

Independent and Combined Effects of Biological Maturation and aerobic performance on the gross motor coordination in prepubertal girls

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Biological Maturation;
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ABSTRACT

The present study analyzed the effect of biological maturation on the performance in the test of gross motor coordination in girls, before and after having its effect controlled by body mass index (BMI) and aerobic performance. The sample was composed by 63 pre-pubertal girls (8.0-8.99 years). The girls who were less advanced in biological maturation presented lower body size and better physical performance in the tasks of walking backward on balance beams ($t=2.706$; $p<0.01$; $d=0.70$), moving sideways on boxes ($t=2.128$; $p<0.05$; $d=0.48$), hopping for height on one leg ($t=2.076$; $p<0.05$; $d=0.54$) and 20-m shuttle run ($t=3.162$; $p<0.05$; $d=0.61$). The maturation no longer influenced performance in the tasks of gross motor coordination when considering BMI and aerobic fitness.

Palavras Chave:

Maturação Biológica;
Aptidão Aeróbica;
Competência Motora;
Destreza Motora.

RESUMO

O presente estudo analisou o efeito da maturação biológica no desempenho em teste de coordenação motora grossa de meninas, antes e depois de ter seu efeito controlado pelo índice de massa corporal (IMC) e pelo desempenho aeróbico. Participaram 63 meninas pré-pubescentes de 8,0 a 8,99 anos. As meninas menos avançadas na maturação biológica apresentaram menores dimensões corporais e melhores desempenhos físicos nas tarefas de equilíbrio à retaguarda ($t=2,706$; $p<0,01$; $d=0,70$), transposição lateral ($t=2,128$; $p<0,05$; $d=0,48$), saltos monopodais ($t=2,076$; $p<0,05$; $d=0,54$) e 20-m shuttle run ($t=3,162$; $p<0,05$; $d=0,61$). A maturação deixou de influenciar o desempenho nas tarefas de coordenação motora grossa quando levou-se em consideração o IMC e a aptidão aeróbica.

Palavras Chave:

Maduración Biológica;
Aptitud Aeróbica;
Competencia Motora;
Destreza Motora.

RESUMEN

El presente estudio analizó el efecto de la maduración biológica sobre el desempeño en prueba de coordinación motora gruesa de niñas, antes y después de tener su efecto controlado por el índice de masa corporal (IMC) y por el desempeño aeróbico. Participaron del estudio, 63 niñas pre-pubescentes de 8 años. Las niñas menos avanzadas en la maduración biológica presentaron menores dimensiones corporales y mejores desempeños físicos en las tareas de equilibrio a la retaguardia ($t=2,706$; $p<0,01$; $d=0,70$), transposición lateral ($t=2,128$; $p<0,05$; $d=0,48$), saltos monopodales ($t=2,076$; $p<0,05$; $d=0,54$) y 20-m shuttle run ($t=3,162$; $p<0,05$; $d=0,61$). La maduración dejó de influenciar el desempeño en las tareas de coordinación motora gruesa cuando se tuvo en cuenta el IMC y la aptitud aerobia.

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INTRODUCTION

Motor competence and physical fitness are complex and multidimensional concepts (Luz et al., 2018a). The motor competence of the pediatric population can be characterized in the literature by a variety of terms - motor performance, motor ability, motor coordination, motor proficiency, among others (Robinson et al., 2015); while physical fitness is commonly designated as an indicator of readiness for physical performance (Malina et al., 2004).

Motor competence encompasses motor coordination, which can be defined as the harmonious and economic interaction of the musculoskeletal system, the nervous system and the sensory system with the purpose of producing precise and balanced motor actions (Schilling & Kiphard, 1974). Several test batteries have been used in the evaluation of motor coordination in children (Cools, Martelaer, Samaey & Andries, 2009). In this context, the Körperkoordinationstest für Kinder (KTK) has been widely used in many countries with elementary school children (Krombholz, 2006; Catenassi et al., 2007, Lopes, Stodden, Bianchi, Maia & Rodrigues, 2012; D'Hondt et al., 2014; Lopes, Santos, Moreira, Pereira & Lopes, 2015).

In recent years, studies that have focused on the behavior of schoolchildren regarding the aspect of motor competence, highlighting evidences of a positive association of it with health-related physical fitness (Stodden et al., 2008; Cairney et al. 2010) and with the habitual level of physical activity (Stodden et al., 2008; Rivilis et al., 2011). In addition, there appears to be a consensus in the literature that motor competence interacts with physical growth and biological maturation in children and younglings (Malina et al., 2004, Lopes et al., 2012, Luz et al., 2015), but few studies have evaluated the relationship of maturational status on performance in motor coordination tests in pediatric populations (Freitas et al., 2016; Luz et al., 2016; Luz et al., 2018b) especially in conditions where the maturation effect is controlled by variables commonly associated with both the weight and the level of physical fitness related to health.

