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Evolution of neuromotor profile and functional capacity of physically active women according to chronological age

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ABSTRACT

Background and purpose: There are few longitudinal studies to determine the effect of aging on physical fitness and functional capacity of physically active women. The purpose of this study was to compare the evolution of neuromotor profile and functional capacity in active elderly women in one-year period as related to chronological age at the baseline. **Methods:** Sample consisted of 117 women from 50 to 79 years of age ($\bar{x}$: 65 ± 6.6 years) engaged in an aerobic program, twice a week, 50 minutes per session during 5.4 ± 3.0 years and divided in three age groups: 50-59 (n: 23); 60-69 (n: 60); 70-79 (n: 34). Motor function and mobility tests included: lower and upper limb strength, agility, trunk flexibility, velocity of rising from a chair, static balance, gait speed and maximum gait speed. Results at the baseline and in two evaluations made at six-month interval were compared using a Two Way ANOVA, with a post-hoc Scheffé. **Results:** There were no differences regarding neuromotor performance, although velocity of rising from a chair and gait speed evidenced significant differences in groups 50-59 and 60-69 years, showing better results (10-20%); and for maximum gait speed there was an increase (8%) in 60-79 age groups. **Conclusion:** Present results suggest that physical fitness and functional capacity evolution had a similar pattern among physically active women, regardless of chronological age. This evolution supports the hypothesis of regular physical activity as a powerful tool to promote health, being of utmost importance to a healthy aging.

Key words: Aging. Neuromotor variables. Physical activity. Functional capacity. Longitudinal study.

INTRODUCTION

Between the ages of 25 and 65 years, there is a significant decrease of the lean or fat-free mass, of about 10 to 16%, due to musculoskeletal, bone mass and total body water losses that occur with aging. The gradual musculoskeletal and strength loss that takes place over the aging process, also known as sarcopenia, has been defined by some authors[1] as the loss of muscular mass corresponding to more than two standard deviations below the expected average mass for that gender, in young age, or for other individuals, with the same standard-deviation criteria, but considering the appendicular skeletal mass (mass in kilos divided by the square of the height). The loss of muscular mass, thus of muscular power, is, to us, the main reason for a decrease in mobility and functional capacity of an aging individual. This has raised an interest of investigators to seek the causes and mechanisms involved in the loss of muscle power with aging, in order to create strategies that lessen this deleterious effect, and allow individuals to keep or enhance quality of life at that stage in life. Sarcopenia is a generic expression that indicates loss of mass, power and quality of the skeletal muscle, and has a significant impact in public health due to its well known functional consequences in gait and balance, increasing the risk of falling and loss of functional physical independence, and increasing the risk of chronic diseases, such as diabetes and osteoporosis. According to most studies analyzed by Cartee[2] and Porter *et al.*[3], the conclusions are quite consistent: the size of the type-II fiber reduces with aging, whereas the size of the type-I fiber (slow-contraction fiber) is less affected. In our opinion, this is explained by the fact that type-II fibers are also very important in responding to dai-

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ly urgencies, as they play a role in reaction, and particularly, in response time, that otherwise would prevent an appropriate response from the body to emergency situations, as a sudden loss of balance. The loss of muscle mass is clearly associated to a decrease in voluntary strength, at a rate of 10-15% per decade, which typically becomes apparent only from age 50 to 60 years. From age 70 to 80 years, a higher loss has been reported, reaching 30%[4]. Healthy 70-80 year-old subjects have a performance 20-40% lower (reaching 50% in older people) in muscle strength tests, compared to young subjects. Such lower performance can be also explained by changes in the intrinsic features of muscle fibers.

Considering the information from Rogers and Evans[5] and Booth *et al.*[6], we can conclude that the loss of muscle fibers, moto-neurons, motor units, muscle mass and muscle strength begins at age 50-60 years, reaching 50% at age 80. It seems that the two main reasons for this effect of aging are the progressive neurogenic process and the decrease of muscle load, which may suggest such muscular atrophy is not necessarily an unavoidable consequence of aging. Physically active people have only moderate muscle mass losses, but one does not know how much of this muscle mass loss is from aging itself and/or a reduction of physical activities[6].

Increasing and/or maintaining regular physical activity may add to life expectation of elderly women, but seems to benefit less those under 75 years of age[7]. As most of such epidemiological evidence supports the positive effect of an active life-style (and/or the engagement of individuals in exercise or physical activity programs) for prevention and lessening of the deleterious aging effects (American College of Sports Medicine[8]), scientists stress more and more the need for physical activity as an instrumental part of health promotion programs worldwide. Today, one cannot think about "preventing" or minimizing aging effects without including, in addition to general health measures, physical activity. This concern has been discussed not only in the so-called developed or first-world countries, but also in developing countries, such as Brazil.

