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Changes in Functional Fitness, Mood States and Salivary IgA Levels after Exercise Training for 19 Weeks in Elderly Subjects

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This study analysed the influence of a 19 week exercise program in the functional fitness, salivary IgA and mood states of an elderly population. Thirty three subjects with ambulatory capacity and without any medical contraindications to exercise aged between 68 and 95 years old participated and were distributed into 2 groups: 15 subjects performed aerobic exercise that included low-impact rhythmic work sequences with music, three times a week, and 18 remained sedentary. The exercising group attained improvements in all components of functional fitness with significant differences registered for aerobic endurance, lower and upper body strength. The exercising group also showed improvements in the mood states, with statistically significant less depression, less tension, less fatigue, more vigour and less anger. On the other hand, the sedentary control group showed an increase in confusion and a loss of vigour. For the exercising group salivary IgA levels were higher after the 19 week exercise program with no changes for the control group. This study shows a positive effect of exercise on physical, psychological and mucosal immune parameters in elderly populations which may improve quality of life.

key words: *mucosal immunity, salivary IgA, mood states, aging, functional fitness*

Introduction

Physical activity has been recognized as one of the main determinants for the improvement of life expectancy and quality of life in the elderly(ACSM, 2006; Jones & Rose, 2005; Spirduso et al., 2005). The beneficial effects of physical exercise in the elderly are wide and potentially include psychological, sociological,

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physical and physiologic components. Some of the best documented are: reduction of body fat(Pratley et al., 2000), increase in muscular mass, increase in bone density and flexibility(Layne & Nelson, 1999). At the metabolic level a decrease in blood pressure and an improvement of the lipidic profile(Halverstadt et al., 2007; Paffenberger et al., 1993) have been shown.

Decreases in function or diminished regulation of the immune system with age are thought to contribute to the increase in incidence of malignancy, autoimmune disorders and infectious diseases particularly those of the upper respiratory tract (Nieman et al., 1993; Shephard & Shek, 1995). Salivary IgA antibodies provide protection against infections and play a significant anti viral role in the mucosal surface(Lamm et al, 1995). Salivary IgA deficient persons are susceptible to recurrent infections, mostly of the upper respiratory and gastrointestinal tracts. Because salivary IgA levels reportedly decrease with age(Miletic et al., 1996; Tanida et al., 2001) this may facilitate pathogenic microorganisms invasion and increase susceptibility to upper respiratory tract infections (URTI) in the elderly. Exercise has been proposed as a mean of attenuating immunosenescense in the elderly(reviewed by Kohut & Senchina, 2004) and reduction in URTI has been reported in moderately active subjects when compared to inactive ones(Kostka el al., 2000; Nieman el al., 1993). Several researchers have studied the impact of heavy training on the susceptibility to URTI(Mackinnon et al., 1994) and suppression of salivary IgA levels has been associated with increased incidence of URTI in elite athletes(Gleeson et al., 1999) but very few studies have looked at the effect of a moderate exercise program on salivary IgA levels(Akimoto et al., 2003; Kimura et al., 2006; Klentrou et al., 2002) and none of these have looked at the psychological effects of exercise.

According to Biddle(2000) the mood is a set of affective states that everyone experiments in a day-by-day basis. Reduction in anxiety and depression levels and an improvement in self esteem and better tolerance to stress and a significant decrease in hostility levels, after four weeks of exercise, when comparing to the results of a control group have been reported(Hanin, 2000; Sakuragi & Sugiyama, 2006)

Physical activity could then act as a mediator between stress and individual health, functioning as an efficient method for controlling stress, when compared to methods like relaxation or passive rest, with the added bonus of also improving the general health of the individual. The successful aging as a qualitative description depends not only on the biological factors but also on the sociological and psychological determinants.