The present study aimed to analyze the effect of biological maturation on the performance in the KTK of prepubescent girls, before and after having its effect controlled by body mass index and aerobic performance.

METHODS

It is a cross-sectional descriptive study, in which the data were collected in schools in Arapiraca,

State of Alagoas, Brazil. It was conducted observing international standards for experimentation with humans (in accordance with the Declaration of Helsinki) and approved by the Research Ethics Committee of the Federal University of Alagoas (UFAL), under registration number CAAE 09200413.5.0000.5013. The schools were randomly selected, stratified by the educational system type, two public schools and two private schools. The terms of consent were given to the students, and their respective parents.

Sample

The sample consisted of 63 female children between 8.0 and 8.99 years of age. Failure to provide the informed consent, physical inability to perform physical tests or absence on the day of data collection were exclusion criteria.

Anthropometry

The study assessed stature, waist circumference, body mass and skinfolds. For all measurements, the girls were in appropriate clothing, which allowed the tests to be performed and the procedures used had as reference the recommendations brought by Lohman et. al. (1988). To evaluate the stature and the waist circumference it was used an anthropometric steel strap (Sanny Medical Starret, São Paulo, Brazil) accurate to 0.1cm, which was fixed to a smooth surface wall without footboard for the stature assessment. The waist circumference was measured in the moment of minimal breathing, at the midpoint between the lowest ribs and the iliac crest. The body mass was measured in a digital scale (Techiline, São Paulo, Brazil), with an accuracy of 0.1kg. The skinfolds were measured with a Lange adipometer (Beta Technology, Santa Cruz, California, USA), accurate to 1mm. Body mass index (BMI) and fat percentage estimation were calculated (Slaughter et al., 1988). From the estimate of fat percentage, the fat mass and the fat free mass were estimated.

Biological maturation

The evaluation of the biological maturation status was performed using the predicted maturity stature (PMS), by the method proposed by Khamis and Roche (1994), using measures of chronological age, stature, body mass and mean stature of the biological parents. From the PMS, the percentage of the PMS reached by the child (% PMS) was calculated. In this study, % PMS was expressed as z-score relative to the mean and standard deviation of the sample from the Berkeley Guidance Study, University of California (Bayer & Bayley, 1959). For the purposes of analysis, girls with z-score < 0 were

considered less mature ($n = 41$) and girls with z -score > 0 were considered more mature ($n = 22$).

Motor coordination

Gross motor coordination was assessed using the Körperkoordinationstest für Kinder (KTK), proposed by Kiphard and Schilling (1974). Its application requires an area with 4x5 meters and consists of four tasks: walking backward (WB), jumping sideways (JS), moving sideways (MS) e hopping for height (HH). A better description of the method can be found in Luz et al. (2015). The sequence of KTK tasks was uniformly applied in the following order: WB, JS, MS and HH.

Aerobic performance

As an aerobic performance test, the 20-m shuttle run was used, proposed by the EUROFIT protocol (Committee for the development of sports, 1998). The test consists of round-trip races, in a space of 20 meters in length marked by cones, having as reference for the rhythm of the race a sound signal, emitted by sound system. The frequency of this signal is increased every minute, which means a speed increase in the race of 0.5 km/h. The test starts with a run of 8.5 km / h. When the subject is unable to proceed, the distance accumulated at the last race is used for aerobic performance purposes (in meters). The test was performed on a different day from the KTK tasks.

Data analysis

Initially, descriptive statistics were performed, followed by Kolmogorov-Smirnov normality test. Estimation of fat mass, moving sideways and performance in the 20-m shuttle run underwent logarithmic transformation for the inferential analyzes. Subsequently, a comparison was made between groups of different maturational states by the Student t test, with chronological, anthropometric, motor coordination and aerobic performance as dependent variables. The size effect of the differences between means were calculated through the Cohen's d values (Hopkins et al., 2009). Finally, ANCOVAs with BMI and aerobic performance as covariables were undertaken, having the biological maturation as independent variable and the KTK tasks as dependents. All tests adopted $p < 0.05$ as value of significance. Software IBM SPSS 22.0 (SPSS, Inc., Chicago, IL) was used.

RESULTS

The descriptive results are presented in table 1. The girls present an average chronological age of 8.41 years. The mean of the predicted mature stature is 162.2 cm and the percentage of the predicted mature stature values range from 75.6% to 88.3%.

