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PHYSICAL FITNESS AND FUNCTIONAL CAPACITY OF MASTERS ATHLETES ACCORDING TO THREE LEVELS OF ENERGY EXPENDITURE

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José Carlos Lopes Penha
Universidade Paulista – UNIP
Santos, São Paulo, Brasil
https://orcid.org/0000-0001-5631-0743

Wagner Correia Santos
Universidade Federal de São Paulo – UNIFESP
São Paulo, São Paulo, Brasil
https://orcid.org/0000-0003-4102-7376

Oliver Augusto Nascimento
Universidade Federal de São Paulo – UNIFESP
São Paulo, São Paulo, Brasil
https://orcid.org/0000-0003-3138-2219

Emilson Colantonio
Universidade Federal de São Paulo – UNIFESP
Baixada Santista, São Paulo, Brasil
https://orcid.org/0000-0002-6955-324X

José Roberto Jardim
Universidade Federal de São Paulo – UNIFESP
São Paulo, São Paulo, Brasil
https://orcid.org/0000-0002-7178-8187

Abstract: The aim of this study was to compare the physical fitness and functional capacity of masters athletes based on three energy expenditure levels (METs). Methods: Ninety-one masters athletes from Santos, SP, of both sexes, who practice high-intensity sports (HI) (> 6.5 METs: swimming, adapted volleyball, track and field and tennis); moderate-intensity sports (MI) (4-6.5 METs: choreography, ballroom dancing and table tennis); and low-intensity exercises (LI) (< 4 METs: chess, shuffleboard, bocce, dominoes, checkers and gin rummy) physical fitness were evaluated. Results: Right and left handgrip strength was higher in the MI group; the best results on average in vertical thrust (18.0 cm), getting up from a chair in 30 seconds (19.2 repetitions) and static balance (29.3 seconds) occurred in the HI group; flexibility in the MI and HI groups ranged from 27.4 to 25.8 cm without significant differences; stationary gait in the HI group averaged 135.6 repetitions; in the Shuttle run the MI and HI groups had the shortest time on average, 15.8 and 15.7 seconds respectively, with significant differences. Conclusion: Masters athletes who practice sports in HI have greater flexibility, balance, agility and aerobic power compared to LI practitioners, indicating better health, physical fitness and functional capacity.**Keywords**: sports, physical exercise, metabolism, aging, quality of life

INTRODUCTION

It is recognized that older adults have less physical capacity and more fatigue, which can be partially attributed to age-related declines in muscle mass. Decreased skeletal muscle mass and strength (sarcopenia) in older adults is associated with functional impairment, physical disability, morbidity, and mortality (JANSSEN *et al.*, 2002, p. 889-896).

Strategies to reduce the loss of muscle mass and, consequently, muscle strength (dynapenia) have been developed with the aim of improving or maintaining quality of life with aging. It can be said that the practice of physical activity in the elderly is of fundamental importance for public health (PAYNE & DELBONO, 2004, p. 36-40).

A health recommendation for seniors is regular exercise. Practicing a master's sport not only keeps seniors engaged in an exercise they enjoy, but also maintains their physical capacity, thereby improving their health and quality of life (GOŹDZIEJEWSKA *et al.*, 2016, p. 19-28). For older adults to maintain their physical and functional fitness levels, regular physical activity two to three days per week may be sufficient. However, for older adults involved in masters competitions, five to seven days of training per week are necessary to achieve and maintain physical fitness levels and peak performance conditions. The ideal training volume is one that meets reasonable fitness goals (ACSM, 2023)**.**

Masters athletes are cited in several scientific studies as an example of longevity due to their high intensity exercise (HAWKINS *et al.*, 2003, p. 1009-1011). According to Caspersen *et al.* (2000, p. 1601-1609), to achieve the state corresponding to the definition of being physically active, it is important to include resistance and flexibility exercises. In old age, there are numerous changes in the athlete's life that interfere in different aspects of their sporting and personal life (HATTERSLEY *et al.*, 2019, p. 11-16).

There are few reports in the literature on the assessment of physical activity levels in master athletes using the metabolic equivalent of task (METs). A MET is defined as the resting metabolic rate. This knowledge can guide experienced and elderly athletes to adjust physical activity/exercise variables (e.g. intensity, frequency and duration) to obtain maximum benefits and avoid exhaustion. Therefore, considering that the accurate determination of physical activity intensity is expressed as a function of energy expenditure, epidemiological studies in this area using METs as a measurement parameter are important (POELHMAN *et al.,* 2022, p. 1004-1009; VARO *et al.,* 2003, p. 138-146; RISING *et al.,* 1994, P. 800-804).

