

## Effect of the Aquatic Program on Strength and Indicators of Sarcopenia in Elderly Efecto del programa acuático sobre la fuerza y los indicadores de sarcopenia en ancianos

\*Antonio Michel Aboarrage junior, \*\*Fabiana Rodrigues Scartoni, \*\*\*Alexandre Fernandes Machado, \*\*\*Danilo Sales Bocalini,  
\*Flavia Giovanetti Yazigi

\* University of Lisbon (Portugal), \*\* Catholic University of Petrópolis (Brasil) \*\*\*Federal University of Espirito Santo (Brasil)

**Abstract.** The present study investigated the effect of implementing the Hidrotreinamento® aquatic program on strength and sarcopenia indicators in older people who have already practiced aquatic exercises. Methods: 51 Volunteers were organized into two groups. The experimental Hidrotreinamento® (HTG) followed a new periodized program with controlled load progression, and the Aquatic Exercise Community (AEC) control group maintained the community aquatic program they had previously carried out, a non-periodized program without controlled load progression. Both groups were subjected to the same battery of tests at the baseline and after 16 weeks of the aquatic program. Handgrip, Time Up and Go (TUG), Chair Stand Test (CST), Chair Sit and Reach Test (CSRT), Back Scratch Test (BST), body composition, and the questionnaires SARC-F and IPAQ. ANCOVA was used to compare differences between groups. Results: A significant correlation was found between age and Sarc-F ( $p > 0.05$ ), age and TUG ( $p > 0.05$ ), BMI and TUG ( $p > 0.05$ ), BMI and Handgrip ( $p > 0.05$ ), Fat mass and all strength variables ( $p > 0.05$ ) and between IPAQ sitting time and handgrip ( $p > 0.05$ ). Regarding physical tests, a significant group effect was found for handgrip and the BST ( $p > 0.05$ ). Relative results for changes within each group HTG and AEC, respectively, after the aquatic program were: handgrip (11.75%; 0.04%); TUG (117.2%; 12.06%); CST (21.6%; 2.96%); BSTR (21.7%; 2.5%); BSTL (12.2%; 13.6); CSRTR (6.6%; 2%); CSRTL (1.9%; 1.2%) Conclusion: The Hidrotreinamento® aquatic program appears to be effective in combating sarcopenia and increasing strength in older adults.

**Keywords:** Muscle strength, older adults, sarcopenia, physical fitness, aging.

**Resumen.** El presente estudio investigó el efecto de la implementación del programa acuático Hidrotreinamento® sobre los indicadores de fuerza y sarcopenia en personas mayores que ya practicaron ejercicios acuáticos. Métodos: 51 voluntarios se organizaron en dos grupos. El experimental Hidrotreinamento® (HTG) siguió un nuevo programa periodizado con progresión de carga controlada, y el grupo control Aquatic Ejercicio Community (AEC) mantuvo el programa acuático comunitario que habían realizado previamente, un programa no periodizado y sin carga controlada. Ambos os grupos fueron sometidos a la misma batería de pruebas al inicio y después de 16 semanas del programa acuático. Handgrip, Time Up and Go (TUG), Chair Stand Test (CST), Chair Sit and Reach Test (CSRT), Back Scratch Test (BST), composición corporal y los cuestionarios SARC-F e IPAQ. Se utilizó ANCOVA para comparar las diferencias entre grupos. Resultados: Se encontró correlación significativa entre edad y Sarc-F ( $p > 0,05$ ), edad y TUG ( $p > 0,05$ ), IMC y TUG ( $p > 0,05$ ), IMC y empuñadura ( $p > 0,05$ ), masa grasa y todos variables de fuerza ( $p > 0,05$ ) y entre tiempo sentado IPAQ y agarre manual ( $p > 0,05$ ). En cuanto a las pruebas físicas, se encontró un efecto grupal significativo para la prensión manual y el BST ( $p > 0,05$ ). Los resultados relativos para los cambios dentro de cada grupo HTG y AEC, respectivamente, después del programa acuático fueron: agarre de la mano (11,75%; 0,04%); TUG (117,2%; 12,06%); CST (21,6%; 2,96%); BSTR (21,7%; 2,5%); BSTL (12,2%; 13,6); CSRTR (6,6%; 2%); CSRTL (1,9%; 1,2%) Conclusión: El programa acuático Hidrotreinamento® parece ser eficaz para combatir la sarcopenia y aumentar la fuerza en adultos mayores.