In our Research Center, over the past few years, we have developed a number of muscle-strength training protocols for women over the age of 50 [9]. Continuing our scientific studies, and considering the scarcity of longitudinal data from developing countries, as in some developed countries[10-13], in 1997 an idea for a longitudinal study to assess the aging process on physical fitness and on the levels of physical activity and functional capacity came out. The project included the assessment of anthropometric and neuromotor physical fitness variables, assessment of functional capacity, measurement of the physical activity level, assessment of psychological variables (self-image, mood profile, depression) and assessment of food intake.

This study was carried out with the purpose to establish the progression, over one year, of physical fitness neuromotor variables and functional capacity in physically active women with chronological age ranging from 50 to 79 years.

METHODOLOGY

Sample

The subjects of our study were 117 women, aged 50 to 79 years ($\bar{x}$: 65 ± 6.6 years), participants of the longitudinal aging and fitness project *Projeto Longitudinal de Envelhecimento e Aptidão Física de São Caetano do Sul*, coordinated by CELAFISCS, which, since 1997, assesses physical fitness and functional capacity of physically active women every six months. The subjects took part in the physical activity program offered by the center for elders *Centro da Terceira Idade Moacyr Rodrigues*, of the city of São Caetano do Sul, twice a week, in sessions of 50 minutes; at their assessment, their time of practice ranged from two to eight years ($\bar{x}$: 5.4 ± 3.0 years). The program includes aerobic, stretching, and flexibility and balance exercises under the guidance of a physical education expert. The sample of the study was randomized according to convenience, and inclusion criteria were: female gender; older than 50 years; apparently healthy; registered in the Center's physical exercise program; attendance of at least 75% of the classes; practice time of at least two years.

The sample was divided according to chronological age:

Group 50 – 59 years: 23 women
Group 60 – 69 years: 60 women
Group 70 – 79 years: 34 women

Methods

All tests employed to measure physical fitness neuromotor profile, and variables of mobility and functional capacity followed the international standards adopted by CELAFISCS[14]. Prior to the beginning of the investigation, the participants signed a consent form agreeing to take part in it, and for the use of their data. The research project was sent to and approved by the Ethics Committee of the Federal University of São Paulo School of Medicine (*Universidade Federal de São Paulo – Escola Paulista de Medicina*).

The measured physical fitness neuromotor variables were: a) Muscle strength of the upper limbs, indirectly determined with a hand-grip test or manual dynamometry, using an adjustable *Grip A* dynamometer, with a scale from 0 to 100 kilograms; b) Muscle strength of lower limbs, indirectly assessed by the vertical impulsion test without the use of upper limbs; c) Trunk flexibility measured by the sit and reach test, using a 48-cm bench and a 55-cm scale posted on it, with the zero mark close to the subject; d) Agility, with the *shutlle run* test; e) Balance, measuring static balance with visual control.

The tests to measure functional capacity included: a) Normal walking speed, using a track 33.3 centimeters in width, and 3.33 meters in length; b) Maximum walking speed, with the subject walking on the same track as fast as possible, but without running; c) Velocity in rising from a chair, to measure the subject's ability to move from a sitting to a standing position. Reliability of the test was assessed in a part of the sample, and results evidenced moderate to high, and significant correlation values ($p < 0.01$), ranging from 0.60 to 0.91.

Statistics

Statistical analysis to compare the physical fitness of each age group for the different evaluations was the ANOVA two way variance analysis for repeated measurements of the same group. To identify differences, Bonferroni's post-hoc test was used. The adopted significance level was $p < 0.01$. The magnitude of possible differences among the evaluations was calculated with the proportional delta (Δ%) from the first to the second and third assessments, and from the second to the third assessment. For the statistical data analysis, the software *Statistical Package for the Social Sciences (SPSS)* version *10.0 for Windows* was used.

RESULTS

Results from neuromotor variables strength of upper and lower limbs, flexibility, agility, and balance are presented in tables 1 to 5. Beginning with upper limb strength, measuring left and right limbs with manual dynamometry tests (table 1), we did not observe statistically significant differences among the three age groups of the study.

Progression of lower-limb strength, as assessed by the vertical impulsion test, is presented in table 2. Muscle strength of lower limbs had a similar behavior of upper-limb strength and flexibility over the period of time under study. Even though no statistically significant differences were found in the three evaluations of the different age groups, there was a slight tendency for results to increase at the end of one year, and, similarly to flexibility, such proportional increase reduced as chronological age progressed. Thus, for the youngest group (50-59 years) the percentage of increase was close to 10%, reaching 12% in the group 70-79 years. As one can see, progression of lower-limb strength was similar for the three groups, according to chronological age.

Flexibility of the lower part of the body presented a tendency similar to other neuromotor variables. According to data presented in table 2, for all age groups this variable showed a discrete increase, with no statistical difference over the years. In terms of proportion, this increase was of 15% for the 50-59 years group, 6.4% for the 60-69 years group, and 12% for the 70-79 years group.

The results from body agility and static balance, also assessed according to chronological age over the one-year period, are presented in table 3.