The increase in physical fitness varies between 10 and 25% from 4 METs. The ideal would be to reach aerobic fitness up to 10 METs, from 10 multiples of METs the risk of death no longer decreases (KOKKINOS *et al.,* 2010, p. 790-797; KOKKINOS & MYERS, 2010, p. 1637-1648). The current American College of Sports Medicine recommendations for exercise for health gains are 150 min/week of moderate-intensity activity or 75 min/week of vigorous-intensity activity, equivalent to 7.5 MET-hours/week (ACSM, 2023; GARBER *et al.,* 2011, p. 1334-1359). Vigorous-intensity exercise appears to provide greater health benefits for primary and secondary prevention than moderate-intensity exercise at a similar volume (WEN *et al.*, 2011, p. 1244-1253; SWAIN & FRANKLIN, 2006, p. 141-147). A recent World Health Organization (2022) overview suggested that individuals who engage in recommended levels of physical activity have a 20% to 30% reduced risk of premature death, which is corroborated by the literature (MATTHEWS *et al.*, 2020, p. 686-697; OJA *et al.,* 2017, p. 812-817)**.**

Thus, the aim of this study was to compare the physical fitness and functional capacity of masters athletes according to three levels of energy expenditure based on METs.

METHODS

SAMPLE

The sample was recruited by convenience, according to the following inclusion criteria: master athletes over 60 years of age who participated in official competitions, both genders, with regular training in the city of Santos (Brazil), without limitations that would hinder the evaluations and who signed the Free and Informed Consent Form. Those who had serious injuries or illnesses or did not agree to participate in the study were excluded. The study was approved by the Research Ethics Committee of the University (number 473,532).

The sample was divided into three sports groups according to energy expenditure, metabolic equivalent of task (METs), according to Ainsworth *et al.* (2011, p. 1575-1581). Group A (<4 METs), considered as low-intensity (LI) sports, the athletes practiced the following sports: chess, shuffleboard, bocce, dominoes, checkers and cards; Group B (4 to 6.5 METs), considered as moderate-intensity (MI) sports, choreography, ballroom dancing and table tennis; and Group C (>6.5 METs), considered as high-intensity (HI) sports, swimming, adapted volleyball, track and field and tennis.

MEASUREMENTS

Body mass was measured using a digital scale (Toledo - model 2096PP/2-SP, Brazil) and recorded in kilograms. The athletes were barefoot and wore comfortable clothes. The scale was recalibrated after every ten athletes. Height was measured using a metallic tape measure (graduated in centimeters and decimeters) fixed to a wooden pillar and an anthropometric wooden cursor. Body mass index (BMI) was calculated as the ratio between body mass (in kilograms) and height in meters squared (BM/H^2), according to Heyward & Stolarczyk (2000).

Bioimpedance - Bioelectrical impedance analysis (BIA) was performed (Quantum BIA-101Q, MI., USA) to assess fat mass and fat-free mass (both in Kg and %). Values were obtained using the resistance and reactance parameters applied in an appropriate equation and measured with the patient in supine with electrodes positioned in the right hand and foot. Measurements were performed after fasting for at least four hours (KYLE *et al.*, 2004, p. 1226-1243; BRAZILIAN ASSOCIATION OF NUTROLOGY & BRAZILIAN SOCIETY OF PARENTERAL AND ENTERAL NUTRITION, 2009).

Waist and hip circumference - Waist and hip circumferences were measured using a flexible tape measure, with an accuracy of one millimeter according to Heyward & Stolarczyk (2000). Two measurements (in centimeters) were performed with the individuals standing, facing the examiner, and legs slightly apart. Waist circumference was measured at the midpoint between the inferior border of the lowest rib and the iliac crest, considering the recommendations of the World Health Organization (1995). The hip circumference was measured at the level of the largest lateral extension of the hips, with the participant in the right lateral position and using only the underwear. The waist-hip ratio (WHR) was calculated as the ratio between the waist and hip circumferences. According to the World Health Organization (1998), the cutoff value for the waist/hip ratio is < 0.85 for females and < 1.0 for males, and higher values are associated with health risk.

