38. It shows the mean and standard deviation values for all intervention and CG.

Table 38. Global sample descriptive of the Mini-Mental State Examination.

	IG		**OG**		**CG**	
	Mean ± SD					
	pre	**post**	**pre**	**post**	**pre**	**post**

MMSE	20.28 ± 4.82	20.83 ± 5.67	22.42 ± 7.61	22 ± 7.23	21.57 ± 4.61	21.14 ± 4.56

Note: CG, control group; IG, indoor group; OG, outdoor group; MMSE, Mini-Mental State Examination; SD, standard deviation.

Table 39 shows the means and standard deviation values of the functional tests, namely: 30 seconds chair stand, timed up and go, 6-minute walk test, in the three moments, for the three groups.

Table 39. Global sample descriptive of the Functional Capacity.

	IG			**OG**			**CG**		
	Mean ± SD								
	pre	**intermediate**	**post**	**pre**	**intermediate**	**post**	**pre**	**intermediate**	**post**
30 seconds chair stand	14.57 ± 3.77	17 ± 4.12	17.33 ± 2.94	14.14 ± 4.29	13.85 ± 4.67	14.85 ± 5.75	11.85 ± 3.62	11.71 ± 3.63	11.71 ± 3.72
Timed up and go	6.04 ± 0.77	6.02 ± 1.59	5.3 ± 0.63	8.7 ± 4.4	7.39 ± 3.07	8 ± 3.71	11.74 ± 4.01	11.9 ± 3.77	12.96 ± 4.51
6-minutes walk	530.14 ± 62.38	567 ± 44.97	509.33 ± 62.14	463.28 ± 51.78	485.14 ± 44.66	451.14 ± 117.1	429.14 ± 58.76	409.28 ± 58.39	394.85 ± 58.57

Note: CG, control group; IG, indoor group; OG, outdoor group; SD, standard deviation.

Table 40 shows analysis of the QoL scores for the three groups.

Table 40. Difference between groups and assessments for Quality-of-life scores.

	IG		OG		CG		pre				post				
	Median (interquartile range)						t^a	df^a	p^a	Pairwise comparisons (groups)[a,c]	t^a	df^a	p^a	Pairwise comparisons (groups)[a,c]	Pairwise comparisons (moments)[b,c]
	Pre	post	pre	post	Pre	post									
Personal Development (5-15)	9 (2)	8 (3)	11 (4)	9 (4)	9 (2)	9 (1)	1.772	2	*p*>0.05	d	1.047	2	*p*>0.05	d	d
Self-Determination (5-15)	10 (3)	10 (2)	13 (3)	13 (2)	11 (1)	12 (4)	5.617	2	*p*>0.05	d	2.899	2	*p*>0.05	d	d
Interpersonal Relations (5-15)	11 (3)	12.5 (3)	12 (4)	14 (4)	11 (6)	12 (3)	.538	2	*p*>0.05	d	3.824	2	*p*>0.05	d	d
Social Inclusion (5-15)	13 (4)	11.5 (4)	9 (5)	11 (5)	10 (2)	10 (2)	5.154	2	*p*>0.05	d	2.606	2	*p*>0.05	d	d
Rights (5-15)	10 (2)	9.5 (3)	10 (2)	10 (1)	7 (3)	9 (4)	4.381	2	*p*>0.05	d	2.37	2	*p*>0.05	d	d
Emotional Well-being (5-15)	15 (2)	13.5 (3)	14 (2)	15 (1)	14 (4)	15 (1)	1.847	2	*p*>0.05	d	3.515	2	*p*>0.05	d	d
Physical Well-being (5-15)	13 (3)	13.5 (1)	14 (4)	15 (1)	13 (1)	13 (3)	1.603	2	*p*>0.05	d	7.7	2	*p*=0.021	2≠3	d
Material Well-being (5-15)	9 (6)	6.5 (2)	7 (2)	7 (3)	7 (3)	6 (4)	.975	2	*p*>0.05	d	.093	2	*p*>0.05	d	d

Note: CG, control group; IG, indoor group; Max, maximum; Min, minimum; OG, outdoor group; *t*, test statistic; *df*, degrees of freedom; *p*, significance; a, *Kruskal–Wallis*; b, *Wilcoxon*; c, *Bonferroni correction*; d, no differences detected.

At the initial moment, there were no differences between groups in the most diverse domains ($p \geq 0.05$). After 24 weeks of intervention, significant differences between groups were found only in the Physical Well-being (p=0.021). After *Bonferroni* correction, these differences were only observed between OG and CG (t=2.762; p=0.017; η^2=0.545). At the same time, there were no differences between moments considering the groups and the domains.

Table 41 shows analysis of the MMSE scores for the three groups.

Table 41. Difference between groups and assessments for Mini-Mental State Examination scores.

MMSE	IG		OG		CG		pre				post				
	Median (interquartile range)														
	pre	**post**	**pre**	**post**	**pre**	**post**	***t*** [a]	***df*** [a]	***p*** [a]	**Pairwise comparisons (groups)** [a,c]	***t*** [a]	***df*** [a]	***p*** [a]	**Pairwise comparisons (groups)** [a,c]	**Pairwise comparisons (moments)** [b,c]
	20 (7)	21 (7)	25 (8)	25 (10)	22 (8)	22 (6)	1.752	2	$p>0.05$	d	.86	2	$p>0.05$	d	d

Note: CG, control group; IG, indoor group; OG, outdoor group; Max, maximum; Min, minimum; MMSE, *Mini-Mental State Examination*; *t*, test statistic; *df*, degrees of freedom; a, *Kruskal–Wallis*; b, *Wilcoxon*; c, *Bonferroni correction*; d, no differences detected.

The groups were not different at the initial assessment ($p \geq 0.05$). Non-significant differences were found in MMSE scores before and after the 24-week intervention in term of group and moments.

Table 42 shows analysis of the Functional capacity scores for the three groups.

Table 42. Difference between groups and assessments for Functional capacity scores.

	IG			**OG**			**CG**			**pre**				**intermediate**				**post**				
	Median (interquartile range)									***t*[a]**	***df*[a]**	***p*[a]**	**Pairwise comparisons (groups)[a,c]**	***t*[a]**	***df*[a]**	***p*[a]**	**Pairwise comparisons (groups)[a,c]**	***t*[a]**	***df*[a]**	***p*[a]**	**Pairwise comparisons (groups)[a,c]**	**Pairwise comparisons (moments)[b,c]**
	pre	**intermediate**	**post**	**pre**	**intermediate**	**post**	**pre**	**intermediate**	**post**													
30 seconds chair stand	12.5 (5.75)	15 (6)	17 (5)	13 (5.7)	13 (5)	13.5 (6.5)	13 (4.25)	13 (4.25)	13 (6)	.866	2	*p*>0.05	c	5.348	2	p>0.05	c	6.617	2	***p*=0.037**	**1≠3**	**pre ≠ post (IG)**
Timed up and go	5.93 (1.1)	5.93 (2.05)	5 (1.2)	7.08 (7.4)	7.2 (3.6)	7.1 (6.2)	11.12 (6.)	13 (6.2)	13.2 (7.7)	5.18	2	*p*>0.05	c	9.513	2	***p*=0.009**	**1≠3**	10.896	2	***p*=0.003**	**1≠3**	**pre ≠ post (IG)**
6-minutes walk	551 (75)	582 (36.5)	509 (104.5)	456 (101.3)	485 (89)	482 (193.5)	434 (48.3)	414 (50.5)	394.85 (86)	5.875	2	*p*>0.05	c	14.048	2	***p*≤0.001**	**1≠3**	6.597	2	***p*=0.037**	**1≠3**	d

Note: CG, control group; IG, indoor group; OG, outdoor group; Max, maximum; Min, minimum; *t*, test statistic; *df*, degrees of freedom; a, *Kruskal–Wallis*; b, *Friedmann*; c, *Bonferroni correction*; d, no differences detected

The groups showed no differences between each other at the initial moment, given the three functional tests (*p*≥0.05).

There were differences between group post intervention for 30 seconds chair stand (*p*=0.037). After Bonferroni correction, these differences were only observed between IG and CG (*t*=2.572; *p*=0.03; η^2=0.47). Similarly, there was a difference between moments in IG (pre ≠ post; *Bonferroni* corrected: *t*=-3.031; *p*=0.007; *W*=0.65).

Regarding Timed up and go test, there were differences between group at the intermediate moment (*p*=0.009). After *Bonferroni* correction, these differences were only visible between IG and CG (*t*=-2.973; *p*=0.009; η^2=0.631). Similarly, there were differences between group in post intervention moment (*p*=0.004). After *Bonferroni* correction, these differences were only observed between IG and CG (*t*=-3.253; *p*=0.003; η^2=0.756). There were also differences between moments in IG (pre ≠ post; *Bonferroni* corrected: *t*=3.031; *p*=0.007; *W*=0.656).

Considering 6-minute walk test, there were differences between groups at the intermediate moment (*p*≤0.001). After *Bonferroni* correction, these differences were only observed between IG and CG (*t*=3.747; *p*=0.001; η^2=1.003). Similarly, there were differences between groups at post intervention moment (*p*=0.037). After *Bonferroni* correction, these differences were only detected between IG and CG (*t*=2.541; *p*=0.033; η^2=0.461).

10.4. Discussion

Taking this introductory approach into consideration, the present non-randomized experimental study aimed to assess the effects of 24-week exercise program on functional capacity, dementia/cognitive function, and QoL in individuals with IDD. Up to our knowledge, this is the first study to evaluate the effects of a physical exercise program on the evaluated variables, considering the two different contexts.

10.4.1. Quality of life

After the intervention with exercise program, we found significant differences in Physical Well-being when comparing the OG with the CG. Our results indicate that an intervention with outdoor physical exercise has a significant impact on Physical Well-being, when compared with the CG. On the other hand, analysing the dispersion measures of the IG at the post-intervention moment, the values also seem to have increased, showing that any of the interventions seem to increase the perception of Physical Well-being.

Besides being a low-cost and accessible intervention for all socioeconomic statuses, this interaction between outdoor/nature and physical health in the general population has demons (Thompson Coon et al., 2011). Although the significant differences concern general well-being ($p \leq 0.001$), a meta-analysis carried out by Brito et al. (2022) also demonstrated better outcomes for OG. An outdoor intervention seems to be more effective in promoting Physical Well-being, in agreement with the ecological dynamic framework given that exploration and involvement in nature affordance promote well-being (Araújo et al., 2019). That benefits can be explained by the synergies of the benefits of physical exercise and the benefit of interaction with nature.

On the other hand, for an impact on all factors of QoL its seems other multidisciplinary approaches or interventions are needed that, combined with a physical exercise intervention, have a direct impact on the remaining factors of QoL (Pérez-Cruzado & Cuesta-Vargas, 2016). Individuals with IDD prefer to choose sedentary lifestyles activities rather than engage in physical activity, exercise, or a regular sport practice. Support and guidance provided to this population should be reviewed and based on self-determination theory (Deci & Ryan, 1985), to encourage their practice/choice.

10.4.2. Dementia/Cognitive function

After a 24-week intervention with exercise, there were no significant differences in the dementia/cognitive function score between groups and moments. However, analysing the dispersion measures of the groups at post-intervention moment, the values seem to have increased in the IG (providing indications that an IG program may reduce the risk of onset of dementia/cognitive function). In the population with IDD, there is little investigation of this subjective relationship because, so far, there is no validated questionnaire for this population. The tool used in this study, although also used in previous studies may not be adapted to the population under study, and the lack of significant results may be justified by this. However, our literature review indicates that physical exercise may be related to some variables on the MMSE subscales, in other words, associated with dementia/cognitive function (Ptomey et al., 2018). Several authors associate the practice of physical exercise with brain development, namely the frontal and temporal area, due to the cortical activity it incites, derived from the state of excitability, affecting brain plasticity, promoting the production of angiogenesis, neurotrophies, synaptogenesis and neurotransmitters such as serotonin, noradrenalin and dopamine, a process that may justify this apparent relationship (Corbett et al., 2013). Additional, in the intervention programs no task was assigned that directly focused on the MMSE subscales (orientation; registration; attention and calculation; recall; language; complex commands), and a multi-task exercise intervention should be considered in future studies.

10.4.3. Functional Capacity

There were differences between groups post intervention for the 30 seconds chair stand, namely between the IG and CG and differences between the initial and final moment in the IG. Although not significant, the OG also showed a slight improvement in post-intervention values. Our results show that an intervention with physical exercise, namely using weight-training equipment, seems to be effective in improving the strength and resistance of the lower limbs. The results for the study sample, confirm previous results, where exercise was associated with improved muscle strength/endurance were associated with moderate-to-large average effect sizes (g=0.777, p<0.001) (Kapsal et al., 2019). Another meta-analysis com 351 participants that showed an strong effect when comparing the EG to the CG, standard mean difference = 0.86, 95% CI [0.30, 1.42] (St. John et al., 2020).