**Palabras clave:** Fuerza muscular, adultos mayores, sarcopenia, condición física, envejecimiento.

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Antonio Michel Aboarrage junior

ninousa@hotmail.com

### Introduction

Evidence shows that physiological and functional declines in older individuals are more closely related to poor physical fitness than aging (Dantas et al., 2022; Fletcher et al., 2018; Scartoni et al., 2020), Presenting physiological changes that propagate in the cardiovascular system (Sant'Ana et al., 2020), the respiratory system (Fraga, Cader, Ferreira, Giani, & Dantas, 2011), the neuromuscular system (Bondi et al., 2021; Hoffmann et al., 2022), and in the nervous system (O. G. L. Ferreira, Maciel, Costa, Silva, & Moreira, 2012) affecting functional capacity and often independence of movement (Cipriani, Meurer, Benedetti, & Lopes, 2010).

One of the systems most affected by aging is the neuromuscular system, which determines the ability to exert strength, endurance, and power, considered primary components in quality locomotion. Besides the motor factor, these changes can trigger and accelerate the process of

sarcopenia (dos Reis et al., 2020). However, physical exercises are already well-established as the primary intervention to minimize the detrimental effects of aging. Among the variety of modalities to be used as a dose-response for this purpose are aquatic exercise programs, which have shown positive and significant effects on changes in the functional fitness of older individuals (Silva, 2018) in prevention, rehabilitation, and training (Fuentes-Lopez et al., 2021; Ha, Yoon, Yoo, Kang, & Ko, 2018; Irandoust et al., 2019; Kim, Vakula, Waller, & Bressel, 2020; Martinez-Carbonell Guillamon, Burgess, Immins, Martinez-Almagro Andreo, & Wainwright, 2019).

Specifically, the literature reports positive effects of this practice on overall muscle strength, cardiorespiratory endurance, muscular power, range of motion, balance, agility, and controlling symptoms of musculoskeletal system diseases (Aboarrage Junior et al., 2018; Alberton, Antunes, et al., 2011; Alberton, Cadore, et al., 2011; Colado & Garcia-Masso, 2009; Colado et al., 2010; Colado, Triplett,

Tella, Saucedo, & Abellan, 2009; J. P. Ferreira et al., 2020). While many scientific articles have been published on the effects of aquatic exercises on the neuromuscular system and their various mechanisms of action, few controlled protocols are easily reproducible. There are many articles on the effects of aquatic exercise programs in populations with distinctive characteristics, but they are often inadequately delineated in methodology, lacking clarity and conciseness regarding exercise programs with defined movement patterns. Within this context and considering all the reasons previously mentioned, and understanding physical exercise as a practice that involves planning and systematization for the maintenance and/or improvement of physical fitness (Strath et al., 2013), it becomes relevant and, at the same time, necessary to conduct a preliminary evaluation of the variables that make up physical fitness. This is essential for correctly prescribing training programs tailored to this population (O. G. L. Ferreira et al., 2012).

Therefore, this study aims to evaluate the effects of two aquatic exercise programs on muscle strength and indicators of sarcopenia in elderly individuals.

## Methods

### Sample recruitment

For this study, 127 participants were selected by convenience, intentionally, and not probabilistically. Inclusion criteria include being a practitioner of aquatic exercises for at least 6 months, knowing how to read and write, and having functional autonomy. The following exclusion criteria were adopted: hip or knee arthroplasty or knee surgery 6 months before the study and knee injections in the last 3 months: unstable medical conditions, dermatological conditions, or any other medical contraindications to physical exercise.

After analyzing the inclusion and exclusion criteria, 51 participants were selected, as shown in Figure 1.

To better characterize the sample, participants responded to the International Physical Activity Questionnaire short form (IPAQ) to monitor the amount of physical activity throughout the study, not to classify the levels of this activity (Lee, Macfarlane, Lam, & Stewart, 2011).

The Simple Questionnaire to Rapidly Diagnose Sarcopenia (SARC-F) was used to screen for self-reported signs suggestive of sarcopenia (Malmstrom, Miller, Simonsick, Ferrucci, & Morley, 2016), and the Beck Depression Inventory was also used to classify the severity of depression according to the clinical definition (Beck, Steer, Ball, & Ranieri, 1996).

The present study met the standards for researching human beings, resolution 196/96, the National Health Council of 10/10/1996 (Ministry of Health), and the Helsinki Resolution (Assembly, 2004; Association, 2000). All study participants agreed to sign the informed consent form containing the study objective, assessment procedures, and the voluntary nature of the subject's participation. An information term was also prepared for the institution where the

research was conducted, with the same items as the informed consent form. The study had its research project submitted to the Research Ethics Committee Involving Human Beings Faculty of Human Motricity of the University of Lisbon, approved under n° 0013/2023.