Considering the body agility values (lesser time in seconds meaning better performance), they were also stable in the assessment of the three groups that were set according to chronological age. No statistically significant differences were found, and the proportion of variation between assessment at baseline and final was of 1.8 (youngest

TABLE 1
Upper-limb strength progression (assessed by dinamometry) in women participating in a physical exercise program, according to chronological age, at baseline (I), after six months (II) and after 12 months (III)

Variable		50-59 years			60-69 years			70-79 years		
		I	II	III	I	II	III	I	II	III
Right dinamometry (kg)	x̄	26.7	27.9	28.7	25.2	25.0	26.8	25.1	24.1	25.6
	s	6.6	5.2	4.9	5.2	4.9	5.3	5.6	5.6	5.4
	n	22	23	23	60	59	60	34	34	34
	Δ%	4.4	3.1	7.6	–0.6	7.1	6.4	–3.8	6.0	2.0
Left dinamometry (kg)	x̄	26.2	26.7	27.4	23.8	23.2	25.5	24.1	22.7	25.7
	s	5.6	4.9	5.2	5.1	4.4	4.9	5.8	5.2	5.4
	n	22	23	23	60	59	60	34	34	34
	Δ%	2.0	2.8	4.9	–2.8	10.0	6.9	–5.8	13.1	6.6

Δ% – the order of the figures corresponds to the percentage variation between evaluations: II and I-II and III-III and I.
* p < 0.01 – regarding the comparison of assessments II and III in relation to assessment I.

TABLE 2
Lower-limb strength (vertical impulse) and flexibility progression in women participating in a physical exercise program, according to chronological age, at baseline (I), after six months (II) and after 12 months (III)

Variable		50-59 years			60-69 years			70-79 years		
		I	II	III	I	II	III	I	II	III
Vertical impulse (cm)	x̄	17.6	19.2	19.3	15.5	16.0	16.5	13.6	13.2	15.3
	s	3.7	5.3	5.2	3.7	4.7	3.9	3.9	4.8	4.2
	n	22	23	23	59	58	59	33	33	33
	Δ%	9.5	0.2	9.8	3.7	2.6	6.4	–3.4	15.9	12
Flexibility (cm)	x̄	26.4	28.9	30.4	26.5	28.2	28.1	22.2	22.9	24.9
	s	9.6	9.0	9.4	7.5	7.8	8.4	8.7	8.2	8.5
	n	21	23	23	59	59	60	34	34	34
	Δ%	9.6	–5.0	15.1	6.4	–0.6	5.8	3.2	8.9	12.3

Δ% – the order of the figures corresponds to the percentage variation between evaluations: II and I-II and III-III and I.
* p < 0.01 – regarding the comparison of assessments II and III in relation to assessment I.

TABLE 3
Body agility and balance progression in women participating in a physical exercise program, according to chronological age, at baseline (I), after six months (II) and after 12 months (III)

Variable		50-59 years			60-69 years			70-79 years		
		I	II	III	I	II	III	I	II	III
Agility (seg)	x̄	17.29	17.38	17.60	19.12	19.06	18.89	21.11	20.75	21.25
	s	1.9	1.4	1.4	3.0	3.0	3.1	3.6	3.0	4.0
	n	22	23	23	59	60	59	33	34	33
	Δ%	0.5	1.3	1.8	–0.3	–1.2	–1.5	–1.7	2.4	0.7
Balance (seg)	x̄	20.58	19.59	21.58	19.55	19.48	16.98	10.95	12.12	9.02
	s	11.5	11.1	9.9	10.5	9.2	9.5	9.3	8.0	7.3
	n	20	23	23	58	59	59	29	33	34
	Δ%	–4.8	10.1	4.9	0.4	–12.8	–13.2	10.7	25.6	–17.6

Δ% – the order of the figures corresponds to the percentage variation between evaluations: II and I-II and III-III and I.
* p < 0.01 – regarding the comparison of assessments II and III in relation to assessment I.

group) to 2.4% (oldest group). For static balance, the variable whose best result is 30, the 50-59 and 60-69 groups presented a progression similar to anthropometric variables and to the other neuromotor variables.

The progression of balance in these groups was practically stable (chart 1), with no significant differences among the evaluations, with proportional variations for the two groups ranging from –13,2% to 10%. Interestingly, the progression for the group of chronologically older women (70-79 years) presented an increase in time of about 26%, non statistically significant, from the first to the second assessments (I x II). However, considering the progression for the assessment at baseline to the last one, there was a non-significant decrease of approximately 18%.