Regarding the Timed up and go test, there are differences between groups at the intermediate moment between IG and CG. Likewise, there was a difference between groups post intervention between IG and CG. There was also a difference between moments in the IG (pre ≠ post; *Bonferroni* corrected: p=0.007; η^2=1.31). Like what happened in the 30 seconds chair stand, an intervention with physical exercise, namely using weight-training equipment, may significantly impact the mobility, namely speed, agility and dynamic balance. Our results are in accordance with a previous systematic review, where the authors mentioned that physical exercise is a good method to promote the variable in focus (Bartlo & Klein, 2011).

For the 6-minute walk test, there are differences between groups at the intermediate moments only between IG and CG. Likewise, there were differences between groups post intervention only between IG and CG. For this test, the differences found are the same as in the other two functional tests, showing that an indoor exercise program can be effective in promoting cardiorespiratory capacity. The 6-minute walk test was performed outdoors, so the temperature was not controlled. Since the third assessment moment occurred during a hot week in Portugal, the inexistence of significant differences between moments and the decrease in the values of the dispersion measures can be explained by this fact and not by the existence of some gap in the prescription of the intervention programs (intensity adjusted according to the recommendations (ACSM, 2021).

Although there were no significant differences, the OG dispersion measures also seems to have been promoted post-intervention. For a sample where sedentary behaviours prevail and there is low adherence to physical exercise, the assessment and prescription of adapted exercise in any context seems to promote physical fitness and functional capacity. This improvement in physical fitness and functional capacity has a direct impact on the successful performance of activities of daily living (Bartlo & Klein, 2011) and consequent QoL (Schalock & Verdugo, 2002). On the other hand, the inexistence of significant results in physical fitness in OG can be justified with the difficulty in controlling the training intensity, namely the participants associating the perceived effort to a numerical scale. Likewise, gripping the TheraBand can also be performed in different ways by the participants (with hands nearer or farther apart), thus creating different tensions, which may have influenced the results.

10.4.4. Adverse effects

Some adverse events were recorded such as: muscle pain and fatigue resulting from the prescribed intensity. On rest days, these participants were referred to the physiotherapy office.

10.4.5. Strengths and limitations

The strength of our study is that it provides two fully available exercise programs that seem to be effective and may mitigate/attenuate the barriers this population has to exercise. To the best of our knowledge, this is the first experimental study with physical exercise that relates the variables studied to the IDD population, in different practice contexts. Knowing that exercise is beneficial to the general population, we did not want to advise against it to the GC, whatever activities they may have performed may have influenced our results. The inclusion of various levels of IDD in the groups and the fact that the exercise sessions were only conducted by two accredited instructors may also have limited our results. The quality/quantity of support provided in explanation, demonstration, support, and feedback is not the same for all individuals, leading to the fact that the rest time between sets may have been longer than prescribed.

For future studies, we suggest monitoring the quantity of physical activity practiced by all study participants (e.g., accelerometers; International Physical Activity Questionnaire), nutrition, and medication intake. The prescription of physical exercise with cognitive stimulation tasks or multidisciplinary interventions (physical exercise plus: cranial electrotherapy stimulation; socialization; health education; educational advice) should be prescribed in the future, to reach more robust conclusions across the domains of QoL or dementia/cognitive function. Future studies should also ensure that all stakeholders are blinded to interventions and/or assessments. They should also try to include a larger sample, so as not to limit the conclusions, as well as carry out a follow-up to see if the effects of the intervention were maintained, or what happened in the long term. We recommend that all assessments be performed in a laboratory setting, so that as many variables as possible (e.g., temperature, humidity) are controlled. Similarly, we suggest investigating the effects of sports practice on all the variables assessed in this study, that the prescribed exercises may be varied throughout the intervention program, and that other motivational interventions take place (e.g., games).

10.5. Conclusion

An outdoor, low-cost intervention in contact with nature seems to be effective in improving Physical Well-Being. None of the interventions showed significant differences for the variable dementia/cognitive function. Finally, an indoor intervention using weight-training machines seems to be a good method to promote functional capacity and physical fitness.

Knowing that the study of QoL of individuals with IDD has been the object of study by several researchers, the results of the present experimental study justify the importance of regular physical exercise for this population.

Chapter 11 – Effects of 24-week exercise program on anthropometric, body composition, metabolic status, cardiovascular response, and neuromuscular capacity in individuals with Intellectual and Developmental Disabilities (study 10)

Jacinto, M., Matos, R., Monteiro, D., Antunes, A., Caseiro, A., Gomes, B., Campos, M.J.C., & Ferreira, J.P. (2023). Effects of a 24-week exercise program on anthropometric, body composition, metabolic status, cardiovascular response and neuromuscular capacity, in individuals with Intellectual and Developmental Disabilities. *Frontiers in Physiology*, 14:1205463. https://doi.org/10.3389/fphys.2023.1205463.

11. Abstract

The prevalence of overweight and obesity has increased in the last decades, including in people with IDD. This is even more concerning when it is globally accepted that a low physical condition contributes to the deterioration of functionality and increases the risk of developing chronic diseases during life, with effective implications for health and well-being. The aim of the present study is to investigate the effects of two physical exercise intervention programs on institutionalized individuals with IDD. Twenty-one adults with IDD (43.04 ± 11.18 years) were split by convenience into three groups: i) an indoor training group (IG; N=7; 24-week machine-based gym intervention), ii) an outdoor training group (OG; N=7; 24-week outdoor intervention with low-content materials), and iii) a CG (N=7). Assessed outcomes included indicators of health and neuromuscular capacity. The *ShapiroWilk* (n<50) and *Levene tests* were used to verify data normality and homoscedasticity. A *Kruskal-Walli test* was performed to understand if there were differences between the groups. For comparison purposes and to assess hypothetical differences between groups, the *Wilcoxon signed-rank test* and the *Friedman test* were used. The respective effect size was calculated, and the significance level was defined at 0.05. There was a difference in fat mass in OG (initial ≠ intermediate; Bonferroni corrected: t=2.405; p=0.048; W=0.08 and initial ≠ final moments; Bonferroni corrected: t=2.405; p=0.048; W=0.08). Indoor intervention programs seem to be more effective than outdoor intervention programs for reducing heart rate rest (t=-2.912; p=0.011; W=-0.104) when compared with CG. A low-cost outdoor intervention in contact with nature appears to be more effective for fat mass reduction. The results for HRV are not clear and robust. Finally, an indoor intervention using weight-training machines appears to be a good method to promote neuromuscular capacity.

Keywords: cardiorespiratory training, health variables, indoor training, outdoor training, resistance training, strength capacity.

11.1. Introduction

IDD is defined as a deficit in intellectual and adaptive functioning in the conceptual, social, and practical domains, which can be identified with mild, moderate, severe, and profound degrees and develops before 22 years old (Schalock et al., 2021). Several studies show that this population has a higher prevalence of hypertension, obesity, hypercholesterolemia, diabetes type II, and metabolic syndrome compared to the disabled population (Krause et al., 2016). At the same time, studies show that hypertension, dyslipidemia, obesity, diabetes, and impaired glucose metabolism are associated with lower HRV (Coopmans et al., 2020; Maciorowska et al., 2020). In individuals with IDD, the functioning of the autonomic nervous system seems to be impaired (Zwack et al., 2021), as well as low HRV values (Chang et al., 2012), which can be related to high blood glucose levels that lead to damage to peripheral nerve fibers, increasing sympathetic activity and decreasing parasympathetic activity (Chang et al., 2012; Font-Farré et al., 2021). All these comorbidities are considered cardiovascular and metabolic risk factors, which, in turn, are associated with an increased risk of premature death (O'Leary et al., 2018).

To decrease the risk of cardiovascular and metabolic diseases, medications are often prescribed (O'Dwyer et al., 2016), increasing healthcare spending instead of adopting healthy and active lifestyles. Besides being inactive, people with IDD are a mostly sedentary population (Dairo et al., 2016), not complying with recommendations for health maintenance or gains (WHO, 2020). The latest recommendations are for adults to participate in at least 150-300 mins of moderate-intensity physical activity per week or 75-150 mins of vigorous-intensity physical activity per week. Individuals with IDD should also participate in exercise sessions that focus on flexibility, aerobic capacity, and endurance that involve all major muscle groups on at least two days per week (ACSM, 2021) for the maintenance/development of functional independence.

As a result of an inactive and sedentary lifestyle, it is thus evident that individuals with IDD have reduced values in all physical fitness, including strength (Borji et al., 2014; Wouters et al., 2020). Similarly, this loss of muscle strength is strongly associated with a decline in physical and functional capacity (Carmeli et al., 2012), health, and life expectancy (Zghal et al., 2019). Muscle strength has been associated with cardiovascular risk, showing that higher levels of strength are associated with decreased waist WC and triglycerides in children, adolescents, and adults (De Lima et al., 2021). In fact, the higher levels of upper and lower muscle strength observed in adults are associated with a lower risk of mortality (Garcia-Hermoso et al., 2020). On the other hand, regular exercise has been shown to be an effective method for improving functionality, cardiorespiratory capacity, mobility, performance in activities of daily living and mental health, and decreasing the risk of cardiovascular and metabolic diseases (Jacinto, et al., 2021a; Jacinto, et al., 2021b; Obrusnikova et al., 2021).

One of the reasons found in the literature for increased physical inactivity and sedentary lifestyles in individuals with IDD is the existence of barriers to promoting regular practice, namely the lack of adapted exercise programs for individuals with IDD, limited financial resources, and a lack of places to exercise (Jacinto, et al., 2021c). On the other hand, there is a scarcity of research, little clarity in intervention protocols, or diverse methodologies that approach the applicability of non-pharmacological, psychologica,l and psychosocial interventions, such as exercise programs for the improvement of the health-related variables that may be related to cardiovascular and metabolic diseases (Sheehan et al., 2014).

The prescription and implementation of exercise programs that decrease the mentioned barriers to practice become fundamental to achieving clinically demonstrated and significant health benefits in the variables (Bartlo & Klein, 2011). On the other hand, in addition to promoting the practice and adherence to exercise programs, it may delay the functional and physical decline of individuals with IDD, which begins around the age of 40-50 years old, which, combined with improved medical and health care, may promote QoL (Schalock et al., 2002).

To our knowledge, this will be the first study to prescribe and implement exercise programs in different contexts, assessing their impact on several aspects of physical health and fitness. It is an attempt to present an effective strategy/tool for decreasing barriers to physical exercise and promoting these variables. Therefore, the present non-randomized experimental study aimed to assess the effects of two 24-week exercise programs (indoor and outdoor/low cost) on anthropometric, body composition, metabolic status, cardiovascular response, and neuromuscular capacity in institutionalized individuals with IDD. For the present study, the following hypotheses were defined: i) the indoor group (IG) significantly improved all variables assessed after a 12-week exercise program; ii) the IG significantly improved all variables assessed after a 24-week exercise program; iii) Compared to the outdoor group (OG), the IG significantly improved all variables assessed after a 12-week exercise program; iv) Compared to the OG, the IG significantly improved all variables assessed after a 24-week exercise program; v) Compared to the CG, IG significantly improved all variables assessed after a 12-week exercise program; vi) Compared to CG, IG significantly improved all variables assessed after a 24-week exercise program; vii) OG significantly improved all variables assessed after a 12-week exercise program; viii) OG significantly improved all variables assessed after a 24-week exercise program; ix) Compared to IG, OG significantly improved all variables assessed after a 12-week exercise program; x) Compared to IG, OG significantly improved all variables assessed after a 24-week exercise program; xi) Compared to CG, OG significantly improved all variables assessed after a 12-weeks exercise program; xii) Compared to CG, OG significantly improved all variables assessed after a 24-week exercise program.

11.2. Methods

11.2.1. Research design

This study follows a non-randomized experimental design, according to the Helsinki Declaration (World Medical Association, 2013) and (Harris et al., 2019) and the Standards for Ethics in Sport and Exercise Science Research was approved by the Ethics Committee of the Faculty of Sport Sciences and Physical Education - University of Coimbra, with the approval code CE/FCDEF-UC/00872021. All subjects and their families were informed of the purpose and methods of the experimental methodology and signed an informed consent form. The total methodology was presented in a preliminarily published study protocol (Ferreira et al., 2022).

11.2.2. Participants

The experimental study recruited adults volunteer, institutionalized in a support Institution, placed in Leiria. Inclusion criteria were defined as 1) adults with IDD; 2) no medical contraindications for adherence to a physical activity program; 3) 18 years old or older; 4) participants diagnosed with mild, moderate, or severe IDD diagnosis (DS inclusive); 5) successful in performing movements such as pulling/pushing; and 6) the ability to carry out the intended assessments. Exclusion criteria were defined as 1) subjects who can not commit for 24 weeks; 2) subjects with other associated pathologies; 3) incapacity to walk unassisted; 4) profound IDD; 6) inability to communicate; and 7) failure to provide a duly signed informed consent form.