ASSESSMENTS

The assessments were carried out in the morning at the Rebouças Sports and Recreation Center, located in the city of Santos (Brazil). The tests used aimed to measure the neuromotor profile of physical fitness and the mobility variables of functional capacity and followed the international standardization adopted by Matsudo (MATSUDO, 2004).

Tests:

a) Upper limb muscle strength, determined indirectly using the handgrip test or manual dynamometry, with an adjustable and calibrated dynamometer with a scale of 0 to 100 kilograms (Sanny®, Brazil); b) Lower limb muscle strength, measured indirectly using the vertical jumping test without the aid of the upper limbs and the test of rising from a chair in 30 seconds; c) Trunk flexibility, measured with the Wells "sit and reach" test using a 48 cm wooden bench, with a 55 cm measuring tape attached to the bench, starting at 0 (zero) at the part closest to the person being assessed; d) Static balance with visual control, where the athletes were instructed to look at a fixed point on the wall, at a distance of two meters, with their hands on their waist and flex the knee of one leg at 90°, remaining in this position for at least thirty seconds; e) For agility, the Shuttle run test (seconds) was used; f) Metabolic capacity was assessed using the two-minute stationary gait test, which indirectly measures aerobic endurance (number of steps) in elderly individuals. A group of 18 masters athletes from this sample underwent two assessments seven days apart, with the aim of determining the reproducibility of the tests (MATSUDO, 2004).

The athletes answered a questionnaire that included questions about education, medications used and general anamnesis. In addition, a questionnaire about the training program included time and weekly frequency of strength training, muscular resistance, flexibility, cardiovascular endurance, balance, reaction and movement time, agility and coordination.

STATISTICAL ANALYSIS

The sample was chosen by convenience, according to the registry of master athletes in the Municipal Department of Sports. Data are presented as mean and standard deviation. A questionnaire was used to describe the characteristics of the sample, the responses were grouped by similarity and the percentage was calculated. The groups were compared using one-way ANOVA and the Bonferroni post-hoc test was used to identify differences between the groups. The reproducibility of the tests was determined by calculating Pearson's linear correlation coefficient between the two assessments performed. The neuromotor variables of physical fitness were measured and described as mean and standard deviation between the groups. Inferential analyses were performed using the Statistical Package for the Social Sciences (SPSS, IBM Corp., USA), version 10.0 for Windows, and the significance level was set at $p < 0.05$ (two-tailed).

RESULTS

Table 1 shows that there was a higher proportion of female athletes, aged around 65 years, with a wide range of education levels, with 39.6% of the athletes having only completed elementary school and 23.1% having completed higher education. Seventy percent of the athletes were retired. Regarding their economic situation, 70.3% of the masters athletes had a monthly income of one minimum wage (the minimum wage at the time was US$334).

Table 2 shows the groups of masters athletes grouped by energy expenditure in METs and the variables related to muscle and fat mass. Masters athletes participating in the most vigorous activities, i.e. HI (>6.5 METs), had significantly higher percentages of lean mass and lower body weight, body mass index, percentage of body fat, and waist-to-hip ratio than masters athletes in the light and moderate activity groups, i.e. LI and MI (<4 METs and 4 to 6.5 METs, respectively).

The results of the metabolic and neuromotor variables, upper and lower limb strength, flexibility, balance, agility by Shuttle run and stationary gait are summarized in Table 3. Aerobic endurance measured by the stationary gait test was greater in the group > 6.5 METs with an average of 135.6 (±17.2) steps. Lower limb strength, assessed by the 30-second chair-rise test, was greater in the group > 6.5 METs with an average of 19.2 (±4.8) times. Regarding upper limb strength, measured by dynamometry using the right (15.7 kgf ±7.8) and left (15.0 kgf ±6.9) hands, it was better in the group (< 4 METs) compared to the other groups. The behavior of lower limb muscle strength, determined by the vertical jumping test, was greater in the group > 6.5 METs, with 18.0 cm (±5.9).