Table 2 shows the results of the biological maturation effect on chronological and anthropometric variables, KTK tasks and the 20-m shuttle run. The less maturing

Table 1. Descriptive statistics (mean, standard deviation and 95% confidence interval of the mean) for the total sample of school girls aged 8.0–8.99 years old ($n = 63$).

Variable	Unit	Mean \pm SD	95% CI	Kolmogorov-Smirnov	
				Value	p
Chronological age	years	8.41 \pm 0.27	8.34 to 8.48	0.86	0.200
Predicted mature stature (PMS)	cm	162.2 \pm 5.8	160.7 to 163.7	0.80	0.200
Attained PMS	%PMS	80.4 \pm 2.6	79.8 to 81.1	0.68	0.200
Stature	cm	130.4 \pm 5.8	128.9 to 131.9	0.64	0.200
Body mass	kg	30.5 \pm 6.9	28.8 to 32.2	0.85	0.200
Body mass index	Kg.m ⁻²	17.8 \pm 3.3	17.0 to 18.6	0.11	0.074
Waist circumference	cm	59.6 \pm 7.4	57.7 to 61.4	0.87	0.200
Fat mass	%	28.5 \pm 6.3	26.9 to 30.0	0.99	0.200
Fat mass	kg	9.0 \pm 4.1	8.0 to 10.1	0.12	<0.05
Fat-free mass	kg	21.5 \pm 3.3	20.6 to 22.3	0.80	0.200
Walking backward	#	38.2 \pm 12.3	35.1 to 41.3	0.64	0.200
Jumping sideways	#	30.1 \pm 9.5	27.7 to 32.5	0.11	0.053
Moving sideways	#	32.0 \pm 8.3	29.9 to 34.1	0.16	<0.05
Hopping for height	#	29.8 \pm 12.6	26.6 to 33.0	0.11	0.057
20-m shuttle run	m	266.4 \pm 125.0	234.9 to 297.8	0.13	<0.05

SD (standard deviation); 95% CI (95% confidence interval of the mean); # (Counts).

group presented lower values of stature, body mass, BMI, waist circumference, fat percentage estimation, fat mass estimation and fat free mass estimation in comparison to the more maturing group. In contrast, in terms of physical performance, girls who were less advanced in biological maturation presented better performance in the walking backward ($t = 2.706$; $p < 0.01$; $d = 0.70$), moving sideways ($t = 2.128$; $p < 0.05$; $d = 0.48$) and hopping for height ($t = 2.076$; $p < 0.05$; $d = 0.54$) tasks of the KTK, as well as a better result in the 20-m shuttle run ($t = 3.162$; $p < 0.05$; $d = 0.61$).

Table 3 presents the effect of covariates (BMI and aerobic performance) on the different performances in KTK tasks. The BMI has no effect on the results obtained in the KTK tasks. The effect of aerobic performance in jumping sideways tasks ($F = 21.520$; $p < 0.001$) and hopping for height of KTK ($F = 31.309$; $p < 0.001$) was observed. The maturational state no longer had a significant effect on the performance of KTK tasks when its effect was analyzed along with the covariates (BMI and aerobic performance).

Table 2. Descriptive statistics and results of independent t test for maturity status groups including effect size.

Variable	Unit	Contrasting somatic maturation		t(61)	p	Cohen's d
		Z-scores<0 (n=41)	Z-scores>0 (n=22)			
Chronological age	Years	8.35±0.25	8.52±0.28	-2.386	<0.05	0.64
Predicted mature stature (PMS)	cm	162.6±5.8	161.4±5.9	0.829	0.411	0.20
Attained PMS	% PMS	78.9±1.5	83.2±1.8	-10.347	<0.001	-2.63
Stature	cm	128.3±5.3	134.5±4.7	-4.409	<0.001	-1.20
Body mass	kg	26.6±3.7	37.8±5.3	-9.816	<0.001	-2.55
Body mass index	Kg.m ⁻²	16.1±1.9	21.0±3.0	-7.820	<0.001	-2.06
Waist circumference	cm	55.6±4.4	67.0±6.1	-8.567	<0.001	-2.22
Fat mass	%	25.9±4.3	33.2±6.7	-5.110	<0.001	-1.36
Fat mass ^a	kg	7.0±1.9	12.8±4.4	-7.677	<0.001	-1.89
Fat-free mass	kg	19.6±2.1	25.0±2.0	-9.775	<0.001	-2.57
Walking backward	#	41.1±12.1	32.7±11.1	2.706	<0.01	0.70
Jumping sideways	#	31.0±10.1	28.4±8.2	1.013	0.315	0.27
Moving sideways ^a	#	33.4±9.0	29.4±6.3	2.128	<0.05	0.48
Hopping for height	#	32.1±12.4	25.4±12.1	2.076	<0.05	0.54
20-m shuttle run ^a	m	292.7±109.0	217.3±140.2	3.162	<0.05	0.61

(Counts); ^a Log-transformed values were used in the analysis.