Due to the characteristics of this population and logistical constraints inherent in the development of intervention studies, the sample consisted of the first 21 participants who agreed to participate in the program, aged between 18 and 65 years (10 females, 11 males, *M* age = 43.04; *SD*=11.18 years old). A power analysis (calculated using G*Power, version 3.1.9.7 (Faul et al., 2007) showed that a sample of at least 15 was required to detect a medium effect size (*ES*) of 0.5 (α = .05, $1 - \beta$ = 0.95) using a repeated-measures analysis of variance (*ANOVA*), in agreement with some previous studies (Cicone et al., 2018; Fujita et al., 2021). An effect size of 0.5 was chosen given that this value was confirmed from studies that explored the effects of exercise on the variables of interest in our study (Bartlo & Klein, 2011; Obrusnikova et al., 2021; St. John et al., 2020).

11.3. Materials/Instruments

11.3.1.1. Anthropometry

Portable stadiometer seca (model 870) scale was used to measure body weight and height. BMI was calculated using the weight (kg)/height (m^2) formula and the WC was assessed with a flexible measuring tape directly on the skin from the middle of the iliac crest and the tenth rib. All these methods were viable, reliable, and accurate for IDD participants (Casey, 2013; Oppewal & Hilgenkamp, 2018; Temple et al., 2010; Wouters et al., 2017).

11.3.1.2. Body composition

A bioelectrical impedance device (InBody770) was used to measure body composition, being a viable, reliable, and non-invasive method (Havinga-Top et al., 2015; Patusco et al., 2018; Wouters et al., 2017). The variables that were assessed were WC, body weight, BMI, fat mass, and muscle mass.

11.3.1.3. Metabolic status

To assess metabolic status, blood samples were collected (glycemia, cholesterol, and triglycerides) by accredited specialists using the venous point technique (WHO, 2010). The results were analyzed in a certified laboratory and sent by email to the main study investigator.

11.3.1.4. Cardiovascular response

The digital sphygmomanometer Omron Digital Blood Pressure Monitor HEM-907 (Omron Healthcare Europe BV, Matsusaka, Japan) was used to measure hemodynamic parameters such as resting blood pressure (systolic (SBP) and diastolic (DBP)) and resting heart rate (HRrest). Before data collection, participants remain completely at rest for five minutes, legs uncrossed, back and arms supported without talking and/or moving (Muntner et al., 2019). Two measurements were taken with an interval of 1-2 min and the average of these readings was recorded. If the values deviate ≥ 5 mmHg, a third measurement was taken (Muntner et al., 2019). Measurements were taken in the morning after breakfast, and participants were instructed to avoid caffeine, exercise, and smoking at least 30 min before the measurement (Muntner et al., 2019).

HRV was also measured according to Proietti et al. (2017) and Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology (1996) guidelines, with the Polar ProTrainer (Kempele, Finland). Participants had the sensor on their chest under the pectoralis major muscle. Participants were instructed to sit comfortably in a chair, keep their eyes open, breathe quietly, and avoid movement during data collection. The test took 10 min in a quiet, silent, and low-light environment. After the test was completed, the data was downloaded via *the Polar Flow Web Service* as ".txt" files and exported for analysis using the *Kubios HRV* software (Kubios HRV, Biomedical Signal Analysis Group, Department of Applied Physics, University of Kuopio, Finland) (Tarvainen et al., 2014). The RR intervals corresponding to the first 2 mins were discarded (stabilization period) and data from the next 5 mins was used to calculate HRV. The following items were calculated in the time domain: i) mean RR (mean of the RR intervals in ms); ii) SDNN (standard deviation of RR intervals in ms); iii) RMSSD (root mean square of consecutive RR intervals in ms); and iv) pNN50 (percentage of successive RR intervals that differ by more than 50 ms). The following items were calculated, in the frequency domain: i) LF (absolute power of the low-frequency band, 0.04–0.15 Hz, in ms2); ii) HF (absolute power of the high-frequency band, 0.15–0.4 Hz, in ms2; iii) ratio of LF-to-HF power (LF/HF).

11.3.1.5. Neuromuscular capacity

Neuromuscular capacity (peak torque) was measured using an isokinetic dynamometer (BIODEX Multijoint System 3 Pro), which is reliable for the target population (Pitetti, 1990), by testing maximal concentric knee flexion and knee extension at an angular velocity of 60 and 120 °/s. Equipment calibration was performed before the assessment session according to the manufacturer's instructions (Biodex Medical Systems, Inc., 2000).

A manual dynamometer was used to perform a handgrip test to assess upper limb strength measurement. The test reliability and validity were confirmed by Cabeza-Ruiz et al. (2019) and Oppewal and Hilgenkamp (2020) and the protocol used was recommended in the *Brockport Fitness Test Manual* (Winnick & Short, 2014).

The "3kg medicine ball throw test" was used (Harris et al., 2011) to assess the muscular power of the upper limbs since it is a valid and reliable test for people with IDD (Aertssen et al., 2018; Lencse-Mucha et al., 2015; Tatar, 2018; Wouters et al., 2017). The participant was seated in a chair with the ball held close to their chest. At the starting signal, the participant threw the ball, using a chest pass, as far as possible.

11.3.2. Procedures

All the participants were assessed at the Faculty of Sport Sciences and Physical Education - University of Coimbra, using specific and valid test protocols to assess individuals with IDD. The space was large and isolated, the temperature was controlled, and each stage of the assessment was organized as comfortably and privately as possible for all participants. The researchers provided information about the procedures and objectives for each test and were available to answer questions at any time.

During the exercise program, three assessments were carried out (initial, week -1; intermediate, week 12; final, week 24). To minimize procedural differences, tests were carried out always using the same research team. Additionally, all assessments were carried out in a controlled environment, in the morning, after fasting, due to the specific characteristics of the participants and their medication needs.

Participants were allocated to one of the three groups: i) IG with sessions carried out in a gym, using weight machines; ii) OG with outdoor sessions using low-cost materials; and iii) CG with participants continuing to do their normal activities. Interventions with physical exercise were based on a 24-week combined exercise program offered twice a week for approximately 45 mins each session. The exercise program was conducted following the guidelines recommended by the ACSM (Bayles, 2023). The attendance of the participants was calculated, revealing that the IG and OG showed attendance average values of 78% and 76%, respectively. The CG participants were encouraged to continue their usual lifestyle throughout the period of 24 weeks.

11.3.3. Intervention

All the exercise sessions were conducted and supervised by two instructors who had graduated in sports science with expertise regarding people with disabilities, specifically those with IDD. Both instructors encouraged participants to complete their exercise sessions and provided instruction and demonstration. Feedback was adjusted to assure correction and safety during the execution of the exercises. In both interventions, all sessions were structured following the phases: warm-up (5 to 7 min), the main part of the session (aerobic plus resistance exercise, 33 to 35 min), and static stretches or return to calm (5 min), with a progressive load method. Participants from both groups were encouraged to conduct their daily activities as usual besides the intervention and to maintain the same nutritional pattern/diet.

11.3.3.1. Indoor training program

The indoor exercise program was carried out in a gym using weight machines for resistance training (Table 26).

11.3.3.2. Outdoor training program

The outdoor exercise program was carried out in a natural environment near the institution (Table 27). Natural environments are defined, for the purpose of this experimental study, as "any outdoor spaces with elements of nature, from pure or semi-natural areas to urban green or blue spaces, including green infrastructure" (Brito et al., 2022).

11.3.4. Statistical Analysis

Descriptive statistics including mean and standard deviation were calculated for the studied variables. Normality and homoscedasticity data were verified by *Shapiro–Wilk* (n<50) and *Levene* tests. Thus, a *Kruskal–Wallis* test was performed to understand if there were differences between groups. The *Wilcoxon* signed-rank test and *Friedman* test were used for the comparison and identification of possible differences in each group. Both these tests are non-parametric *ANOVAs* and were adjusted for small sample testing. The multiple comparison test used the *Bonferroni* correction (i.e., alpha level/ number of tests) to avoid error Type I (Ho, 2014). The effect size η^2 (suitable for the *Wilcoxon* test, allowing comparison of two paired groups) was calculated and the assumed reference values were: "small" effect ≥ 0.01, "medium" effect ≥ 0.3, and "large" effect ≥ 0.5 (Cohen, 1988; Fritz et al., 2012). Therefore, *Kendall's W* effect size (suitable for the *Friedman* test, allowing comparison of two paired groups) was calculated and the assumed reference values were as follows: "small" effect ≥ 0.01, "medium" effect ≥ 0.3, and "large" effect ≥ 0.5 (Cohen, 1988; Fritz et al., 2012). The significance level for rejecting the null hypothesis was set at 5% and the analysis was performed in IBM SPSS.

11.4. Results

Table 43 presents descriptive statistics, namely, group means and standard deviation values regarding anthropometry and body composition values (initial, intermediate, and final assessments).

Table 43. Global sample descriptive for the anthropometry and body composition values

	IG			**OG**			**CG**		
	Mean ± standard deviation								
	initial	**intermediate**	**final**	**initial**	**intermediate**	**final**	**initial**	**intermediate**	**final**
WC (cm)	93.18 ± 12.95	93.04 ± 12.12	92.45 ± 11.92	90.37 ± 16.72	89.52 ± 16.49	89.42 ± 16.49	93.55 ± 15.81	93.28 ± 16.56	95.57 ± 18.15
Body weight (kg)	73.87 ± 11.75	73.41 ± 12.08	73.35 ± 11.33	75.21 ± 19.86	74.44 ± 19.3	73.55 ± 18.81	73.27 ± 18.19	73.4 ± 18.86	73.65 ± 18.71
BMI (kg/m^2)	28.82 ± 5.53	28.81 ± 5.67	29.5 ± 5.57	30.34 ± 8.7	30 ± 8.42	29.65 ± 8.24	28.24 ± 6.87	28.27 ± 7.12	28.41 ± 7.02
Fat mass (kg)	27.08 ± 11.31	25.87 ± 11.83	28.5 ± 11.83	30.11 ± 17.87	29.08 ± 17.52	28.62 ± 17.06	27.22 ± 14.09	26.78 ± 14.7	27.69 ± 14.55
Muscle mass (kg)	25.74 ± 4.16	26.28 ± 3.88	26.02 ± 4.07	24.78 ± 5.08	25.04 ± 4.88	24.85 ± 4.8	25.2 ± 3.97	25.48 ± 4.06	24.93 ± 4.35

Note: BMI: body mass index; IG: indoor group; OG: outdoor group; CG: control group; WC: waist circumference.

Table 44 presents the descriptive statistics for the cardiovascular response, taking into consideration the three assessments for the three groups.

Table 44. Global sample descriptive for cardiovascular response

	IG			**OG**			**CG**		
	Mean ± standard deviation								
	initial	**intermediate**	**final**	**initial**	**intermediate**	**final**	**initial**	**intermediate**	**final**
SBP (mm Hg)	116.71 ± 10.85	112.71 ± 15.17	102.67 ± 16.44	127.57 ± 12.52	119.57 ± 13.16	116.43 ± 12.89	129 ± 28.15	128.43 ± 27.79	128.43 ± 29.38

DBP (mm Hg)	73.29 ± 7.85	76.43 ± 7.32	76 ± 10.11	81.71 ± 15.76	78.57 ± 13.17	79.14 ± 9.24	84.86 ± 8.68	85.29 ± 9.81	87 ± 10.23
HRrest (mm Hg)	66.71 ± 7.97	70 ± 10.34	66.71 ± 8.86	76.14 ± 18.06	76 ± 16.98	74.14 ± 19.29	80 ± 12.91	82.57 ± 9.18	85 ± 8.83
Mean RR (ms)	878.80 ± 147.99	616.29 ± 156.34	837.84 ± 198.43	832.30 ± 181.12	843.21 ± 160.34	779.56 ± 227.09	722.30 ± 132.17	608.320 ± 116.10	512.91 ± 353.87
SDNN (ms)	39.27 ± 14.36	43.55 ± 30.53	40.28 ± 25.98	40.28 ± 25.98	45.65 ± 31.95	32.76 ± 21.67	27.61 ± 17.17	29.99 ± 17.68	28.2 ± 14.69
Mean HR (ms)	69.76 ± 10.53	101.94 ± 21.24	74.48 ± 14.7	75.7 ± 19.96	73.82 ± 16.63	82.42 ± 22.44	85.08 ± 12.95	101.29 ± 16.53	92.12 ± 16.4
RMSSD (ms)	27.76 ± 10.77	15.75 ± 9.2	23.68 ± 14.59	29.21 ± 15.29	33.23 ± 27.98	19.63 ± 15.36	20.17 ± 20.81	15.84 ± 16.8	17.12 ± 16.07
pNNxx (%)	7.73 ± 8.55	1.01 ± 1.35	8.07 ± 14.25	10.51 ± 10.66	11.19 ± 15.92	5.36 ± 10.79	2.2 ± 5.29	2.83 ± 6.93	2.84 ± 6.95
LF log	5.6 ± 1.17	4.76 ± 1.63	5.32 ± 1.16	5.96 ± 1.19	5.87 ± 1.78	5.68 ± 1.57	5.12 ± 1.27	4.88 ± 1.36	4.55 ± 1.96
HF log	5.12 ± 1.13	3 ± 1.53	4.79 ± 1.40	5.47 ± 1.59	4.79 ± 2.44	4.24 ± 1.63	4.57 ± 1.58	2.57 ± 1.89	3.73 ± 1.97
LF n.u.	57.96 ± 21.67	80.75 ± 21.63	63.26 ± 10.9	57.94 ± 27.75	62.53 ± 23.8	77.74 ± 12.64	60.41 ± 23.59	76.09 ± 16.64	57.82 ± 28.09
HF n.u.	41.87 ± 21.81	19.16 ± 21.51	36.7 ± 10.88	41.87 ± 21.81	37.45 ± 23.79	22.21 ± 12.62	39.51 ± 23.52	23.78 ± 16.52	31.99 ± 16.14
LF/HF ratio	2.05 ± 1.61	8.77 ± 6.48	1.89 ± .69	4.18 ± 6.2	3.27 ± 3.67	6.14 ± 5.69	3 ± 3.31	5 ± 3.72	2.57 ± 2.7

Note: IG: indoor group; OG: outdoor group; CG: control group; SBP: systolic blood pressure; DBP: diastolic blood pressure; HR_{rest}: heart rate rest; mean RR: mean of the RR intervals; SDNN: standard deviation of RR intervals; RMSSD: root mean square of consecutive RR intervals; pNN50: percentage of successive RR intervals that differ by more than 50 ms; LF: absolute power of the low-frequency band, 0.04–0.15 Hz, in ms^2; HF: absolute power of the high-frequency band, 0.15–0.4 Hz, in ms^2; LF/HF.