Lower body flexibility showed the best results in the 4 to 6.5 METs and > 6.5 METs groups, with averages of 27.4 (±8.9) and 25.8 (±7.1) cm, respectively. In the case of static balance, in which the expected result is 30 seconds, the > 6.5 METs group presented the best result, 29.3 (±17.0) seconds, but without significant differences between the groups. Regarding general mobility of functional capacity, the Shuttle run showed a significant difference in the 4 to 6.5 METs and > 6.5 METs groups, which presented the shortest times, on average, 15.8 (±2.5) seconds and 15.7 (±2.9) seconds, respectively (Table 3).

Regarding the results of the reproducibility of the neuromotor tests of the 18 masters athletes, there was a significant and excellent correlation (equal to or greater than 0.98) in all variables, ranging from 0.98 to 1.00 (Table 4).

DISCUSSION

The aim of this study was to compare the physical fitness and functional capacity of masters athletes according to three levels of energy expenditure based on METs. The study showed that athletes with higher energy expenditure (>6.5METs) presented significantly higher values in the percentage of lean mass, lower values of body mass and BMI, percentage of body fat and waist/hip ratio; however, there was no significant difference between the three groups of athletes in the physical and neuromotor fitness tests; with the exception of the agility test (Shuttle run). However, the highest values were obtained with the group of athletes with the highest energy expenditure.

The endurance capacity of the individuals was assessed by the two-minute walk test. Masters athletes who practiced exercises with high energy expenditure (> 6.5 METs) presented a greater number of steps (mean value: 135.5 times) among the three groups. The step values given in our study are in agreement with those found in a study carried out in the American population with the same age group (RIKLI & JONES, 1999, p. 129-161; MIOTTO *et al.,* 1999, p. 339-353); as well as in a study with Brazilian individuals (NETO & FILHO, 2006), with the same age group as the present study. A decreased value in the stationary gait is indicated as a predictor of mortality and predisposes the elderly to suffer accidents due to falls and fractures (GEERSE *et al.*, 2019, p. 203-210).

Handgrip strength reflects upper limb muscle strength, but is also recognized as a reflection of overall muscle strength (MATSUDO *et al.,* 2000, p. 21-32). O valor médio da dinamometria das mãos direita e esquerda (15,7kgf e 15,0kgf, respectivamente) foi melhor no grupo <4 METs do que nos outros dois grupos. It is recognized that individuals who maintain high levels of handgrip strength in middle age are less likely to experience functional disability in old age (MARTIN *et al.,* 2012, p. 494-504)**.** This knowledge confirms the observations made by Spirduso (2005) that the muscular forces used in daily activities tend to present a more stable pattern during the aging process, than the muscles used in more specialized activities.

The vertical jump test, without the aid of the arms, indirectly assesses the strength of the lower limbs. The highest result was obtained in the group of athletes with > 6.5 METs, which could be expected, since these are the athletes who participate in sports that require greater physical capacity. The vertical jump movement primarily involves the gastrocnemius, quadriceps, hamstrings and gluteus muscles. In addition, the abdominal and lumbar muscles are used to stabilize the trunk and maintain balance, which are also the most trained muscles in athletes who practice intense exercises such as swimming, adapted volleyball, track and field and tennis. According to Ramírez-Campillo *et al*. (2014, p. 51-57), high-speed resistance training is more effective than low-speed resistance training in increasing functional capacity and muscle performance in older adults. The training of athletes in the >6.5 METs group includes these types of exercises.

The sit-and-reach test (Wells Bench) assesses trunk flexibility, and in this study showed the best results in the groups 4 to 6.5 METs and > 6.5 METs, with averages of 27.4 (±8.9) and 25.8 (±7.1) cm, respectively, with no difference between them, but higher than in the < 4 METs group, which presented 23.1 (±12.3) cm. There is not enough information on the evolution of this variable with age and in master athletes, although the test is widely used in the area of sports science. According to Rikli & Edwards (1991, p. 61-67), a functional gymnastics program in previously sedentary women aged 57 to 85 years evaluated its effects in a three-year study. After the first year of training, a significant increase in static balance, trunk and shoulder flexibility and hand grip strength were observed, as well as an improvement in reaction time. Women maintained the values obtained after the first year of exercise in the following two years.

Hip flexibility has been considered important for better performance of activities of daily living (POLLOCK *et al.,* 1994, p. 88-95), such as climbing stairs, tying shoes, putting on socks, and getting on and off buses. The reduction of this capacity has been considered as the major cause of discomfort and physical dependence in elderly individuals (JETTE & BOTTOMLEY, 1987, p. 1537-1542). Flexibility is also an important capacity for health, to improve range of motion and joint mobility (MAZO *et al.,* 2009).