Table 3. Descriptive statistics (mean ± standard deviation) of KTK items by contrasting somatic maturation and results of ANCOVAs to test the effect of the covariates (BMI, 20-m shuttle-run result) and the maturity status after controlling for the covariates on the dependent variables (n=63).

Variable	Unit	Contrasting somatic maturation		BMI F(p)	20-m shuttle-run ^a F(p)	Maturity status F(p)
		Z-scores<0 (n=41)	Z-scores >0 (n=22)			
Walking backward	#	41.1±12.1	32.7±11.1	0.047	2.773	2.451
Jumping sideways	#	31.0±10.1	28.4±8.2	0.022	21.520*	0.546
Moving sideways ^a	#	33.4±9.0	29.4±6.3	0.052	1.102	1.785
Hopping for height	#	32.1±12.4	25.4±12.1	0.604	31.309*	0.424

BMI (body mass index); # (counts); ^a Log-transformed values were used in the analysis; * $p < 0.001$.

DISCUSSION

The results showed that the biological maturation, on its own accord, had a positive effect on body size and a negative one on the motor competence of girls, evaluated by KTK. Though, when analyzed in combination with covariates (BMI and aerobic performance), biological maturation no longer exerted a significant effect on performance in KTK tasks. The BMI did not influence the results obtained in the KTK tasks, but it was noted that the aerobic performance did, namely in the tasks of jumping sideways and hopping for height.

Recently, hierarchical multiple regression was used to assess the influence of bone age, alone or combined with stature and body mass, on fundamental motor skills and KTK tasks. In children aged 7 to 10 years, bone age alone, or associated with body size, represented only 7% to 9% of the variances in the KTK tests and in six fundamental motor skills evaluated with the Test of Gross Motor Development, in both sexes (Freitas et al., 2015). However, evidence from the literature suggests that inter-individual differences in maturation status may either positively or negatively affect performance in motor competence tests, depending on the individual and the nature of the task to be performed (Beunen et al., 1997; Katzmarzyk et al., 1997). The results found in the present study showed that girls classified as less matured had significantly lower body mass, lower amount of fat mass and fat free mass in relation to their more matured pairs. Furthermore, the KTK scores were higher in the later biological maturing groups, with a significant difference in the walking backward, moving sideways and hopping for height tests. These results confirm the trend in the literature in which the most advanced subjects in the maturational aspect present a disadvantage in motor coordination tasks (Freitas et al., 2015), which can be explained by the greater corpulence associated with the more advanced state of biological maturation.

Motor competence seems to be positively associated with the level of physical activity, physical fitness and other health-related variables in young individuals (Janssen & Leblanc, 2010; D'Hondt et al., 2014). Girls are often assumed to be less active and less physically fit than boys during the first two decades of life, which may indicate that participation in programs of physical activity and sport could be decisive for girls in the acquisition of better motor performance, regardless of their maturational and ponderal state (Sherar, Esliger, Baxter-Jones & Tremblay, 2007; Cumming, Standage, Gillison & Malina, 2008). In fact, the present study revealed a positive effect of aerobic fitness on the motor

coordination, results consistent with a review study published by Lubans et al. (2010) on the relationship between motor coordination and health benefits in children and adolescents, which showed that levels of motor coordination are inversely correlated with body mass but positively correlated with aerobic fitness and perceived motor competence in both cross-sectional and longitudinal studies. In addition, cardiorespiratory fitness, muscular strength, muscular endurance, anaerobic capacity and muscular power have been negatively associated, to varying degrees, with poor motor coordination in another review study performed in pediatric population (Rivlis et al., 2011).

The present study has as limitations the transversal data collection, which does not allow causal declarations, and to have used as indicator of somatic maturational the percentage of maturation predicted height reached at the moment of the study, with values of mother and father's stature obtained through self-report. The disadvantage of this technique is that an adult value is required and, consequently, maturity status can only be applied retrospectively. However, the results were, for the most part, consistent with studies that used skeletal age as an indicator of maturational status.

In conclusion, there seems to be a positive effect of biological maturation on body size, which in turn establishes a negative effect on gross motor coordination in girls, especially in tasks where body mass is displaced. Finally, the aerobic fitness effect found in the present study reinforces the importance of a greater involvement in physical-sports activities for improvement on coordinative performance in girls.

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