Through the collection of blood tests, the variables blood glucose, cholesterol, and triglycerides were analyzed in two different assessments (initial and final). The descriptive statistics values for metabolic status are presented in table 45.

Table 45. Global sample descriptive for metabolic status.

	IG		OG		CG	
	Mean ± standard deviation					
	initial	**final**	**initial**	**final**	**initial**	**final**
Glycemia (mg/dL)	84.28 ± 17.06	85.5 ± 13.85	102.71 ± 24	100.85 ± 24.63	101.71 ± 30.4	100.57 ± 31.74
Cholesterol (mg/dL)	174 ± 42.27	170.07 ± 45.38	207.85 ± 35.96	201.85 ± 31.29	188.71 ± 51.11	191.1 ± 69.75
Triglycerides (mg/dL)	120.42 ± 42.16	127.83 ± 53.2	124.14 ± 51.83	123.71 ± 50.82	167 ± 99.96	166.71 ± 109.01

Note: IG: indoor group; OG: outdoor group; CG: control group.

In table 46, it can be observed the mean and standard deviation values of the neuromuscular capacity variables, namely the peak torque of both lower limbs at 60 º/s and 120 º/s.

Table 46. Global sample descriptive of the neuromuscular capacity variables.

	IG			OG			CG		
	Mean ± standard deviation								
	initial	intermediate	final	initial	intermediate	final	initial	intermediate	final
PT cc KE 60º/s right (N.M)	67.35 ± 30.88	78.7 ± 40.24	76.7 ± 16.65	64.24 ± 59.59	82.65 ± 64.77	73.78 ± 65.44	45.41 ± 23.01	57.57 ± 22.71	49.98 ± 33.37
PT cc KE 60º/s left (N.M)	81 ± 25.47	80.84 ± 28.76	91.4 ± 27.36	69.7 ± 68.7	67.1 ± 67.22	76.92 ± 59.33	53.85 ± 26.49	59 ± 31.04	46.5 ± 35.1
PT cc KF 60º/s right (N.M)	37.5 ± 22.47	37.95 ± 26.17	37.85 ± 13.21	33.34 ± 30.31	46 ± 38.69	37.14 ± 38.2	14.32 ± 8.66	21.31 ± 7.88	17.27 ± 11.88
PT cc KF 60º/s left (N.M)	43.62 ± 22.31	51.48 ± 21.58	49.5 ± 8.82	31.6 ± 28.82	41.64 ± 34.5	37.64 ± 33.86	18.02 ± 11.91	23.5 ± 12.95	15.41 ± 9.5
PT cc KE 120º/s right (N.M)	55.48 ± 23.76	58.82 ± 32.45	61.57 ± 17.14	50.42 ± 56.22	60.31 ± 51.35	53.18 ± 53.99	36.22 ± 11.39	36.98 ± 21.11	40.95 ± 23.5
PT cc KE 120º/s left (N.M)	60.84 ± 26.77	59.14 ± 26.89	68.7 ± 23.35	51.31 ± 58.71	55.82 ± 55.39	54.92 ± 51.13	41.5 ± 15.2	38 ± 22.32	48.15 ± 32.25
PT cc KF 120º/s right (N.M)	32.65 ± 13.93	34.02 ± 20.06	30.52 ± 9.71	28.11 ± 31.29	34.28 ± 32.14	31.27 ± 37.70	10.15 ± 7	14.38 ± 7.92	18.48 ± 7.70
PT cc KF 120º/s left (N.M)	30.85 ± 21.27	39.42 ± 24.95	38.67 ± 4.78	27.32 ± 29.77	27.87 ± 28.99	29.14 ± 31.64	12.26 ± 6.45	18.62 ± 16.26	17.7 ± 6.22
3kg medicine ball throw (m)	2.36 ± 0.68	2.6 ± 0.55	2.6 ± 0.36	2.3 ± 1.21	2.6 ± 1.33	3.2 ± 1.83	2.14 ± 0.68	2.1 ± 0.62	1.9 ± 0.73
manual dynamometer (kg)	24.02 ± 4.08	25.25 ± 5.76	26.05 ± 5.63	20.27 ± 10.25	20.68 ± 11.59	24.28 ± 11.37	15.9 ± 5.49	15.52 ± 5.6	15.01 ± 5.84

Note: IG: indoor group; OG: outdoor group; CG: control group; PT: peak torque; cc: concentric; KE – knee extension; KF: knee flexion.

Table 47, it can be observed the differences between groups and assessments for anthropometry and body composition.

Table 47. Difference between groups and assessments for anthropometry and body composition values.

	IG			OG			CG			intermediate				final				
	Median (interquartile range)																	
	initial	**intermediate**	**final**	**initial**	**intermediate**	**final**	**initial**	**intermediate**	**final**	t^a	df^a	p^a	**Pairwise comparisons (groups)**[b,c]	t^a	df^a	p^a	**Pairwise comparisons (groups)**[b,c]	**Pairwise comparisons (moments)**[b,c]
WC (cm)	89.5 (24.5)	90.4 (22.7)	90.5 (22)	96 (36)	95 (35.4)	97 (34)	91.6 (30.1)	90.4 (32.2)	92 (36)	.139	2	$p>0.05$	d	.248	2	$p>0.05$	d	d
Weight (kg)	76.9 (18.2)	77.3 (22.4)	78.4 (22)	75.5 (35.4)	73 (33.7)	71.9 (29.6)	72 (34.1)	72 (36.5)	69.3 (40.9)	.002	2	$p>0.05$	d	.030	2	$p>0.05$	d	d
BMI (kg/m^2)	29.3 (7.3)	30 (16.5)	29.55 (6.8)	29.2 (19.1)	28.8 (18.5)	28.1 (17.8)	26.5 (13.2)	26.5 (13.4)	25.5 (14.3)	.141	2	$p>0.05$	d	.119	2	$p>0.05$	d	d
Fat mass (kg)	29 (23.6)	29.5 (24.8)	30.8 (24.6)	27.3 (29.9)	26.7 (30.2)	25.2 (28.1)	25 (22.6)	23.3 (22.7)	29.35 (26)	.247	2	$p>0.05$	d	.035	2	$p>0.05$	d	**initial ≠ intermediate (OG); initial ≠ final (OG)**
Muscle mass (kg)	24.4 (6.4)	26 (5.2)	25.2 (5.35)	23.5 (10.9)	24.6 (8.5)	23.7 (8.6)	24.9 (7.7)	25.2 (8.1)	24.3 (9.5)	.23	2	$p>0.05$	d	.459	2	$p>0.05$	d	d

Note: IG: indoor group; OG: outdoor group; CG: control group; *t*: test statistic; *df*: degrees of freedom; a: *Kruskal–Wallis*; b: *Friedmann*; c: *Bonferroni correction*; d: No differences detected.

No significant statistical differences were found for the anthropometry and body composition variables between groups at the initial assessment as well as at both the intermediate and final assessments.

A significant difference was found between assessments for fat mass on OG (OG (initial ≠ intermediate; Bonferroni corrected: t=2.405; p=0.048; W=0.08 and initial ≠ final; Bonferroni corrected: t=2.405; p=0.048; W=0.08).

Table 48, it can be observed the differences between groups and assessments for cardiovascular response.

Table 48. Difference between groups and assessments in capacity for cardiovascular response

	IG			OG			CG			intermediate				final				
	Median (interquartile range)																	
	initial	**intermediate**	**final**	**initial**	**intermediate**	**final**	**initial**	**intermediate**	**final**	t^a	df^a	p^a	**Pairwise comparisons (groups)**[b,c]	t^a	df^a	p^a	**Pairwise comparisons (groups)**[b,c]	**Pairwise comparisons (moments)**[b,c]
SBP	113	105 (28)	105 (44)	121.5	124 (23)	120 (23)	115	119.5 (42)	113.5	1.523	2	$p>0.05$	d	3.117	2	$p>0.05$	d	initial ≠ final

(mm Hg)	(25)			(25)			(67)		(43)									(IG and OG)
DBP (mm Hg)	70 (12)	77.5 (14)	77 (18)	77.5 (43)	80 (43)	79 (27)	80.5 (24)	81.5 (28)	83 (15)	2.338	2	*p*>0.05	d	3.904	2	*p*>0.05	d	d
HRrest (mm Hg)	67.5 (15)	68.5 (13)	64 (14)	67.5 (11)	68.5 (10)	68 (17)	85 (18)	86 (14)	88.5 (14)	4.611	2	*p*>0.05	d	8.516	2	*p*=0.014	1≠3 (*t*=-2.912; *p*=0.011	initial ≠ final (CG)
Mean RR (ms)	865.06 (208)	538.83 (302.84	745.89 (317.46)	879.15 (240.81)	880.50 (193.02)	782.94 (349.02)	659.47 (89.74)	566.68 (97.45)	621.09 (614.38)	6.865	2	*p*>0.05	d	5.432	2	*p*>0.05	d	pré ≠ intermediate (IG)
SDNN (ms)	35.45 (31.12)	36.86 (61.21)	36.12 (24.48)	32.64 (53.4)	37.08 (55.95)	30.40 (36.63)	24.86 (33.35)	37.43 (32.41)	26.51 (25.96)	1.091	2	*p*>0.05	d	1.455	2	*p*>0.05	d	d
Mean HR (ms)	69.47 (16.10)	111.36 (44.45)	80.47 (26.39)	68.25 (18.89)	68.15 (14.62)	77.63 (32.08)	91.01 (11.54)	105.97 (18.16)	95.7 (19.18)	6.865	2	*p*>0.05	d	3.948	2	*p*>0.05	d	pré ≠ intermediate (IG)
RMSSD (ms)	31.57 (16.6)	17.94 (14.13)	19.99 (23.11)	31.32 (24.44)	32.79 (37.04)	19.2 (23.39)	12.05 (18.18)	10.04 (17.44)	11.25 (14.52)	3.792	2	*p*>0.05	d	2.071	2	*p*>0.05	d	d
pNNxx (%)	8.92 (15.66)	.78 (2.31)	1.91 (15.25)	8.59 (20.47)	9.63 (20.3)	1.85 (10.02)	0 (3.75)	0 (4.78)	0 (4.64)	2.994	2	*p*>0.05	d	2.712	2	*p*>0.05	d	d
LF log	5.89 (2.11)	5.5 (3.47)	5.36 (2.3)	5.56 (2.30)	6.24 (3.67)	6 (2.45)	5.37 (2.44)	4.94 (2.74)	4.62 (2.71)	2.226	2	*p*>0.05	d	1.922	2	*p*>0.05	d	d
HF log	5.39 (.49)	3.51 (3.45)	4.88 (2.69)	5.84 (2.59)	5.77 (3.12)	4.01 (2.08)	4.26 (1.56)	2.71 (4.29)	4.1 (2.06)	3.703	2	p>0.05	d	1.477	2	p>0.05	d	initial ≠ intermediate (IG)
LF n.u.	63.38 (44.14)	89.54 (14.70)	66.07 (13.28)	53.57 (46.25)	74.47 (38.45)	69.28 (26.26)	62.95 (53)	78.71 (17.41)	72.04 (31.79)	3.614	2	p>0.05	d	3.058	2	p>0.05	d	d
HF n.u.	36.58 (44.14)	10.44 (14.53)	33.91 (13.36)	36.58 (44.14)	25.51 (38.44)	30.53 (26.26)	37.03 (52.93)	21.21 (17.4)	27.57 (26.74)	3.614	2	*p*>0.05	d	3.703	2	*p*>0.05	d	d
LF/HF ratio	1.73 (2.62)	8.57 (8.03)	1.95 (1.12)	1.15 (6.25)	2.91 (2.92)	2.26 (11.71)	1.69 (5.39)	3.71 (4.41)	2.57 (2.16)	3.614	2	*p*>0.05	d	3.058	2	*p*>0.05	d	d

Note: IG: indoor group; OG: outdoor group; CG: control group; *t*: test statistic; *df*: degrees of freedom; a: *Kruskal–Wallis*; b: *Friedmann*; c: *Bonferroni correction*; d: No differences detected; SBP: systolic blood pressure; DBP: diastolic blood pressure; HR_{rest}: heart rate rest; mean RR: mean of the RR intervals; SDNN: standard deviation of RR intervals; RMSSD: root mean square of consecutive RR intervals; pNN50: percentage of successive RR intervals that differ by more than 50 ms; LF: absolute power of the low-frequency band, 0.04–0.15 Hz, in ms2; HF: absolute power of the high-frequency band, 0.15–0.4 Hz, in ms2; LF-to-HF power (LF/HF).