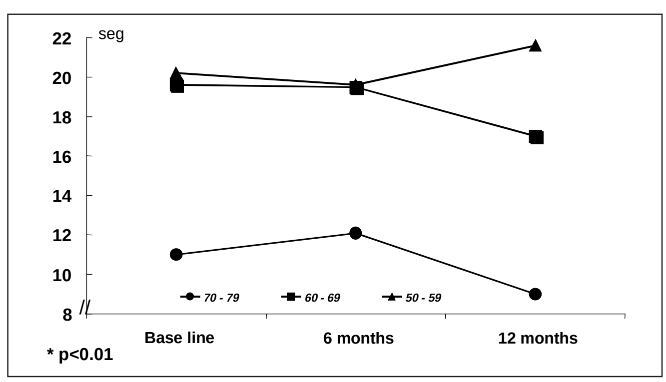

***Chart 1** – Static balance progression in women participating in a physical exercise program, according to chronological age, at base line and after a six- and a 12-month interval*

TABLE 4
Functional capacity (velocity of rising from a chair, regular walking speed, maximum walking speed) progression in women participating in a physical exercise program, according to chronological age, at baseline (I), after six months (II) and after 12 months (III)

Variable		50-59 years			60-69 years			70-79 years		
		I	II	III	I	II	III	I	II	III
Chair-rising	x̄	0.79	0.68	0.62*	0.87	0.71*	0.69*	0.85	0.81	0.76
speed	s	0.16	0.16	0.17	0.26	0.25	0.15	0.19	0.27	0.19
(seg)	n	22	23	23	60	60	58	33	34	34
	Δ%	–13.9	–8.8	–21.5	–18.4	–2.8	–20.7	–4.7	–6.2	–10.6
Walking	x̄	1.07	1.19*	1.18*	1.03	1.07	1.13*	0.99	1.03	1.04
speed	s	0.14	0.19	0.13	0.16	0.18	0.13	0.10	0.15	0.15
(m/seg)	n	22	23	23	60	60	58	34	34	34
	Δ%	11.2	–0.8	10.3	3.9	5.6	9.7	4.0	1.0	5.0
Maximum	x̄	1.33	1.40	1.46	1.26	1.31	1.36*	1.18	1.22	1.27*
walkinga	s	0.17	0.19	0.18	0.16	0.16	0.16	0.11	0.14	0.14
speed	n	22	23	23	60	60	58	34	34	34
(m/seg)	Δ%	5.3	4.2	9.8	4.0	3.8	7.9	3.4	4.1	7.6

Δ% – the order of the figures corresponds to the percentage variation between evaluations: II and I-II and III-III and I.
* $p < 0.01$ – regarding the comparison of assessments II and III in relation to assessment I.

The values from the variables that measured part of the functional capacity overall mobility functions, such as velocity in rising from a chair, and walking velocity, are presented in table 4.

Differently from the progression seen in most anthropometric and neuromotor variables, the velocity in rising from a chair and the regular walking speed show a distinctive progression pattern according to chronological age. The chair-rising velocity increased for the three chronological-age groups, being statistically significant for the groups 50-59 and 60-69 (chart 2).

From the first to the second assessments, i.e., after a six-month interval, the groups 50-59 and 60-69 significantly reduced their time for performing the movement, in 13.5% and 18.7%, respectively, while the proportion of decrease for the 70-79 group was non-significant, of only 5.2%. The same happened after 12 months, when one could see a significant improvement ($p < 0.01$) in performance (reduction in time), which was about 21% for the groups 50-59 and 60-69 years.

On the other hand, walking speed and maximum walking speed (charts 3 and 4) showed a different progression profile, according to the chronological age evaluation at six and 12 months after baseline assessment.

While the results from the regular walking velocity presented significant differences for groups 50-59 and 60-69 years, the maximum walking velocity values for the three chronological-age groups, over the same period of time, presented statistically significant differences for groups 60-

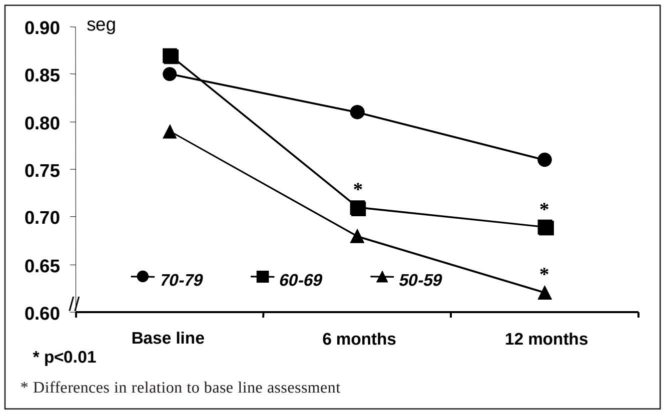

Chart 2 *– Progression in the velocity of rising from a chair, in women participating in a physical exercise program, according to chronological age, at base line and after a six- and a 12-month interval*

69 and 70-79. As to regular walking speed, there was a statistically significant improvement for the group 50-59, of about 10% in both assessments, at six and 12 months after the baseline assessment. The group 60-69 presented a similar tendency, with an improvement of almost 10% from baseline to the third assessment. For the group 70-79, even though there was an improvement tendency of about 4%, it was not statistically significant.