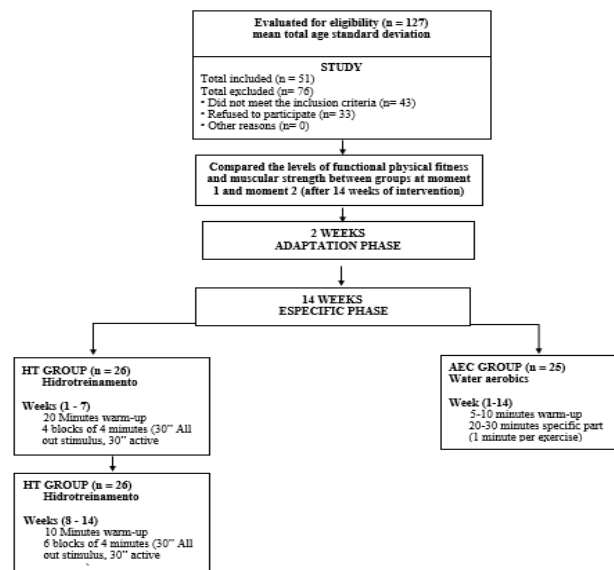


Figure 1: Flowchart of experimental design

### Experimental Design

After purifying the sample, the participants were divided into 2 groups, the Hidrotreinamento Group (HTG) and the Community Aquatic Activity (AEC) group, according to the facilities where they practiced their aquatic exercises. Community exercises. Both groups simultaneously attended 16 weeks of an aquatic program, where the first 2 weeks aimed to develop the motor skills of aquatic adaptation, followed by 14 weeks of specific training intervention, with a frequency of twice a week and 45 minutes of duration of each session.

Also, all participants underwent 4 aquatic adaptation sessions to familiarize themselves with the movements, aiming to correct any gestures that could compromise the exercise during the study, reducing the possibility of injury risk or improper utilization of water resistance due to body misalignment. They all had at least 6 months of experience in aquatic exercise and were familiar with basic fundamental movements (BFM) such as running: Hip flexion with alternating knee flexion with arms at the sides with alternating elbow flexion. Rock horse: Hip flexion with knee extension on the left leg and hip extension with knee extension on the right leg. Kick: Hip flexion with alternating knee extension. Twist: trunk rotation with arms to one side and knees to the other. Pendulum: Abduction and adduction of the hip to the left and right with the arms in the opposite direction. Jumping jacks: Abduction and adduction of the hip with horizontal abduction and adduction of the shoulders. Skiing: Alternating hip flexion and extension with alternating shoulder flexion and extension and bouncing.

They did not use any equipment, and only the elderly

participants who achieved a minimum attendance rate of 85% in the training sessions were included in the analysis.

The pool environment had an air temperature of around  $27^{\circ}\text{C} \pm 1^{\circ}\text{C}$ , and the water temperature was controlled at  $30.5^{\circ}\text{C} \pm 0.5^{\circ}\text{C}$ , as AEA (2018) recommendations.

HTG followed a periodized program with controlled overload progression, while AEC followed a non-periodized program without controlled load progression throughout the program. Each group completed the training intervention, as shown in Figure 1.

### ***Aquatic Exercise protocols***

#### **1 – Hidrotreinamento® (HTG)- experimental group**

The program focuses on developing muscular strength, consisting of a series of primary and specific fundamental neuromotor exercises standardized by Aboarrage Junior (2021) and based on the Aquatic Exercise Association (AEA, 2018).

The structure of the sessions consisted of large muscle groups and fundamental basic movements.

During the central part of the session, specific strategies were used to increase the resistance offered by the water.

Interval training was used in conjunction with the “All Out” method. In the “All Out” method, participants were encouraged to perform movements at their maximum intensity, with the speed of movement representing this effort (Machado et al., 2018). To maintain intensity control, participants made efforts between 14 and 17 on the Subjective Perceived Exertion Scale (PSE) proposed by Gunnar Borg (1998).

The specific training phase was structured with gradual periodization, increasing the overload weekly.

#### **2 – Community Aquatic Exercise (AEC) Control Group**

This group underwent an exercise program with social and recreational characteristics. This program included general movements without specific periodization for muscular strength or cardiorespiratory capacity. However, the guidelines of the Aquatic Exercise Association (AEA, 2018), the American College of Sports Medicine, the Exercise Prescription Guidelines (ACSM, 2017), and the analysis of previous study protocols (Yazigi, Carnide, Espanha, & Sousa, 2016), were used as a reference in prescribing the exercises.

The program consisted of a series of exercises performed in a vertical position, with general movements, and without controlling the training intensity.

Specific training was carried out with continuous exercises for 20 to 30 minutes, with modifications every 1 minute, without a sequence that overloaded specific muscle groups.