In the case of static balance, the three groups presented similar and inferior results to the ideal. A study that evaluated balance in men and women aged 75 years, found that the best performance in balance tests in women was associated with good visual acuity, low vibro-tactile thresholds and high psychomotor speed (ERA *et al.*, 1996, p. 53-63).

The best result in the chair-rise test in 30 s was observed in the group > 6.5 METs, which achieved an average of 19.2 (± 4.8) repetitions. Sports in the > 6.5 METs group usually require power training, which contributes to masters athletes having greater functional capacity compared to traditional training[39]. To perform daily activities, lower limb strength is essential. The preservation of mobility and functional capacity during aging is extremely positive, since scientific evidence indicates an annual loss of 1.4% in lower limb strength (VETROVSKY *et al.,* 2019, p. 113-131).

This annual loss generally occurs in sedentary individuals, a different result when evaluated in physically active individuals, as in the present study with masters athletes. The preserved lower limb muscle strength found in these athletes can be explained by the performance of exercises that involve muscle contraction, as well as vigorous and moderate physical activities, which play an important role in maintaining muscle strength (VETROVSKY *et al.,* 2019, p. 113-131).

Neuromotor performance in relation to BMI was lower than expected in patients with higher BMI, especially in agility tests, and in agreement with the literature (ANDRADE *et al.,* 1995, p. 5-14). Athletes in the group that performed higher intensity exercises generally had a higher percentage of lean mass and were those who presented better results. These results suggest that anthropometric variables can affect the neuromotor performance of elderly individuals (PENHA *et al.,* 2022, p. 2-14).

Body agility, assessed by the Shuttle run test, had its lowest value in the <4 METs group, which included exercises with lower physical demand. This group also showed the lowest physical fitness in other tests. An annual physiological loss of 1% in agility has been described, which may be associated with the loss of muscle fiber size, reaching 26% between the ages of 20 and 80 in type II fibers (ANDRADE *et al.,* 1995, p. 5-14).

Low body mass, income and educational level are factors that can interfere with the decline in physical fitness, especially in muscle strength, balance and walking, as also found in the study by Seeman *et al.* (1994, p. 97-108), when evaluating independent elderly individuals aged 70 to 79 years over a three-year period. In the present study, the distribution of educational level and economic situation of the groups of master athletes showed that more than 70% of the athletes were retired, had an income below the minimum wage and 25.3% had only primary education.

There are some limitations to the study that we should consider. If nutritional variables were analyzed, they would allow us to better understand the effects of physical activity on aging processes related to muscle mass, fat accumulation, and health conditions. Another limitation is related to the cross-sectional design of the study, which makes it difficult to establish cause-and-effect relationships and monitor energy expenditure over time.

CONCLUSION

Masters athletes with high energy expenditure have better results for body mass, muscle mass, as well as relatively better aerobic endurance and lower limb strength, suggesting a better level of physical fitness and functional capacity than those with low energy expenditure. Maintaining physical activity throughout life should be encouraged, given its possible benefits to health, longevity and social interaction.

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Variables	x (sd)
Male N (%) Female N (%)	37 (40,7%) 54 (59,3%)
Age (years)	69,5 ± 6,8
Body mass (kg)	70,2 ± 14,5
Height (cm)	161,2 ± 14,5
Level of Education	**frequency (%)**
Elementary School	23 (25,3%)
Midle School	13 (14,3%)
High School	34 (37,4%)
College / University	21 (23,1%)
Economic Situation	**frequency (%)**
Income up to 1 minimum wage	64 (70,3%)
Income1-3 minimum wage	7 (4,4%)
Income 3-5 minimum wage	4 (8,3%)
Income > 5 minimum wage	8 (8,8%)
Family dependent	8 (8,8%)

Table 1. Sociodemographic characteristics of masters athletes of Santos city, Brazil, (N = 91).

x (sd): mean (standard-deviation).