The results from the maximum walking speed for the three age groups showed a tendency for increase of velocity (of about 8%), being such differences statistically significant for groups 60-69 and 70-79.

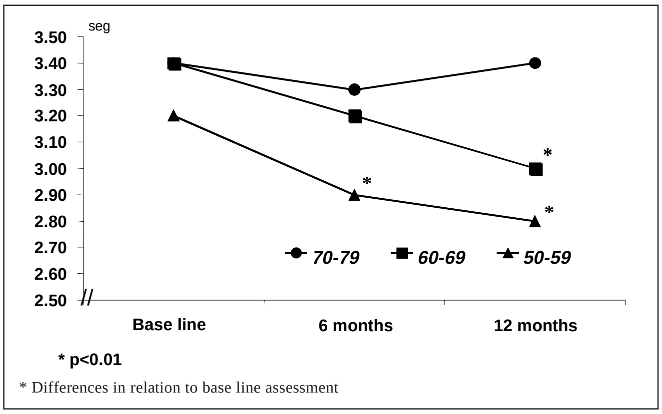

Chart 3 *– Progression of regular walking speed in women participating in a physical exercise program, according to chronological age, at base line and after a six- and a 12-month interval*

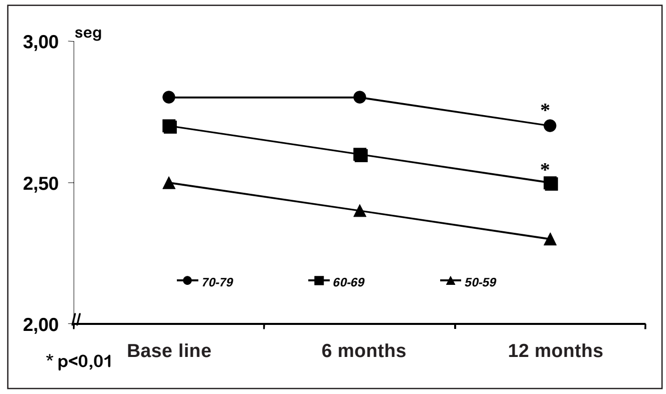

Chart 4 *– Progression of maximum walking speed in women participating in a physical exercise program, according to chronological age, at base line and after a six- and a 12-month interval*

DISCUSSION

The assessed neuromotor variables included upper- and lower-limb muscle strength, trunk flexibility, agility, and balance. Considering the progression of muscle strength, we could see that most data came from cross-analyses of data from men and women of different age groups[15,16], or, in some few cases, from studies carried out with time intervals of more than a decade, with male subjects[17,18]. However, we did not find in the available literature studies that assessed, on a similar way, the progression of this variable in physically active women, at a six-month or one-year interval. However, studies with different outlines that ours are well documented in the literature, showing a decrease of muscle strength with aging, being more dramatic after the age of 70, and such decrease is faster in lower rather than upper extremities[19]. Monteiro *et al.*[20] assessed a group of physically active women aged 60 to 69 and older than 70, and did not find significant differences in handgrip. The similar handgrip values between active and sedentary subjects may be explained by the use of hands and wrists in home-making tasks or other daily activities, and by the little attention given to handgrip development in a workout routine[21]. Muscle strength of the upper limbs at an adult age has been associated to functional incapacity at old age[22]. Handgrip values have showed a significant association with functional incapacity: subjects with less strength values present lower walking speed and a risk twice as high of self-care inability, suggesting that measuring this variable at an adult age may serve as a prognosis for physical incapacity at old age. Analyzing this variable, Rantanen *et al.*[18] observed that decrease of upper-limb strength was almost four times higher in depressed and underweight subjects, and twice as higher in depressed, normal weight subjects, compared to non-depressed, overweight subjects. These data suggest that depression and low weight in elders are considerable determining upper-limb muscle strength factors. If we are to consider the manual handgrip decrease of 0.6 to 1% reported in the literatura[23], the values found in our study were stable (for both right and left side) over the one-year period. Variations of up to 10% were found; however, they were not significant for any of the three age groups assessed. In spite of the physical exercise program developed at the center for elders not including specific handgrip activities, perhaps the engagement of these women, of the three age groups investigated, in house tasks and daily-life activities that require this type of strength might have been enough for them to present the handgrip values found at six and 12 months, as previously described by Rikli and Edwards[21]. Similarly, these data confirm Spirduso's observations[24], that the strength of muscles used in daily-life activities tend to present a more stable pattern during the aging process than the muscles used in more specialized activities.