At the initial and intermediate assessments, there were no significant differences between groups for the blood pressure and HRV variables ($p \geq 0.05$). Significant statistical differences were found between groups for the HRrest variable ($p=0.014$) at the final assessment. After

Bonferroni correction, these differences were observed between IG and CG (*t*=-2.912; *p*=0.011; *W*=-0.104). There were also significant differences between assessments when considering the CG (initial ≠ final moment; *Bonferroni* corrected: *t*=-2.405; *p*=0.048; *W*=0.17)

There was a significant difference between assessments in the SBP variable in the IG (initial ≠ final moment; *Bonferroni* corrected: *t*=2.454; *p*=0.042; *W*=0.08) and in the OG (initial ≠ final; *Bonferroni* corrected: *t*=2.405; *p*=0.048; *W*=0.08). Considering DBP, there was a difference between initial and final assessments in the CG (*Bonferroni* corrected: *t*=2.405; *p*=0.048; *W*=0.08). Regarding the mean RR variable, there was a significant difference between assessments in the IG (initial ≠ intermediate; *Bonferroni* corrected: *t*=2.598; *p*=0.028; *W*=0.09). There are differences between assessments in the IG for the mean RR variable (initial ≠ intermediate; *Bonferroni* corrected: *t*=-2.598; *p*=0.028; *W*=0.09). Similarly, there was a significant difference between assessments in the IG regarding the HF log (initial ≠ intermediate; *Bonferroni* corrected: *t*=2.405; *p*=0.048; *W*=0.08).

In Table 49, it can be observed the differences between groups and assessments for metabolic status.

Table 49. Difference between groups and assessments for metabolic status.

	IG		**OG**		**CG**		**final**				
	Median (interquartile range)						t^a	df^a	p^a	**Pairwise comparisons (groups)**[b,c]	**Pairwise comparisons (moments)**[b,c]
	initial	**final**	**initial**	**final**	**initial**	**final**					
Glycemia (mg/dL)	89 (32)	85 (8.5)	98 (29)	94 (23)	87 (53)	83 (53)	*1.172*	*2*	*p*>0.05	d	d
Cholesterol (mg/dL)	171 (65)	177.5 (66)	199 (66)	192 (64)	170 (78)	202 (118)	*1.795*	*2*	*p*>0.05	d	d
Triglycerides (mg/dL)	132 (49)	141 (87)	113 (95)	100 (86)	180 (167)	145 (173)	*.453*	*2*	*p*>0.05	d	d

Note: IG: indoor group; OG: outdoor group; CG: control group; *t*: test statistic; *df*: degrees of freedom; a: *Kruskal–Wallis*; b: *Wilcoxon*; c: *Bonferroni correction*; d: no differences detected.

Considering metabolic status, there were no differences between groups and assessments.

In addition, in table 50, it can be observed the differences between groups and assessments for metabolic status.

Table 50. Difference between groups and assessments for neuromuscular capacity.

	IG			OG			CG			intermediate				final				
	Median (interquartile range)																	
	initial	**Intermediate**	**final**	**initial**	**intermediate**	**final**	**initial**	**intermediate**	**final**	t^a	df^a	p^a	**Pairwise comparisons (groups)**^{b,c}	t^a	df^a	p^a	**Pairwise comparisons (groups)**^{b,c}	**Pairwise comparisons (moments)**^{b,c}
PT cc KE 60º/s right (N.M)	59.8 (42.50)	79 (63.90)	74.85 (23.80)	55.2 (73.40)	67.3 (76)	75.8 (61.8)	51.1 (43.70)	62.7 (30.60)	55.5 (71.10)	1.3	2	$p>0.05$	d	1.670	2	$p>0.05$	d	d
PT cc KE 60º/s left (N.M)	73.2 (49.80)	78 (56.90)	80.35 (30.10)	44.7 (72.50)	50.2 (82)	53.9 (54.80)	58.6 (38.20)	57.9 (59)	49.6 (60.20)	2.131	2	$p>0.05$	d	4.736	2	$p>0.05$	d	d
PT cc KF 60º/s right (N.M)	35.3 (27.90)	35.3 (39.90)	34.2 (21.60)	20.5 (44.50)	49.6 (47.30)	25.5 (41.10)	16.35 (14)	23 (12.10)	18.9 (25)	2.703	2	$p>0.05$	d	5.818	2	$p>0.05$	d	d
PT cc KF 60º/s left (N.M)	38.2 (17.60)	41.85 (13.33)	51.15 (13.77)	16 (34.65)	34.7 (37.38)	23.4 (33.42)	16.4 (24.05)	27.2 (26.88)	18.3 (11.98)	6.772	2	$p=0.034$	1≠3 ($t=2.585$); $p=0.029$	9.943	2	$p=0.007$	1≠3 ($t=3.145$); $p=0.005$	d
PT cc KE 120º/s right (N.M)	48.9 (49.78)	51 (-.06)	57.15 (29.15)	24.95 (49.25)	40.9 (47.45)	33.45 (43.45)	31.65 (18.66)	29.75 (32.60)	35.5 (25.73)	2.072	2	$p>0.05$	d	4.282	2	$p>0.05$	d	d
PT cc KE 120º/s left (N.M)	35.7 (42.90)	42.9 (27.40)	59.6 (45.20)	14 (53.20)	29.7 (36.25)	24.8 (25)	36.7 (26.05)	41.3 (39.55)	47.7 (44.45)	2.503	2	$p>0.05$	d	4.059	2	$p>0.05$	d	d
PT cc KF 120º/s right (N.M)	23.1 (19.65)	23.1 (11.85)	28.1 (7.75)	16 (36.90)	35.2 (34.15)	8.5 (33.20)	11.2 (12.45)	15.6 (9.8)	17.9 (10.90)	5.28	2	$p>0.05$	d	2.900	2	$p>0.05$	d	d
PT cc KF 120º/s left (N.M)	23.3 (33.60)	29.6 (14.15)	36.5 (6)	6.8 (31.15)	24.7 (25.60)	13.4 (28.85)	11.3 (8.35)	15.6 (34.1)	17.3 (11.05)	3.631	2	$p>0.05$	d	7.577	2	$p=0.023$	1≠3 ($t=2.627$); $p=0.026$	d
3kg medicine ball throw (m)	2.12 (.93)	2.4 (.70)	2.45 (.73)	1.7 (1.47)	1.95 (1.15)	2.45 (1.58)	2.38 (1.01)	2.3 (.91)	2.07 (1.23)	1.52	2	$p>0.05$	d	4.766	2	$p>0.05$	d	initial ≠ final (IG) – $t=-2.887$; $p=0.012$; initial ≠ final (OG) – t=-

																	3.074; *p*=0.006; initial ≠ final (CG) – *t*=2.539; *p*=0.033
manual dynamometer (kg)	23.05 (7.67)	31.35 (10.48)	24.85 (9.90)	16.3 (11.77)	16.5 (16.38)	21.8 (17.83)	13.9 (8.70)	14.5 (11)	13.1 (10.40)	5.106	2	*p*>0.05	d	6.593	2	*p*=0.043	1≠3 (*t*=2.413); *p*=0.047	initial ≠ final (IG) – *t*=-3.175; *p*=0.004; initial ≠ final (OG) – *t*=-2.94; *p*=0.01; intermediate ≠ final (OG) – *t*=-2.673; *p*=0.023;

Note: IG: indoor group; OG: outdoor group; CG: control group; *t*: test statistic; *df*: degrees of freedom; a: *Kruskal–Wallis*; b: *Friedmann*; c: *Bonferroni correction*; d: No differences detected.

Considering neuromuscular capacity, there were no significant differences between groups and assessments for concentric knee extension at 60 °/s for the right and left sides, concentric knee flexion at 60 °/s for the right side, concentric knee extension at 120 °/s for the right and left sides, and concentric knee flexion at 120 °/s for the right side. Considering the intermediate assessment, there was a difference between the IG and CG for concentric knee flexion at 60 °/s for the left side (after *Bonferroni correction*: t=2.585; p=0.029; W=0.09). Regarding the final assessment, there was a difference between the IG and CG (after *Bonferroni correction*: t=3.145; p=0.005; W=0.11). Differences were also found between groups in the concentric knee flexion at 120 °/s left side test when considering the final assessment (IG ≠ CG; *Bonferroni correction*: t=2.627; p=0.026; η^2=0.329).

At the initial assessment, no differences were found between groups in the 3 kg medicine ball throw test ($p \geq 0.05$). Similarly, there was no difference between the intermediate and final assessments. Considering assessments, there were significant differences in the IG (initial ≠ final; *Bonferroni corrected*: t=-2.887; p=0.012; *W=0.1*), OG (initial ≠ final; *Bonferroni corrected*: t=-2.887; p=0.012; *W=0.10*), and CG (initial ≠ final; *Bonferroni corrected*: t=2.59; p=0.033; *W=0.09*), respectively.

Regarding the hand grip force test, there were no differences between groups at the initial and intermediate assessments. Differences were found between groups at the final assessment (p=0.043). After *Bonferroni correction*, these differences were only observed between the IG and CG (t=2.413; p=0.047; W=0.08). There were also statistical differences between assessments in the IG (initial ≠ final; *Bonferroni corrected*: t=-3.175; p=0.004; W=0.02) and the OG (initial ≠ final; *Bonferroni corrected*: t=-2.94; p=0.01; W=0.10 and intermediate ≠ final; *Bonferroni corrected*: t=-2.673; p=0.023; W=0.09).

11.5. Discussion

The present non-randomized experimental study aimed to assess the effects of 24-week exercise programs on health indicators and neuromuscular capacity in individuals with IDD. To our knowledge, this is the first study to evaluate the effects of an exercise program on the evaluated variables, considering the different contexts. A low-cost outdoor intervention appears to be effective in reducing fat mass and an indoor intervention seems to be a good method to develop neuromuscular capacity. Thus, we partially accept the hypotheses i, ii, v, vi, vii, and viii.

11.5.1. Anthropometry and body composition

No significant differences were found between groups for all variables. However, the fat mass decreased in the OG for both the intermediate and final assessments when compared to the initial assessment. Although the differences were not significant, this group (OG) also showed a decrease in WC after 12 weeks of training, reducing BMI and increasing muscle mass (12 and 24 weeks). The outdoor intervention seems to be more effective for promoting body composition changes. Intervention studies in the IDD population, besides being limited, have different approaches and lack meta-analysis studies to identify which exercise prescription has the greatest effects on the variables assessed. A possible justification for the lack of significant differences in the remaining variables of body composition may be due to the fact that variables such as diet/calorie intake were not controlled in the present study, although being known that the average value of calories intake is higher in the IDD population (Hoey et al., 2017). Also, individuals with IDD (namely DS) have been shown to have total energy expenditure values lower than those without disability (Ohwada et al., 2021; Polfuss et al., 2018), which negatively affects the ratio of caloric intake to energy expended (Polfuss et al., 2018). Future approaches should take the balance of calorie intake (nutrition) and energy expenditure (physical activity and basal metabolism) into consideration, in the sense that intake should not exceed expenditure. In addition, family members/guardians/caregivers often overestimate the amount of energy expended through physical activity and the amount they should ingest, contributing to overrating the individual's energy needs (Segal et al., 2016). At the same time, they will also be able to provide food support according to the needs/quantities identified. A multidimensional (exercise + diet), literate approach for family/guardians/caretakers/individuals with IDD themselves should be considered in future studies.

Furthermore, a 24-week exercise program with a twice-a-week frequency may not be enough to produce changes in body composition. In this sense, future studies should implement a longer duration program or have a higher weekly frequency as suggested by Yu et al. (Yu et al., 2022). Their study found significant differences in BMI (initial vs final moment: 28.16 ± 3.69 vs 27.5 ± 3.97; CG: 27.37 ± 3.99 vs 28.05 ± 3.75) using a 36 week program (2 sessions per week). However, despite exercising two or three times per week, IDD individuals may still exhibit high rates of sedentary behaviour, compromising the positive impact of a physical exercise program.

The fact that the amount of daily life physical activity practiced outside the intervention programs was not measured and, specifically for the CG, may also have influenced the results and may explain the lack of significant differences. For more robust results, it is suggested that future studies quantify the daily physical activity of all participants in the study throughout the intervention program (e.g., using accelerometers, pedometers; and IPAQ) (Ptomey et al., 2017).