Variables	< 4 METs / LI (n:15)	4 a 6,5 METs / MI (n:58)	> 6,5 METs / HI (n:18)	P
Male (n %)	8 (53,3%)	20 (34,5%)	9 (50, %)	
Female (n %)	7 (46,7%)	38 (65,5%)	9 (50%)	
Age (years)	69,7 (7,2)	68,7 (6,0)	71,7 (8,6)	0,273
Body mass (kg)	74,4 (11,1)	72,4 (15,1)	59,6 (9,2) *	0,02
Height (cm)	165,0 (8,9)	157,7 (7,4)	161,2 (16,9)	0,359
BMI (kg/m^2)	27,3 (3,3)	27,1 (4,1)	23,9 (2,9) *	0,007
WC (cm)	94,3 (10,5)	89,7 (12,8)	87,7 (22,1)	0,419
HQ (cm)	101,3 (7,8)	102,2 (8,7)	92,8 (6,5) *	<0,001
WHR (cm)	0,93 (0,09)	0,88 (0,09)	0,95 (0,27)	0,11
LM (kg)	46,0 (7,4)	42,9 (9,1)	39,7 (6,0)	0,109
LM (%)	62,0 (7,1)	59,7 (7,0)	67,2 (9,2) *	0,001
LMI (kg/m^2)	16,7 (1,4)	16,0 (2,0)	15,9 (1,3)	0,302
FM (kg)	28,5 (7,6)	29,5 (9,0)	19,9 (7,4) *	<0,001
FG (%)	38,0 (7,0)	40,3 (7,0)	32,8 (9,3)	0,001
FMI (kg/m^2)	10,5 (3,0)	11,1 (3,2)	8,0 (3,0)	0,002

Table 2. Anthropometrics characteristics, lean and fat mass variables, according to the METs (metabolic equivalent task) for physical activity by master athletes of Santos city, Brazil (N = 91).

‡ $p < 0,05$ versus group < 4 METs; * $p < 0,05$ versus groups < 4 METs e 4 a 6 METs; Mean (standard-deviation); BMI: body mass index; WC: waist circunference; HC: hip circunference; WHR: waist-hip ratio; LM: lean mass; LMI: lean mass index; FM: fat mass; FMI: fat mass index.

Variables	< 4 METs (n:15)	4 a 6,5 METs (n:58)	> 6,5 METs (n:18)	P
Male (n %)	8 (53,3%)	20 (34,5%)	9 (50%)	
Female (n %)	7 (46,7%)	38 (65,5%)	9 (50%)	
Handgrip right (kgf)	15,7 (7,8)	13,5 (6,8)	12,8 (5,9)	0,458
Handgrip left (kgf)	15,0 (6,9)	13,5 (7,1)	14,0 (6,8)	0,727
VJT (cm)	17,0 (6,2)	17,1 (5,7)	18,0 (5,9)	0,785
Flexibility (cm)	23,1 (12,3)	27,4 (8,9)	25,8 (7,1)	0,278
Static Balance (seg.)	27,8 (12,1)	28,9 (8,4)	29,3 (17,0)	0,271
Chair Test 30 s (nº)	17,7 (4,6)	18,2 (4,9)	19,2 (4,8)	0,673
Gait Test (steps)	128,7 (27,4)	128,3 (24,9)	135,6 (17,2)	0,524
Shuttle Run (seg.)	18,0 (3,5)	15,8 (2,5) ‡	15,7 (2,9) ‡	0,032

Table 3. Physical fitness variables according to the classification by METs (metabolic equivalent task) for sports activities by master athletes of Santos city, Brazil (N = 91).

‡ p < 0,05 versus grupo < 4 METs; * p < 0,05 versus grupos < 4 METs e 4 a 6 METs; VJT: vertical jumping test.

Variables	Test		Retest		
Tests	x	SD	x	SD	r
Handgrip right (kgf)	13,5	7,8	15,7	5,9	0,98*
Handgrip left (kgf)	15,0	6,9	14,0	6,8	0,98*
VJT (cm)	16,0	6,0	18,0	5,0	0,99*
Flexibility (cm)	27,9	10,0	28,6	10,1	1,00*
Balance (seg.)	27,6	8,8	28,1	7,6	1,00*
Chair Test 30s (nº.)	15,1	3,1	15,2	3,1	0,99*
Gait Test (steps)	95,8	17,2	95,8	17,1	1,00*
Shuttle Run (seg.)	19,9	3,8	20,0	3,9	0,99*

Table 4. Mean (x) and standard deviation (SD) values in the test and retest; reproducibility (r) of the tests performed, in the group of 18 volunteer master athletes after one week of the first evaluation.

*p < 0,05.