The test of vertical impulsion without the use of arms, to indirectly assess the strength of lower limbs, evidenced a pattern of stable behavior for the three groups (women from 50 to 79 years of age), similarly to what was found for the upper limbs. Considering that this variable is instrumental for performing daily activities, thus for keeping mobility and functional capacity at old age, this pattern presented by the groups is extremely positive, as scientific evidences typically point to an annual decrease of 1.4% in lower-limb strength[23]. Considering that the exercise program the ladies were regularly involved in did not include exercises with weights for lower limbs, the keeping of lower-limb muscle strength by the three groups over a period of one year may be explained by the practice of exercises involving lower-limb muscle contraction and by the group's walking standard, in addition to house tasks involving vigorous and moderate physical activities, and that play an important role in keeping muscle strength. In the analysis made by Rantanen and Heikkinen[25] to compare maximum isometric muscle strength of individuals over 80 years of age before and after a five-year period according to gender and level of physical activity, it was evidenced a significant decrease of lean mass and muscle strength in female subjects. However, men and women with high level of physical activity practice presented higher muscle strength levels than their sedentary counterparts. Accordingly, Lord *et al.*[26], when analyzing women aged 57 to 75 years involved in physical exercise programs for more than one year, found that their physical performance was better than that of women who did less than 30 minutes of exercise a day. Thus, their data also confirm the results from our study in relation to the keeping of muscle strength that occurred over the period of time investigated, regardless of the chronological age of the subjects.

Data presented by Andrade *et al.*[16] from women aged 30 to 74 who practiced physical activity evidenced a decrease in neuromotor performance with age, being such loss higher for agility and lower-limb strength, rather than upper-limb strength. According to these data, for the variables considered, for subjects aged 30 to 73, the losses were of 67% for agility, 58% for lower-limb strength, and 28% for upper-limb strength. However, the transversal design of their study limit any extrapolation to our findings.

Trunk flexibility, assessed in our study by the sit-and-reach test, showed for the three age groups values whose increase tendency of 6% to 15% did not significantly change at the time interval considered. In spite of this test being broadly used in the area of sports science, there is not much information about progression of this variable with aging in physically active subjects. Some of the available data consider the short-term effects of specific physical activity programs or exercise, as a similar study by Petroski[27], who analyzed the effects of a physical activity program in women and men aged 59 to 73 years, and found significant increase in static balance and trunk flexibility after a 1-year period. With a sample of institutionalized elderly women, Benedetti e Petroski[28] found, after a five-month exercise program, a significant improvement of flexibility, balance, and walking speed, and no significant differences for handgrip. Another national investigation that assessed the effects of water exercises (hydro-gymnastics) in physical fitness was the one carried out by Madureira and Lima[29] with women aged 57 to 77 years. The authors noted that after four months of exercises, there were no significant changes in handgrip and trunk flexibility. In a longer study, Rikli and Edwards[21] assessed the three-year effects of an exercise program in previously sedentary women aged 57 to 85 years. After one year, the authors observed significant increase in static balance, trunk and shoulder flexibility, and handgrip, and improvement of response time.

Results of static balance for the different age groups (50-59, 60-69 and 70-79 years) found in the study did not show statistically significant differences between the assessments, even when the groups of 60-69 and 70-79 years presented positive and negative variations ranging from 13% to 26%. This may be due to the test's error margin, as its reliability was of $r = 0.75$.

In the case of our study sample, women of all age groups managed to keep both mobility and level of physical activity over a one-year period regardless of their chronological age. An unexpected effect in the functional capacity variables was a significant improvement in walking speed and in rising from a chair after the 12-month interval, particularly in the groups of 50-59 and 60-69 years. The velocity of rising from a chair had a significant increase of about 21% for these two groups, whereas the oldest group (70-79 years), in spite of the tendency for improvement, kept its values over that time interval. With a similar pattern, the regular walking speed had a significant increase (10%) in those same groups after 12 months. On the other hand, the behavior of the maximum walking speed had a different progression, significantly increasing in almost 8% in the oldest groups (60 to 79 years). Variables like walking speed and rising from a chair highly depend on the muscle strength of lower limbs, which, as previously stated, was not changed in any of the evaluated groups; this might explain why such mobility variables did not decrease in any of the considered age groups. The aging effects on muscle strength, recently summarized by Matsudo *et al.*[23], include a decrease in strength of 10-15% per decade from age 50 on, and a decrease in muscular contraction velocity that may affect walking speed and rising from a chair movement. However, this did not happen in our group over the period of time considered, probably due to their participation in the exercise program and their level of involvement with home-making tasks.

On the other hand, association among lower-limb muscle mass, muscle strength and neuromotor performance was also analyzed by Visser *et al*[30]. The authors mention that between ages 20 and 70, muscle-skeletal mass of upper and lower limbs decreases about 11% in women and 15% in men. In that study, the authors assessed lower-limb muscle mass and neuromotor performance, with the velocity test to walk six meters and velocity of rising from a chair in five consecutive attempts. Thus, with tests similar to the ones of our study, the authors observed an association between lower-limb low muscle strength, but not muscle mass, and poor neuromotor performance in elderly men and women, suggesting that strength seems to be more important than muscle mass for daily activities neuromotor performance, such as walking and rising from a chair.