Future studies should also analyse gender differences.

11.5.2. Metabolic status

Taking into account metabolic status there were no significant differences between groups and assessments, similar to the results found by (Boer & Moss, 2016), where the authors also prescribed and implemented two different interventions for two groups: continuous aerobic training or interval training three times a week for 12 weeks. The lack of significant differences in glycemia and triglycerides can be explained by the fact that these values were already within the normative standards. As for the cholesterol values, which were high in the OG, it was possible to observe a reduction with exercise, although it was not significant and far from the reference values. Aerobic interval training is a good method for promoting a change in these variables in the IDD population (Boer et al., 2014), so future studies implementing the two training programs used for this study (indoor and outdoor) should increase the duration of the first bout of exercises, or only perform the shuttle run. (Calders et al., 2011) when prescribing a combined exercise program, found a significant difference in cholesterol variables. However, they prescribed more aerobic exercise volume than in the present study, which may be crucial for the positive effects.

11.5.3. Cardiovascular response

After 24 weeks the IG and OG decreased SBP, showing that both the intervention programs performed were beneficial for improving the risk factors of cardiovascular disease. Similarly, Boer and Moss (2016) when prescribing an interval exercise program found a significant difference in SBP at the final intervention (initial vs final: 124 ± 10 mm Hg vs 113 ± 8 mm Hg; CG: 118 ± 10 mm Hg vs 119 ± 10 mm Hg). The practice of any method of physical exercise seems to enhance the reduction of SBP.

Compared to the CG, the intervention in the gym environment seems to have been more effective in reducing HRrest. Moreover, a previous meta-analysis highlighted that resistance training is an effective method for reducing HRrest (Reimers et al., 2018). The fact that, for the IG, the control of the intensity for the aerobic exercise followed a more objective method can explain the higher impact of the exercise program on the HRrest of the IG compared to the OG. A significant increase in HRrest after 24 weeks was also observed in the CG. The effect only occurs over a few months on a mean of three months with three sessions per week. In addition, the age of the participants may be negatively associated with a decrease in exercise-induced HRrest (Reimers et al., 2018). Furthermore, a high HRrest rate increases mortality for all causes by 17% (Aune et al., 2017). The mechanisms of this relationship are still not completely known. Possible mechanisms may be endothelial dysfunction, reduced artery compliance and distensibility, and, consequently, increased arterial wall stress and elevated pulse wave velocity, which is associated with increased afterload and systemic hypertension (Tadic et al., 2018). It is important that assessments and interventions should always take place at the same time since the time of the day has a considerable influence on heart rate patterns (Waninge et al., 2013).

Significant differences were found in increasing mean HR and decreasing mean RR and HFlog in the IG after 12 weeks. A higher state of excitation on the data collection dates or some performed activity of higher intensity that was not controlled/reported before data collection may have influenced the results. The literature shows that a change in mean RR may demonstrate that training induces bradycardia at rest accompanied by an increase in cardiac vagal modulation. Through this mechanism, physical training may be able to exert an antiarrhythmic effect (G. R. H. Sandercock et al., 2005), however, such results were not found in the present study. Furthermore, individuals with IDD may present autonomic dysfunction and HRV values lower than in populations without disability (Chang et al., 2012), which may be influenced by factors such as obesity, low physical fitness, and age (Mendonca et al., 2013). We also highlight the fact that all participants in this study had SDNN values lower than 50 ms, which is related to a higher risk of cardiovascular diseases (Kleiger et al., 2005).

11.5.4. Neuromuscular capacity

Significant differences were found between groups, at the intermediate assessment, namely for knee concentric flexion peak force at 60 º/s and for the left side test. Differences were also found at both intermediate and final assessments, between the IG and CG. Additionally, significant differences were also found between groups for knee concentric flexion peak force at 120º/s left test, at the final assessment. The results are in agreement with the study by (Ko et al., 2012), where the authors also found significant differences in the left lower limb. Such results may be related to hypothetical differences in strength between dominant and non-dominant limbs. Furthermore, the authors also found a significant difference in the extension test for both limbs, something that did not occur in our study as only a slight difference was observed. Additionally, Cowley et al. (2011) found improvements in the bilateral flexor and extensor tests when prescribing an exercise program of only resistance training. Compared to our prescription, the author prescribed the load as a function of 10 maximum repetitions for each exercise. Although a slight increase was seen, the OG showed no significant differences in strength gains when comparing by groups or assessment times. Compared to the CG, the OG seemed to be more effective in increasing the isokinetic force of the hamstring muscles.

At the same time, there were no differences at the intermediate and final assessments. Considering the 3kg medicine ball throw test, there was a difference only between the initial and final assessments in all groups. For the manual dynamometer test, there were differences between the IG and the CG at the final assessment. In the same way, the OG significantly improved the results in all assessments, and the IG improved at the last assessment. The combined exercise program seems to have been fundamental for these results as a previous study found no benefit in terms of strength of the upper limbs when using a continuous or an interval aerobic exercise intervention program (Boer & Moss, 2016). These results are important as muscle strength is an important variable in the functionality, success in performing activities of daily living, and independence of individuals with IDD (Cowley et al., 2010).

11.5.5. Adverse effects

A few adverse events were registered including muscle pain and fatigue as a result of the defined intensity value. On rest days, those participants were sent to the physiotherapy office.

11.5.6. Strengths and limitations

Our study presents two exercise programs that appear to be effective and can mitigate/attenuate the barriers that this population has to exercise and being active. These two programs can be implemented by any institution/organization, taking into consideration the economic and environmental possibilities, and seem to be feasible for any individual with IDD. The OG exercise program can also be performed with body weight only, using bottles with sand or other low-cost materials (Ferreira et al., 2022).

Although our study generally showed promising results, several limitations must be acknowledged when analyzing the results. The lack of monitoring of the amount of physical activity performed by all participants in daily life activities is the main limitation of this study, in the sense that it may have negatively impacted our results. We could not ascertain the impact of exercise on IDD levels because the recruitment institution did not have information regarding all the participants' IQs. The fact that the exercise sessions were conducted by two accredited instructors may also have limited our results, since the quality/quantity of support provided in explanation, demonstration, support, and feedback could not have been the same for all individuals, leading to the fact that the rest time between sets may have been longer than prescribed. Due to logistical constraints and the daily operation of the recruitment institutions, it was not possible to conduct a randomized controlled trial. Finally, the different prescription/control of strength training between the programs does not allow for a clear comparison.

11.6. Conclusion

A low-cost outdoor intervention in contact with nature appears to be effective in reducing fat mass. None of the interventions showed significant differences in the metabolic status variables. Similarly, the difference in cardiovascular response was not clear and robust. Finally, an indoor intervention using weight-training machines seems to be a good method to promote neuromuscular capacity.

Our study presents two comprehensive exercise programs that appear to be effective and may mitigate/attenuate the barriers that individuals with IDD face when attempting to engage in sports, namely the lack of tailored exercise programs and the high financial cost of practice.

Chapter 12 – An overview of the effects of physical exercise programs on individuals with Intellectual and Developmental Disabilities (global discussion and final considerations; study 11)

Jacinto, M., Ferreira, J.P., Monteiro, D., Antunes, R., Campos, M.J., & Matos, R. (2023). An overview of the effects of physical exercise programs on individuals with Intellectual and Developmental Disabilities (global discussion and final considerations). *Motricidade*. https://doi.org/10.1007/10.6063/motricidade.30665.

12. An overview of the effects of physical exercise programs on individuals with Intellectual and Developmental Disabilities (global discussion and final considerations)

IDD is characterized by a deficit in intellectual and adaptive functioning in the conceptual, social, and practical domains, being identified in profound, severe, moderate, and mild degrees, developing before the of 22 years old (Schalock et al., 2021). Although the average life expectancy of these individuals has been increasing in recent years (Dieckmann et al., 2015), they still experience shorter longevity when compared to individuals without IDD (Glover et al., 2017; Heslop & Glover, 2015; McCallion & McCarron, 2014). In addition, they age prematurely, much due to the complications of the disability itself (Coppus, 2013), as well as health problems such as mental health or multimorbidity (Cooper et al., 2015; Hermans & Evenhuis, 2014; Timmeren et al., 2017). The continuous need for medical care, acquisition of medication, among others, also results in high financial costs for their health (Anderson et al., 2013; Krahn & Fox, 2014; Lunsky et al., 2018).

On the other hand, sedentary lifestyles are prevalent in this population, as well as low engagement in physical activity practices (Dairo et al., 2016), failing to meet the guidelines suggested by Bull et al. (2020). This sedentary lifestyle and low engagement in active practices does not promote desirable physical fitness. Several studies indicate that individuals with IDD have low levels of physical fitness (Borji et al., 2014; Chow et al., 2018; Gawlik et al., 2016), which increases the risk of developing other comorbidities, including metabolic and cardiovascular diseases (Winter et al., 2012a). However, one of the reasons reported in the literature for this lifestyle is the presence of barriers to promote of physical activity. In order to identify these barriers, Jacinto et al. (2021c) conducted a systematic review, updating a previously published one (Bossink et al., 2017), aiming to carry out a specific survey of the barriers, analyzing whether it was decreasing or increasing compared to the last study. More specifically, the main barriers to physical activity perceived by individuals with IDD, their families, caregivers/technicians, or even from the perspective of project leaders, can be systematized into personal (6 barriers found), family (4 barriers found), social (13 barriers found), financial (1 barrier found), and environmental (1 barrier found) factors. All these barriers (25) had already been mentioned in a previously published systematic review (Bossink et al., 2017). However, the total number of perceived barriers to physical activity by individuals with IDD decreased, compared to the barriers perceived in the previous published review. This fact may presume a baseline work carried out, with strategies and recommendations, to promote the practice of physical activity.

Although there are several barriers for individual with IDD to promote physical activity, it is agreed that any increase in physical activity or structured exercise for a person who has a sedentary and inactive lifestyle increases the chances of having positive physiological improvements and consequent QoL. In individuals with IDD, the adoption of active lifestyles and regular exercise seem to positively affect physical capacities (strength, aerobic, balance and flexibility), their overall health, as well as their QoL (Bartlo & Klein, 2011; Calders et al., 2011). On the other hand, knowing that one of the barriers to physical activity in this population is the lack of adapted exercise programs (Jacinto et al., 2021c), there is a need for studies that for the assessment and prescription of physical exercise adjusted for individuals with IDD and which training method best meets simultaneously their needs and the purpose of the exercises. This information is a useful tool for promoting physical exercise among individuals with IDD, reducing this identified barrier.

Since this population has a relatively high BMI and WC values (de Winter et al., 2012b; Ramos-Jiménez et al., 2014; Vancampfort et al., 2020) and aiming to identify the most effective type of training to promote this previously mentioned variable (related to metabolic and cardiovascular diseases), a systematic review with meta-analysis was conducted. For the BMI, performing an exercise program seems to have positive effects (p=0.049), with strength training being the most effective (Z=1.197 and p=0,231). On the other hand, for the WC variable, an exercise program also seems to have positive effects on the promotion of the variable (p=0.001), with cardiorespiratory training being the most effective (Z=3.092 and p=0.002). However, the small number of studies included in the meta-analysis does not allow for more robust and concrete conclusions. In the same way, studies in the population without disabilities are also unclear. Skrypnik and collaborates (2015), no significant differences were found between the different training methods. In turn, Garrow and Summerbell (1995), state that cardiorespiratory training reduces fat mass, but with little effect on the preservation of muscle mass. In that sense, Willis et al. (2012) concludes that it is the most effective training method for reducing body mass (cardiorespiratory training). On the other hand, strength training, in addition to increasing muscle mass, can improve energy expenditure and lipid oxidation rates (Hunter et al., 2000). In turns, combining strength training with cardiorespiratory training in the same session has shown to be a good method to increase muscle mass and reduce fat mass (Ho et al., 2012).

Considering the literature review, none of the training methods were discarded, in the sense that both have their potentials. A combined exercise program (cardiovascular fitness and strength in the same training session) may be the method with the most wide-ranging benefits for the population in question. In this sense, for the prescription of exercise programs specific for individuals with IDD, a literature review of strength and cardiorespiratory training intervention studies was carried out.

When considering strength exercise programs results, and besides the increases in upper and lower limb strength, balance and fat-free mass, salivary immunoglobulin concentration, testosterone levels, plasma leptin levels, tumour necrosis factor alpha and interleukins, there is an improvement in the response to systemic inflammation and antioxidant defence system, as well as a decrease in fat mass and WC and oxidative damage. Most studies implemented an exercise program lasting for 12 weeks, three times a week, and with session lengths ranging from 45 to 60 minutes. The exercise program included two to three sets, six to 12 repetitions (per exercise or maximums), six to seven exercises, focusing on the main muscle groups (such as chest press, low row or lat pull-down, elevation, abduction or shoulder press, and abdominals due to their different variants, flexion of the forearm, the extension of the forearm, and leg extension/leg curl/leg press). This exercise program is performed using weight-training equipment, to avoid the use of free weights, for safety reasons (Jacinto et al., 2021b).