According to Spirduso and colleagues(2005) the quality of life model for the elderly should incorporate eleven factors. The factors of cognitive and emotional function reflect everyone's desire to maintain an active interaction with the environment through independency and productivity as well as emotional control and mental health. Social function, recreational activity and sexual function enable people to enrich their lives. The physical dimension of life, which includes health status, physical function, energy and vitality, is present in four of the eleven factors thought to be essential for the quality of life in the later years. Physical activity has the potential to act as a determinant in the majority of the components of the quality of life model both directly and indirectly. Physical activity is essential for performing the activities of daily living, such as personal care, walking, eating, bathing, shopping or dressing.

The purpose of this study is to investigate the effects of a long term physical exercise program on the mucosal immune system of an elderly population by looking at parameters such as the concentration and secretion rate of salivary IgA. The effects of exercise on the psychological status and functional fitness of the participants will also be evaluated.

Methods

Participants

Thirty three sedentary healthy subjects with ambulatory capacity, aged between 68 and 95 years old, participated in this study. A detailed explanation of the risks and potential benefits of the study was given to all the potential subjects before they signed an informed written consent form. Subjects that had acute illness from infection in the preceding 3 months or had undergone major surgery in the preceding 6 months were excluded from the study. They all passed a complete medical examination and received permission from their doctors to be included in the study. All the participants lived in an urban based community. They were then randomly distributed into 2 groups: 15 subjects (4 males and 11 females) with an average age of 79.56±10.24 years old were assigned to an aerobic based exercise program that lasted 19 weeks and had a frequency of three exercise sessions per week (3x); 18 subjects (2 males and 16 females) with an average age of 84.00±4.51 years old remained sedentary and acted as a control group (0x).

Methodology

Functional fitness, mood states and salivary IgA values of all subjects were evaluated before and after the 19-week exercise program. “The Functional Fitness Test” was used to evaluate the functional fitness(Rikli & Jones, 1999) which included the evaluation of upper and lower body strength, upper and lower body flexibility, aerobic endurance and, velocity, agility and dynamic balance. The measuring techniques used for each test are described with detail by Rikli & Jones (2001). Briefly, the lower body strength was determined with the *chair and stand test* measuring the total number of stands completed in 30 seconds. The upper body strength was determined with the *arm curl test* that measures the total number of arm curls executed in the 30 seconds. To assess the lower-body flexibility the *chair sit-and-reach test*, was used, measuring the maximum forward reach toward or past the toes (cm), when sitting on the edge of a chair with one leg bent and the other extended. The upper-body flexibility was determined with the *back scratch test* that measures the distance (cm) of overlap or between the tips of the middle fingers when the arms are reaching up in the middle of the back as far as possible. To assess agility and dynamic balance the *8-foot up-and-go test* was used, measuring the time needed for the participant to get up from the chair, walk as quickly as possible around either side of a cone placed 8 feet away (2,44cm), and to sit back down in the chair. The last test administered was the *6-minute walk* test that measures the distance around a 45,7m course covered in the 6-minute time limit and is used to assess aerobic endurance.

The POMS-SF (Short Form of the Profile of Mood States) questionnaire was used to evaluate the mood states(Viana & Cruz, 1993). It includes dimensions of depression, tension, fatigue, vigour, anger and confusion. The questionnaire was administered individually, in a quiet room, and in the presence of the researchers were on hand to help clarify any doubts encountered by the subjects during the answering process.

Saliva samples were collected using a sterilized cotton swab without citric acid preparation from the saliva-collecting tubes (Salivette,, Sarstedt, Germany). Subjects were told to keep the absorbent cotton wad for 2 minutes in their mouth. Contamination with food debris was avoided by rinsing the mouth with water and by delaying the collection for thirty minutes after rinsing to prevent sample dilution. Samples were centrifuged for 15min at 3000rpm and their volume measured. The samples were then stored at -20°C until further analysis. Concentration of salivary immunoglobulin A (sIgA) was determined by nephelometry (BN2 Analyser, DADE Behring, USA). Salivary IgA secretion rate (μg/min) was calculated by multiplying the sIgA concentration (μg/ml) by saliva flow rate (ml/min), which was calculated by dividing the total volume of salive obtained in each sample (ml) by the time taken to produce the saliva sample (minutes).