According to the review by Daley and Spinks[31], other mechanisms that may be involved in balance and walking changes are skin and proprioceptive sensation threshold, that increase with age, particularly in lower limbs, reducing the vibration perception of knee joint. As a good part of posture-controlling receptors are in the knees, such loss may significantly decrease balance control, and is the main accountable for gait dysfunction in the elderly. However, according to the authors, elderly women who practice exercises show less postural deviation than sedentary ones: the more one is active, the less one presents postural deviation. In this sense, women who took part in energetic activities over periods of time from six weeks to 10 years showed a better performance than sedentary women of the same age. These findings help to understand why, in our study, we observed a stability of balance and an improvement of walking speed over a 12-month period in women of different age groups regularly involved in the practice of physical activity for at least two years at the time of the assessment.

According to the previously mentioned authors, the walking speed of a person has a linear decrease with age, due not only to a decrease in muscle strength, but also to a decrease in the frequency of strides, and particularly to a decrease in length of the strides, variables that were not measured in our study. Daley and Spinks[31] point to the fact that, after the age of 62, there is a decrease in walking speed from 2.5% and 4.5% to 16% and 12% per decade, in males and females, respectively. The length of the stride is also significantly changed at old age, going from 151 to 170 cm in the young population to 135 to 153 cm in elders. For males, changes in walking speed are due to a decrease in the length of the stride, whereas for females it is due to both the length and frequency of the strides as they age. It is also common to see an increase in dorsal flexion and a decrease in ankle plantar flexion. Other factors positively related to walking speed during aging include calf strength, rate of strides, hours spent in activities at the free time, and height. Negatively related factors include variables such as pain in lower limbs and health problems. When these variables were assessed in our study we observed the keeping of lower-limb strength, involvement with regular physical activities, and low prevalence of diseases, aspects that may strengthen the positive effect of walking speed. In this sense, Rantanen *et al.*[32] analyzed balance and muscle strength as the most important requirements for walking, and noted that the risk for an intense walking inability was ten times higher in old people with changes in muscle strength and balance than in those with changes in only one of these two variables. In this scenario, changes in balance reduce participation in recreational activities and home-making tasks for fear of falling, which, on its turn, decreases muscle strength. Likewise, less muscle strength tires or slows people who perform such activities, and hardships in walking and balance lead people to spent more time sitting or at rest, closing a vicious cycle and enhancing functional incapacity. According to data from Frändin and Grimby[33], the level of physical activity of the elderly is moderately and significantly correlated (0.40-0.49) with maximum walking speed, which is highly and significantly correlated (0.67) to the ability of climbing stairs. These observations fully confirm the features presented by the ladies of our study, since not being evidenced a decrease in muscle strength or balance, the walking ability was kept or significantly enhanced over one year for the different age groups evaluated; and their performance of light and heavy house tasks and their pattern for walking and climbing stairs were also kept over this interval of time.

Different investigations have shown a positive effect of physical exercise on walking speed, such as the classic study by Fiatarone *et al.*[34], in which a group of institutionalized elders over 90 years of age was submitted to an eight-week, high-intensity training, and the outcome was a 48% increase in walking speed. In the investigation by Sipila *et al.*[35] with women aged 76 to 78 years, it became evident, after 18 weeks of two different types of training (strength and aerobics), a significant improvement in the maximum walking speed. In another study with residents of a nursing home, MacRae *et al.*[36] determined the effect of a walking program (five times a week, 30 minutes a day), and found a 77% increase of endurance time for walking, and 92% increase in the distance traversed, while walking speed was not significantly changed. In Verfaillie's *et al.*[37] study, the authors found significant improvement in walking velocity, with no changes in stride length, and an improvement of about 30% in chair-rising velocity with the same test of our study. Data suggest that it is likely to be necessary, in addition to aerobic and strength training, a specific walking speed training, in order for an aging individuals to achieve significant improvement in this variable; one must bear in mind, however, that no such walking speed training was provided for the women of our study.

However, in Berg's and Lapp's study[19], an eight-week exercise program with weights adjusted around the ankle was not enough to achieve positive effects on walking speed, suggesting that this type of low-to-moderate intensity training, in spite of improving muscle strength, was not enough to change speed. Similarly, Buchner *et al.*[38] observed that a 26-week of aerobic, strength, and both-combined training was not enough to promote changes in walking speed and in balance of subjects aged 68 to 85 years. Taking into account the scientific evidences, we are led to believe there is great variation in the results of exercises on walking speed, and the different data found by our study for the three age groups are not surprising.