In the same way, cardiorespiratory exercise programs seem to promote an improvement in physical capacity, lipid, hemodynamic and metabolic profile, body composition, neuromuscular and cognitive capacity. Most of the studies included in the systematic review were of 8 to 12 weeks duration, with a frequency of 3 weekly sessions, with a session length of 20 to 60 minutes. The intensity of the sessions is mostly prescribed according to the maximal heart rate (50% to 80%) or peak oxygen consumption (70% to 80%). The most often used cardiorespiratory exercises are walking/running (a cycle ergometer can also be used as a resource) or cycling.

Along with the ACSM guidelines (2021), the above results represent a useful tool, including aspects and recommendations that professionals should consider when structuring, defining and implementing a strength, a cardiorespiratory or combined training program. For a population where a sedentary and inactive lifestyle, early aging, and with several associated comorbidities prevail, the recommendations presented are essential to promote QoL by decreasing the risk of onset of chronic diseases, increasing physical fitness levels and to reduce perceived barriers to practice. Therefore, it is essential to implement this type of exercise programs into the routine of this population, which, when associated with an appropriate lifestyle, promotes a decrease in clinical expenses, an increase in healthy aging, and better general health and QoL.

It is recommended that exercise professionals have an understanding in prescribing programs in an adapted and effective way, in terms of methods, structure, and duration of the sessions. At the same time, professionals also need a thorough knowledge of each of the individuals, their comorbidities, limitations and abilities, and preferences before prescribing any type of exercise program.

Since there is a research gap regarding the most appropriate exercise programs for the IDD population based on the previous results, as well as on the ACSM (2021) and on the CERT recommendations (Slade et al., 2016), two exercise programs were structured and developed. These intervention training programs aim to ensure that the high financial cost of the practice would not be another barrier to exercise (Jacinto et al., 2021c). Monetary barriers may be an obstacle to promoting physical exercise and with the outdoor program (low cost) however no financial or costly investment is needed, since it can be performed in an outdoor space, using only body weight, recycled materials (plastic bottles with sand) or low-cost materials (TheraBand’s and ankle shin guards).

The indoor physical exercise program was carried out in a gym with weight machines. The program was divided into four parts: Part I - playful games or shuttle run (5 to 7 minutes); Part II - aerobic training (treadmill; 10 minutes; 40% to 80% of Heart Rate Reserve; between 12 to 17 according to the Borg RPE Scale (Borg, 1982); between 5 to 8 according to the Borg CR-10 Scale (Borg, 1998); Part III - strength training (around 25 minutes; Leg Press + Chest Press + Leg Extension + Lat Pull Down + Leg Curl + Shoulder Press; 40-80% of 3RM; 10-15 reps; 2-3 sets); Part IV - 4 static stretching exercises (30 to 60 seconds each).

The outdoor physical exercise program was carried out in a natural environment near the institution. Natural environments, which for the purpose of this experimental study are defined as "any outdoor spaces with elements of nature, from pure or semi-natural areas to urban green or blue spaces, including green infrastructure" (Silva et al., 2018). The program was divided into four parts: Part I - playful or shuttle run (5 to 7 minutes); Part II - aerobic training (walking; 10 minutes; 40% to 80% of Heart Rate Reserve; between 12 to 17 according to the Borg RPE Scale (Borg, 1982); between 5 to 8 according to the Borg CR-10 Scale (Borg, 1998); Part III - strength training (more or less 25 minutes; Sit to stand from the chair + TheraBand's; Low row + TheraBand's; Low row + TheraBand's; Sitting unilateral knee extension + shin guards; Chest press + TheraBand's; Standing unilateral knee flexion + shin guards; High row or seated shoulder press + TheraBand's; ≥15 reps depending on the OMNI-RES scale (Robertson et al., 2003); 3 sets); Part IV - 4 static stretching exercises (30 to 60 seconds each). Progression of exercises with changing the resistance of the TheraBand's and shin guards. All the procedures for program assessment and implementation are described in detail in the previously published study protocol (Ferreira et al., 2022). Although there is a clear need to carry out more research on healthy lifestyle interventions for people with more severe levels of IDD (profound IDD), our current intervention is limited to participants with mild to severe IDD, so future studies should take different level of IDD into account. In addition of being adapted to individuals with mild to severe IDD, these programs are accessible to any type of context and financial availability, for both individual and institutions contexts. In addition, the performance of individuals with IDD in these physical exercise programs can contribute to reduce the risk of metabolic and cardiovascular diseases, which decreases healthcare costs and promotes physical fitness, functionality, and QoL.

After development these two programs, an experimental study was conducted aiming to understand if they are effective tools to reduce the barriers that hinder/attenuate the practice. On the other hand, we intend to contribute with a set of recommendations for practice with innovative interventions with physical exercise, and with effective strategies that we believe can positively impact the QoL of individuals with IDD. For that purpose, 21 adults with IDD were recruited and, subsequently, an initial assessment was performed to screen for any chronic disease or other important parameters to be monitored and to identify their initial physical fitness level. According to the results, in addition to low levels of physical fitness, these individuals are at risk of developing metabolic and cardiovascular diseases (according to the existing literature). On the other hand, functional and neuromuscular capacity seems to be associated with a greater perception of QoL, highlighting the importance of an intervention with physical exercise, to promote these variables. This initial anamnesis is important, not only for a "check-up", but also for developing a tailored, effective and safe physical exercise program, according to the physiological characteristics of each participant. By performing an adapted and complete anamnesis, besides promoting trust between professionals and participants as well as a mutual knowledge, it also allows us to collect indispensable data for the intervention and to identify signs and symptoms that we need to be aware. We also highlight that this anamnesis must include a sufficiently robust and valid scientific method according to the literature (ACSM, 2021; Jacinto et al., 2021b). This process should be carried out before implementing any strategy to promote QoL in individuals with IDD. The results of the QoL assessment showed incongruence of response, with individuals with IDD perceiving higher values, compared to the responses of the proxies. These results highlight the importance, not only of measuring the QoL perceptions of individuals with IDD through the perceptions of their family members, but also through self-reports, as both are complementary. On the other hand, if self-reports are not considered when planning intervention strategies, it may have a negative impact on the QoL of individuals with IDD.

After this "initial photograph", the 21 participants were divided by convenience into an indoor training group (N=7) performing exercise in a gym with weight-training equipment; an outdoor training group (N=7) using low-cost materials), and a CG (N=14) (continued with their regular activities). Both intervention programs had more than 75% participation and the individuals were able to complete all the proposed exercises at the defined intensity, series, and repetitions. All the exercises proved to be adequate, adjusted, easy to perform, and perfectly adapted to the population under study. An outdoor, low-cost intervention in contact with nature seems to be effective in improving Physical Well-Being and fat mass. Finally, an indoor intervention using weight-training machines seems to be a good method to promote functional capacity, namely on 30 seconds chair stand, timed up and go and 6-minute walk test and physical fitness. None of the interventions showed significant differences for the variable dementia/cognitive function neither for blood sample variables. To our knowledge, this is the first experimental study with exercise that relates the variables studied to the IDD population in different practice environments. Both exercise programs seem to be effective in several variables and may hinder/attenuate the barriers to practice that this population experiences. These two programs can be implemented by any institution/organization, taking into consideration the economic and environmental possibilities. Finally, the results of the experimental study justify the relevance of regular physical exercise tailored to their individual needs.

The use of elastic bands in strength training in the outdoor exercise program has proven to be a difficult equipment to control the intensity, since the individual can hold the band in different ways (with hands closer or further apart, holding the band in different places between sets) creating different tensions, which can influence the results. Some individuals with DID may not have the capacity to associate a scale to the perceived effort and give a response, and the exercise professionals may be able to perceive this intensity through the difficulty of the exercise execution or through the Talk test (ACSM, 2021; Reed & Pipe, 2014). On the other hand, it was evident that the implementation of aerobic and strength exercises, of a more analytical nature, in a gym environment, using equipment, facilitates this control of intensity. The strength exercises performed with the use of machines may avoid some injuries, because they present a lower degree of amplitude and planes. Aiming to perform the exercises at the intended speed of execution, constant monitoring by the exercise professionals is necessary, because this population sometimes can't control the movement in the eccentric phase, performing it immediately.

Considering the institutional context where the sample was recruited, it was not possible to randomize the participants by group. Logistical difficulties made it impossible to have a larger number of participants. Finally, the fact that the amount of physical activity practiced outside intervention programs and caloric intake were not controlled are the main limitations of this thesis, and its results should be considered with caution.

Considering the results of our study, future research that implement these two exercise programs could conduct one session per week of the indoor exercise program and one session per week of the outdoor exercise program. Similarly, the prescription of exercise with cognitive stimulation tasks or multidisciplinary interventions (exercise plus: cranial electrotherapy stimulation; socialization; health education; educational advice) should be object of study in future investigations, to reach more robust conclusions in the domains of QoL and/or dementia/cognitive function. Future studies should ensure that evaluators have no knowledge of which group the participant belongs to, minimizing the risk of bias. Further studies should recruit a larger sample and from other age groups, not to limit the findings, as well as conduct a follow-up to analyse the long-term effects. Similarly, we suggest investigating the effects of sports practice and modalities on all the variables assessed in this study, and control diet and physical activity outside intervention programs.

For this population to change their sedentary and inactive behaviours, there is a need to raise awareness among people with IDD themselves, parents/families/guardians, professionals and institutions/organizations that support this population, educating and empowering with knowledge and healthy and active practices that will contribute to a healthy life and full social participation, namely through regular physical exercise. Both exercise programs can be replicated by all institutions/organizations working with individuals with IDD, being easy to understand and to implement. They were structured based on scientific evidence and seem to be an effective strategy, as they provoked a set of adaptations and benefits, promoting QoL. In addition, it is necessary that the formation of exercise professionals should include contents such as the dimensions of physical exercise for people with IDD, as well as the characterization of physical, physiological, psychological, social and emotional aspects (Jacinto et al., 2022).

The current overview provides relevant information regarding the health benefits of physical exercise in individuals with IDD, proving that structured and adapted exercise programs can be a key aspect for promoting more active and healthier lifestyles, increasing their physical fitness, functional capacity and consequent improvement in QoL.

This document refers to several aspects and benefits that support physical exercise as a basis for QoL in an individual with IDD. It includes recommendations for assessing and prescribing physical exercise for individuals with IDD, as well as two intervention proposals. With this document, the lack of exercise programs adapted to individuals with IDD and the financial cost of the practice may no longer be a barrier. On the other hand, the intervention strategies used in this population need to be revised. The integration of physical exercise into their daily lives is a key aspect to maintain and increase physical fitness and functional capacity and consequent improvement in QoL.

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Appendixes

Appendix 1. Effects of CT programs in people with IDD

Author, year	Variables on which CT had an impact	Group	Main Results (Mean ± SD)		*p* value	*p* value (vs CG)	*p* value (vs other group)
			Pre	Post			
	Outcomes of anthropometry						
	Weight (kg)	CCT	70.2±14.6	69.2±14.6	-	< 0.05	-
		ICT	71.7±8.4	69.4±8.3	-	< 0.05	< 0.05 (vs CCT)
		CG	74.8±8.4	74.1±8.4	-	-	-
	BMI (kg/m2)	CCT	30.6±6.1	30.2±6.3	-	-	-
		ICT	29.3±4	28.5±5	-	< 0.05	< 0.01 (vs CCT)
		CG	31.2±4.6	30.9±4.2	-	-	-
	Outcomes of fitness capacity						
	8-ft up and go (s)	CCT	5.9±1.2	4.8±0.9	-	< 0.05	-
		ICT	5.8±1.9	4.9±1.1	-	-	-
		CG	6.5±1.3	6.2±1.3	-	-	-
	30 seconds chair stand (s)	CCT	13.1±2	15.2±1.8	-	< 0.05	-
		ICT	14.4±2.3	15.5±1.8	-	-	-
		CG	13.1±2.7	13.3±2.3	-	-	-
Boer et al., (2016)	6-minute walk distance (m)	CCT	499±77.5	563.2±74.9	-	< 0.05	-
		ICT	519.7±82.8	562.6±81.7	-	-	-
		CG	476.2±83.5	495.9±85.2	-		-
	Outcome of cardiorespiratory function						
	Peak VO_2 (L/min)	CCT	32.2±7.1	34.4±7.5	-	< 0.05	-
		ICT	31.9±7.9	37.3±7.9	-	< 0.05	< 0.05 (vs CCT)
		CG	32.1±7.1	30.7±6.1	-	-	-
	Time to exhaustion (s)	CCT	700.5±170.2	813.1±79.4	-	< 0.05	-
		ICT	686.8±180.7	845.4±86.3	-	< 0.05	-
		CG	706.8±142	699.1±134.8	-	-	-
	Rel. peak VO_2 (mL/kg/min)	CCT	2200.6±457.5	2312,3±447.3	-	< 0.05	-
		ICT	2267.1±578.9	2578.3±508.3	-	< 0.05	-
		CG	2363.1±533.1	2271.2±499.9	-	-	-
	Ventilatory threshold (L/min)	CCT	67±15.4	80±13.3	-	< 0.05	-