Exercise Program

The physical exercise program respected the general guidelines proposed by the American College of Sports Medicine(ACSM, 2006) and consisted of three times a week sessions, in alternate days, of 50 minutes, divided into 15 minutes of warm-up, 20min aerobic, strength and flexibility exercises, and 15min relaxation exercises. Aerobic exercise included low-impact rhythmic work sequences with music in the upright position (first half of the main part) and sitting position (second half of the main part). The exercise intensity sessions were estimated between 50 and 60% of maximal heart rate and were aimed at improving aerobic capacity, upper and lower stretching and strength training from sets of callisthenic exercises. The maximal heart rate was estimated as follows: $HR_{maximum} = 208 - 0.7 \times Age$ (Tanaka et al., 2001). Rest heart rate and work heart rate were measured by telemetry with a Polar® device (Polar S-810i, Finland). Additionally the *talk test* was used to control the exercise intensity.

Statistics

A paired samples t-test was used to compare the results obtained for the different variables before and after of the exercise program using the SPSS version 10.0 for Windows program.

Results

Functional Fitness

After the physical exercise program, the experimental group attained improvements in all the components of functional fitness. Significant differences were registered for aerobic endurance (p=.003) which reflects an improvement in the distance walked in the six minute test from 237.06 ± 63.16 to 257.00 ± 65.613 meters; lower body strength (p=.005) with a rise from 9.31 ± 5.50 to 12.44 ± 5.11 repetitions and upper body strength (p=.052) with an increase from 12.82 ± 5.48 to 14.81 ± 3.06 repetitions. The control group also showed statistical differences between the initial and final evaluation for all the six components of the fitness test but with a decline instead of an improvement in the performance of the tests. The descriptive results of the fitness components are shown in Table 1.

Table 1. *Mean and standard deviation results for the functional fitness test parameters evaluated before and after the exercise program. 0x – sedentary group; 3x – exercise 3 days/week*

	Exercise frequency	Before exercise program	After exercise program	Sig (p)
Lower body strength (nºof repetitions)	3x 0x	9.31 + 5.5 4.83 + 3.89	12.44 + 5.11 4.00 + 3.22	.005* .003*
Upper body strength (nºof repetitions)	3x 0x	12.82 + 5.48 8.72 + 4.25	14.81 + 3.06 7.61 + 3.50	.052* .012*
Agility/Balance (seconds)	3x 0x	18.25 + 18.29 27.89 + 15.77	14.17 + 8.46 29.06 + 16.92	.282 .015*
Lower flexibility (cm)	3x 0x	4.88 + 5.90 16.78 + 18.60	3.25 + 6.79 18.17 + 18.16	.318 .001*
Upper flexibility (cm)	3x 0x	33.88 + 14.65 37.33 + 15.02	36.38 + 15.85 39.00 + 15.41	.432 .001*
Aerobic endurance (m)	3x 0x	237.06 + 63.16 185.78 + 72.64	257.00 + 65.13 168.94 + 66.54	.003* .000*

* Significant differences for p .05

Mood States

The results obtained after the exercise program for the six factors of the POMS questionnaire (Table 2) revealed some improvement in the mood states, the exercising group being statistically significantly less depressed (p=.001), with less tension levels (p=.013), less fatigue (p<.0001), more vigour (p=.004) and less anger (p=.022). On the other hand, the control group altered the mood state levels on the opposite direction with statistically significant differences for increased confusion (p=.004) and decreased vigour (p=.001).