In spite of the limited literature in this area, Daley and Spinks[31] suggest the mechanisms that explain the effects of exercise on walking speed with aging. Aerobic exercise and strength training have shown a positive impact in changes of stride length, and in average length of stride in elderly men. However, the exercise would not influence walking speed of elders, except at a slower pace, which partly explains the results from our study, which showed significant improvement over the year in the regular walking speed, but not in the maximum walking speed. The authors presented evidences that five-year exercise programs have shown improvement in hip flexion and rotation in women aged 50 to 71 years, which also would explain in part the improvements of our subjects in walking speed, as at the time of our evaluation the average participating time in a physical exercise program was of approximately five years. Westhoff *et al.*[39] found that a 10-week, low-intensity strength-training program in subjects older than 65 years was enough to significantly enhance functional capacity, measured by the speed of rising from a chair and walking three meters, and the performance of some instrumental and non-instrumental daily-life activities, and these effects were kept for at least six months. More recently, Puggaard[13] presented the results from an eight-month physical fitness and functional capacity program in healthy women divided in age groups of 65, 75 and 85 years. The results evidenced a significant effect on total physical fitness, aerobic power, and maximum walking speed for the three age groups, suggesting that the beneficial effects from physical training occur over the aging process, regardless of chronological age, which is in accordance to the data of our study.

One of the possible explanations for the significant changes in performance of some functional capacity neuromotor variables, as the speed of rising from a chair and the walking speed, is the neural learning effect or the Hawthorne effect, which relates a voluntary improvement to a psychological motivation[40], which were not controlled in our study. On the other hand, variation of test results when performed in two different occasions cannot be ruled out, as, according to the experience from some authors[35], the coefficient of variation of the speed to walking 10 meters (in our study, three meters) in two consecutive measurements was about 5%, and of the chair-rising test was about 6.8%[37], figures that are below the differences found in our study (8 to 21%, respectively) after 12 months. However, it is important to bear in mind that reliability of the tests used to assess these variables was the lowest from the whole set of tests (r = 0.60 for rising-from-the-chair velocity, and 0.73 for walking velocity), a fact that might have interfered in the final results. In the study by Stessman *et al.*[12], the relationship between the level of physical activity and functional performance in daily life activities was clearly presented. The study subjects who worked out at least four times a week at age 70 kept their functional capacity at age 77, regardless of their health status. Data presented by Visser *et al.*[10] from a prospective three-year study with 2,109 men and women aged 55 to 85 years, performance of mobility (measured by the test of walking six meters, and rising from a chair) decreases in 45.6% of the sample. However, the level of physical activity was positively associated to mobility, i.e., those individuals who kept active had a lower decrease in mobility, and, like us in our study, the authors concluded that regular physical activity may reduce the velocity of mobility-performance decrease.

Some of the study limitations that should be considered prior to the conclusion include: the study began its assessment when the group of women had already started, for at least two years, regular participation in the physical exercise program, and it was not possible to establish the physical activity standard over the life of these women, which certainly influenced the progression of the investigated variables. Similarly, we consider that, for this particular group of subjects, one year is perhaps not enough to detect any deleterious effect from aging, as described by other authors for the overall non-physically active population. However, as the project, that has been developed since 1997, has been, to date, regularly carried out at every six months, these evaluations may be done in the future. Although we did not consider for the present study, a simultaneous assessment of a physically inactive group of women, with social-cultural and health status similar to our subjects, in future analyses, this information may enrich the discussion on the short- and long-term effects of physical activity on the aging process. The lack of prior experience with performance tests and the little experience of the evaluators with some mobility tests at the beginning of the project might have negatively interfered in the study results. However, in later studies and with the same evaluators more experienced, we found a test-reliability standard similar to that from a group of women of the same age group undergoing specific physical exercise programs. Another interesting factor worth considering is that, in spite of their attending the physical exercise program twice a week only (according to the city hall scheduling), there seems to be an effect on the analyzed sample of their keeping physical fitness and functional capacity. Anyway, it is always good to bear in mind that, if evidences from the literature point to a decline of physical and functional fitness with aging, the relative stability seen in the results from our sample of the three age groups in terms of physical activity levels[41], anthropometric profile[42], neuromotor profile, and functional capacity (as in the presented study) strongly suggests a positive effect from regular physical activity, which would work at least as preventing or lessening the degeneration that comes along with the aging process.

CONCLUSION

According to the intrinsic and extrinsic features and limitations of this study, our findings allow us to conclude that: a) In general, neuromotor physical fitness and functional capacity of women from their sixth to eighth decade of life taking part in a regular physical exercise program, assessed at every six months over a one-year period, remained stable. b) A significant improvement was seen in walking speed and velocity to rise from a chair, particularly in women aged 50 to 69 years.

The results suggest that progression of physical fitness and functional capacity has a similar behavior, over a one-year period, in physically active women aged 50 to 79 years, regardless of chronological age. The set of these results, showing a stable longitudinal (physical fitness) or even positive (functional capacity) progression, supports the idea of a favorable effect from the regular physical activity as a powerful tool for prevention and health promotion in the elderly. The profile found also suggests that the active participation of people should be re-tested because, as we could see, the progression of physical fitness and functional capacity of physically active women apparently ensures, regardless of their chronological age, the keeping of a functional status of independence, fostering health and quality of life improvement over the aging process.

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