		ICT	67.8±17	88.8±19.4	-	< 0.05	-
		CG	69.9±15.9	72.9±15.2	-		-
			Outcomes of anthropometry				
	WC (cm)	CCT	95.9±9.6	93.4±9.6	-	< 0.05	-
		ICT	95.8±13.1	91.5±13.1	-	< 0.05	-
		CG	95±8.8	95.9±8.2	-	-	-
	Fat (%)	CCT	32.3±7	31.3±6.6	-	< 0.05	-
		ICT	34.2±6.9	30.4±7	-	< 0.05	< 0.05 (vs CCT)
		CG	32±7.1	32±7	-	-	-
			Lipid profile, hemodynamic and metabolic markers				
	Cholesterol (mg/dL)	CCT	162.9±26.6	164±31.3	-	-	-
		ICT	169.8±25.2	154.8±22.9	-	< 0.05	-
		CG	169.6±29.7	171.9±25.8	-	-	-
	HDL (mg/dL)	CCT	48.9±9	49.7±10.6	-	-	-
		ICT	54.9±13.5	59.4±11.4	-	< 0.05	-
		CG	59.3±16.9	55.9±15.6	-	-	-
Boer et al., (2014)	LDL (mg/dL)	CCT	96.4±24.8	97.4±28.5	-	-	-
		ICT	105.2±12.4	95.6±9.3	-	< 0.05	< 0.05 (vs CCT)
		CG	92.6±23.5	96±21.2	-	-	-
	Triglycerides (mg/dL)	CCT	91.5±50.4	87.5±50.3	-	-	-
		ICT	79.2±22.2	70.8±16.7	-	< 0.05	-
		CG	96.6±75.6	95±85.6	-	-	-
	Fasting insulin (IU/mg)	CCT	13±5.3	12±4.7	-	-	-
		ICT	14±5.9	11±4	-	< 0.05	< 0.05 (vs CCT)
		CG	12±3.6	13±3.7	-	-	-
	Homeostasis model assessment of insulin resistance	CCT	2.9±1.3	2.6±1.1	-	< 0.05	-
		ICT	2.9±1.3	2.3±0.8	-	< 0.05	-
		CG	2.6±0.8	2.7±0.9	-	-	-
	Systolic blood pressure (mmHg)	CCT	121±11	119±9	-	-	-
		ICT	124±10	113±8	-	< 0.05	< 0.05 (vs CCT)
		CG	118±10	119±10	-	-	-
			Outcomes of fitness capacity				

	Muscle fatigue resistance (s)	CCT	19.5±9.9	22.5±10.9	-	< 0.05	-
		ICT	13.7±7.5	19.9±6.8	-	< 0.05	-
		CG	21.3±13.8	19.2±11.4	-	-	-
	6-minute walk distance (m)	CCT	538.7±105	619±72.2	-	< 0.05	-
		ICT	598.2±63.6	665.9±69.4	-	< 0.05	-
		CG	567±69.4	591.8±82.7	-	-	-
				Outcome of cardiorespiratory function			
	Peak VO_2 (L/min)	CCT	2.5±0.6	2.4±0.6	-	-	-
		ICT	2.4±0.7	2.6±0.6	-	< 0.05	< 0.05 (vs CCT)
		CG	2.3±0.6	2.2±0.5	-	-	-
	Peak power (w)	CCT	179±42.6	178.7±42.7	-	-	-
		ICT	155±36.6	178.8±41.3	-	< 0.05	< 0.05 (vs CCT)
		CG	166.8±45.7	158.9±46.8	-	-	-
	Ventilatory threshold (w)	CCT	90.3±24.5	98.3±20.3	-	< 0.05	-
		ICT	99.7±25.1	120.6±32.2	-	< 0.05	< 0.05 (vs CCT)
		CG	86.1±27.9	82.9±22.7	-	-	-
	Ventilatory threshold (VO_2)	CCT	1.4±0.3	1.5±0.3	-	< 0.05	-
		ICT	1.6±0.5	1.8±0.5	-	< 0.05	< 0.05 (vs CCT)
		CG	1.2±0.3	1.2±0.3	-	-	-
El Kafy & Helal, (2014)				**Outcome of cardiorespiratory function**			
	Vital capacity (L)	ICT	1.61±0.02	1.72±0.03	< 0.0001	> 0.05	-
		CG	1.63±0.03	1.69±0.36	< 0.0001	-	-
	Forced vital capacity (L)	ICT	1.38±0.02	1.49±0.03	< 0.0001	> 0.05	-
		CG	1.39±0.02	1.48±0.02	< 0.0001	-	-
	Forced expiratory volume (L)	ICT	1.29±0.03	1.39±0.02	< 0.0001	> 0.05	-
		CG	1.28±0.03	1.38±0.02	< 0.0001	-	-
	Peak expiratory flow rate (L/min)	ICT	171.03±1.13	182.3±2.82	< 0.0001	> 0.05	-
		CG	170.29±1.37	180.64±2.76	< 0.0001	-	-
Holzapfel et	Working			**Outcome of cognition**			

al., (2016)	memory	**function**					
		CCT	0.76±1.05	1.65±1.54	< 0.003	< 0.019	-
		Voluntary CG	1.19±1.11	1.06±1.12	> 0.05	-	-
		CG	1±1.34	0.91±1.14	> 0.05	-	-
		Outcome of cognition function					
Holzapfel et al., (2015)	PPT change scores (%) Unimanual right hand	CCT	8.8±18.9	-	-	< 0.007	-
		Voluntary CG	9.9±25.6	-	-	< 0.005	-
		CG	-1.6±38.7	-	-	-	-
	PPT change scores (%) Unimanual left hand	CCT	6.6±17.2	-	-	< 0.006	-
		Voluntary CG	6.2±21.1	-	-	< 0.020	-
		CG	-5.3±19.6	-	-	-	-
	Combined unimanual and bimanual (RLB) score	CCT	16.5±23.3	-	-	< 0.05	-
		Voluntary CG	11.6±26.2	-	-	< 0.034	-
		CG	1.5±68.2	-	-	-	-
	Assembly sub-test	CCT	12.2±14.4	-	-	-	< 0.007 (vs voluntary CT)
		Voluntary CG	5.9±24.4	-	-	-	-
		CG	-2.9±22.8	-	-	-	-
	Cognitive planning ability (measured by the Tower of London test)	CCT	-	-	-	-	< 0.05 (vs voluntary CT)
		Voluntary CG	-	-	-	-	-
		CG	-	-	-	-	-
		Outcomes of anthropometry					
Kim, (2017)	Weight (kg)	CCT	65.6±1.5	61.3±1.6	< 0.05	< 0.05	-
		Half bath group	66.8±1.9	63.1±1.1	< 0.05	-	-
		CG	65.5±1.4	66.1±0.5	-	-	-
	Body fat (%)	CCT	32.3±1.6	27.5±1.1	< 0.05	< 0.01	< 0.01 (vs half bath group)
		Half bath group	3.3±1.5	29.7±1.6	< 0.05	-	-
		CG	32.4±1.1	33.1±1	-	-	-

	Outcome of cardiorespiratory function						
	VO_{2max} (mL/kg/min)	CCT	25.12±1.21	33.07±2.37	< 0.05	-	-
		Half bath group	26.18±1.2	27.07±1.1	> 0.05	-	-
		CG	27.13±1.01	27.05±1	-	-	-
	HR_{max} (beat/min)	CCT	164.51±1.88	171.22±2.77	< 0.05	-	-
		Half bath group	165.87±1.05	167.55±1.4	> 0.05	-	-
		CG	166.77±1.2	166.81±1.04	-	-	-
	Pulse wave velocity (m/sec/height)	CCT	1.63±0.03	1.53±0.06	-	< 0.05	< 0.05 (vs half bath group)
		Half bath group	1.62±0.05	1.57±0.03	-	< 0.05	-
		CG	1.64±0.04	1.64±0.03	-	-	-
Ordoñez et al., (2013)	**Outcomes of anthropometry**						
	Fat mass (%)	CCT	38.9±4	35±3.8	< 0.05	-	-
		CG	-	-	-	-	-
	WC (cm)	CCT	94.7±3.3	91.5±3.1	< 0.05	-	-
		CG	-	-	-	-	-
	Waist-to hip ratio	CCT	1.12±0.01	1±0.01	< 0.05	-	-
		CG	-	-	-	-	-
	Lipid profile, hemodynamic and metabolic markers						
	Plasma leptin levels (ng/ml)	CCT	54.2±6.7	45.7±6.1	< 0.05	-	-
		CG	55.8±6.9	55.4±7	-	-	-
	Outcome of cardiorespiratory function						
	VO_{2max} (mL/kg/min)	CCT	20.2±5.8	23.7±6.3	< 0.01	-	-
		CG	-	-	-	-	-
Ordonez et al., (2014)	**Outcomes of anthropometry**						
	Fat mass (%)	CCT	38.9±4	35±3.8	< 0.05	< 0.05	-
		CG	37.7±3.8	37.8±3.9	-	-	-
	WC (cm)	CCT	94.7±3.3	91.5±3.1	< 0.05	< 0.05	-
		CG	93.5±3.1	93.7±3.2	-	-	-
	Waist-to hip ratio	CCT	1.12±0.0006	1±0.005	< 0.05	< 0.05	-
		CG	1.11±0.005	1.11±0.005	-	-	-
	Lipid profile, hemodynamic and metabolic markers						
	Tumors necrosis factor (pg/ml)	CCT	11.7±1.6	9.2±1.3	< 0.05	< 0.05	-
		CG	11.4±1.5	11.5±1.5	-	-	-

	Interleukin-6 (pg/ml)	CCT	8.2±1.1	6.1±0.9	< 0.05	< 0.05	-
		CG	8.2±1.2	8.3±1.3	-	-	-
	Fibrinogen (g/l)	CCT	3.72±0.48	3.23±0.41	< 0.05	< 0.05	-
		CG	3.74±0.52	3.75±0.52	-	-	-
	High sensitive C-reactive protein (mg/dl)	CCT	0.62±0.11	0.53±0.09	< 0.05	< 0.05	-
		CG	0.6±0.1	0.61±0.1	-	-	-
				Outcome of cognition function			
Ringenbach et al., (2016)	Reaction time	CCT	0.784±0.532	(Δ = -0.234±0.354; Hedges'g = -0.42)	-	< 0.05	-
		Voluntary CG	0.748±0.691	(Δ = -0.02±0.109; Hedges'g = -0.04)	-	-	-
		CG	0.716±0.339	(Δ = -0.051±0.234; Hedges'g = 0.09)	-	-	
	Set-shifting ability	CCT	4.65±2.15	(Δ = 0.47±1.77; Hedges'g = 0.19)	-	-	-
		Voluntary CG	4.25±2.65	(Δ = 1.44±2.39; Hedges'g = 0.57)	-	< 0.05	-
		CG	4.36±2.80	(Δ = 0±0; Hedges'g = 0)	-	-	-
	Response inhibition	CCT	7.94±5.83	(Δ = 1±3.14; Hedges'g = 0.18)	-	-	< 0.05 (vs voluntary CG)
		Voluntary CG	10.31±4.85	(Δ = -1.75±3.57; Hedges'g = -0.32)	-	-	-
		CG	6.27±5.57	(Δ = -1.36±2.91; Hedges'g = -0.25)	-	-	-
	Semantic language fluency	CCT	16.19±9.83	(Δ = 2.47±4.45; Hedges'g = 0.25)	-	< 0.05	-
		Voluntary	16.07±10.27	(Δ = 2.2±3.55;	-	<	-

		CG		Hedges’g = 0.22)		0.05	
		CG	22.4±9.45	(Δ = -1.7±4.83; Hedges’g = -0.17)	-	-	-
Rosety-Rodriguez et al., (2014)				**Outcomes of anthropometry**			
	Fat mass (%)	CCT	38.9±4	35±3.8	< 0.05	-	-
		CG	37.7±3.8	37.8±3.9	-	-	-
	WC (cm)	CCT	94.7±3.3	91.5±3.1	< 0.05	-	-
		CG	93.5±3.1	93.7±3.2	-	-	-
				Lipid profile, hemodynamic and metabolic markers			
	Interleukin-6 (pg/ml)	CCT	8.2±1.1	6.1±0.9	< 0.05	-	-
		CG	8.1±1.2	8.3±1.3	-	-	-
	High-sensitive C-reactive protein (mg/dl)	CCT	0.62±0.11	0.53±0.09	< 0.05	-	-
		CG	0.6±0.1	0.61±0.1	-	-	-
				Outcome of cardiorespiratory function			
	VO_{2max} (mL/kg/min)	CCT	20.2±5.8	23.7±6.3	< 0.05	-	-
		CG	20.4±5.5	20.6±5.7	-	-	-

BMI – Body mass index; CCT – Continuous cardiorespiratory training; CG – Control group; HDL – High-density lipoprotein; ICT – Interval cardiorespiratory training; LDL – Low-density lipoprotein; M – Mean; PPT – Purdue Pegboard Test; RLB – Right, left and bimanual subtests; SD – Standard deviation; VO_{2max} – Maximun oxygen.