Table 2. *Mean and standard deviation results for the six subscales of the Profile of Mood States-Short Form questionnaire (POMS-SF) before and after the exercise program (0x-control group; 3x-exercise 3 days/week)*

	Exercise frequency	Before exercise program	After exercise program	Sig (p)
Depression	3x 0x	1.72 + 86 1.80 + 0.88	0.76 + 0.57 1.83 + 0.82	.001* .877
Tension	3x 0x	1.52 + 0.82 1.84 + 0.92	0.92 + 10.75 1.92 + 0.82	.013* .635
Fatigue	3x 0x	1.95 + 0.9 2.29 + 1.27	0.97 + 0.94 2.16 + 1.00	.000* .514
Vigour	3x 0x	1.77 + 0.93 1.62 + 1.05	2.43 + 0.73 0.80 + 0.64	.005* .001*
Anger	3x 0x	0.73 + 0.92 0.85 + 1.01	0.16 + 0.28 1.07 + 0.93	.022* .200
Confusion	3x 0x	1.17 + 0.92 1.33 + 0.97	0.87 + 0.83 1.97 + 0.92	.178 .004*

* Significant differences for p .05

Salivary IgA levels

Regarding the mucosal immune system, IgA secretion rate increased significantly after the exercise program (p=0.01) but did not change in the sedentary control group (Table 3). Salivary IgA concentration also increased in the exercising group and decreased in the sedentary group. However, in both groups, the changes failed to reach statistical significance.

Table 3. *Mean and standard deviation sIgA concentrations (sIgA) and secretion rates (srIgA), before and after the exercise program*

Group	sIgA Initial (μg/ml)	sIgA Final (μg/ml)	Sig. (p)	srIgA Initial (μg/min)	srIgA Final (μg/min)	Sig (p)
3x	92.92+86.14	133.87+113.95	0.065	53.44+37.9	90.2+82.85	0.018*
0x	197.97+172.09	138.64+89.77	0.153	95.18+77.66	90.03+81.02	0.842

Discussion

Our results show that an improvement in functional fitness could be obtained in older subjects after the implementation of a 19 week exercise protocol. The exercise program was long enough to promote important adaptations, like enhancement of upper and lower body strength and improved aerobic capacity. On the other hand the sedentary control group, after an equal length of time, showed a significant decline in functional fitness performing significantly worse in all the tests of the protocol used.

Improvement at the psychological level was also found with the exercising group experiencing lower levels of depression, fatigue, anger and tension and higher levels of vigour after the 19 week exercising period. On the other hand after the same period of time, the control group had not improved their mood states outcome and had even increased their confusion and decreased their vigour levels. The influence of exercise on mental well-being has now been the subject of several studies (reviewed by Fox, 1999) that suggest that aerobic and resistance exercise enhances mood states and may even improve cognitive function in older adults. These results are in accordance to those found in the present study and seem to indicate that exercise may have important benefits at the psychological level in elderly subjects, not only by enhancing the mood states but also by preventing their deterioration with time.

When looking at the sIgA levels, after the 19 week exercise program, our study showed an increase in sIgA secretion rates, which reflects the total amount of sIgA appearing on the mucosal surface per unit of time, but not in the sIgA absolute concentration. The failure to obtain a statistical difference in the IgA concentrations may be due to the small number of subjects in the sample and also to the high variability between subjects. No changes in the salivary IgA levels were found for the control group.

In similar studies (Akimoto et al., 2003; Klentrou et al., 2002) improvement of salivary IgA levels have also been found after a moderate exercise protocol. In the study of Akimoto et al, (Akimoto et al., 2003) statistical significant increases were found for the exercising group for both sIgA concentration and secretion rates, while no significant changes were found for the control group (Klentrou et al., 2002). A recent study (Shimizu et al., 2007) looking at daily physical activity in the elderly found that those who accumulated moderate‑intensity daily physical activity had higher salivary SIgA concentration and secretion rates than their predominantly sedentary peers. Taken together these results suggest that regular moderate exercise increases salivary IgA levels in older adults which may have an important role in decreasing susceptibility to upper respiratory tract infections.

As a whole, this study shows a positive effect of exercise on physical, psychological and mucosal immune parameters in elderly populations which may lead to an improved quality of life. Lack of exercise on the other hand seems to decrease functional fitness and increase psychological stress. Understanding how thoughts and emotions interact with the immune system and manifest in health and disease and how physical exercise can positively influence that relationship, in the elderly, is of major importance.

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