### ***Outcomes and instruments***

The primary outcomes were indicators of sarcopenia and physical fitness (strength, muscular power). Secondary outcomes were flexibility, strength endurance, body composition, and lifestyle. During the study, all participants were allowed to maintain their usual lifestyle without

changing their diet or medication intake. The participants performed all tests at baseline and 14 weeks later at the end of the exercise intervention using the same protocols and were evaluated by the team member(s).

**Anthropometric measures:** Body mass and height are measured to verify the Body Mass Index, essential for assessing older people's nutritional and anthropometric profiles (Who & Consultation, 2003). The protocol to measure the body mass and height, the participant is weighed barefoot and in physical activity clothes (light clothes, shorts, and shirt), in a standing position, in the central part of the platform of Tanita BF550® segmental body composition monitor Inner Scan V, (Japan) To measure height, the same standard mentioned above is used, with an aluminum stadiometer, with 1mm precision, standing upright, arms extended along the body, feet together, in inspiratory apnea, with the head oriented, according to the Frankfurt plane, measured in centimeters (Marfell-Jones, Stewart, & Olds, 2006).

**Physical and functional fitness:** For the analysis of the physical fitness and functional capacity of the participants, the following tests and assessments were utilized: Chair Sit and Stand Test (CST) (C Jessie Jones, Rikli, & Beam, 1999). This test was used to assess lower limb endurance and strength, Timed Up and Test (TUG) (Barry, Galvin, Keogh, Horgan, & Fahey, 2014; Podsiadlo & Richardson, 1991), this test was employed to evaluate mobility and balance, Chair Sit and Reach Test (C. J. Jones, Rikli, Max, & Noffal, 1998), was used to assess hamstring flexibility, Back Scratch Test measures the overall shoulder range of motion, the Back Scratch Test, as described by Rikli and Jones in 2013, was utilized. In the Handgrip Strength Test, the maximum isometric strength of hand and forearm muscles was assessed using a hand dynamometer from Jamar® Lafayette Instrument Company, USA. The dynamometer was adjusted to fit the hand size of each participant (Balogun, Akomolafe, & Amusa, 1991; Kuzala & Vargo, 1992; Oxford, 2000). These tests and assessments were chosen to evaluate various aspects of physical fitness, including endurance, mobility, flexibility, balance, and strength in different muscle groups and body regions.

**Sarcopenia:** the questionnaire (SARC-F) (Malmstrom et al., 2016) was used as a quick and objective screening tool to identify probable sarcopenia—the questionnaire screens for self-reported signs suggestive of sarcopenia, which include strength deficiencies.

### ***Statistical Analyses***

Statistical analyses were performed using IBM SPSS® version 25.0 (USA). The collected data were presented as mean and standard deviation. A two-way analysis of variance was performed for repeated measures to verify the effect of 14 weeks of aquatic exercise. The significance level ( $\alpha$ ) of the statistical test was 0.05.

Descriptive statistics were used, including frequencies for categorical variables, and means with standard deviation for continuous descriptive statistics were used, including

frequencies for categorical variables and means with standard deviation for continuous variables. The Kolmogorov-Smirnov test evaluated the normal distribution of continuous variables. To evaluate the correlation between continuous variables at the beginning of the study, Pearson's (r) formula was used, interpreted as strong ( $r \geq 0,7$ ), moderate ( $0,5 < r < 0,7$ ), and weak ( $0,3 < r < 0,5$ ). Post-intervention differences (baseline minus post-intervention) were discovered between groups through analysis of covariance, adjusted for baseline outcome values. Comparisons of changes between intervention groups were performed as a primary analysis by univariate covariance (ANCOVA) analysis, in which the dependent variables were adjusted. Mean differences within groups were left as before (baseline) minus after (after intervention).

## Results

After recruitment, 127 elderly individuals who had already participated in aquatic exercise programs for at least 3 months volunteered to participate in this study. However, after verifying the exclusion criteria, fifty-one elderly individuals were eligible to participate. The final sample comprised 51 participants, 8 (15,7 %) male and 43 (84,3 %) female, allocated to the two groups. Hidrotreina-mento® 73,4 e Community Aquatic Exercise 75,2. In Table 1, we can see the descriptive analysis of physical fitness at baseline.

The body composition results for variables weight, body mass index (BMI), fat-free mass, and body fat for the HTG and AEC groups at the beginning of the experiment did not show significant differences ( $p > 0,05$ ). The results in Table 2 revealed that Sarc-f had a significant and positive relationship with age, fat mass, and TUG and a negative and significant relationship with the handgrip test (TP) and CST. Strength tests correlate, but no correlation was found between physical activity and the International Physical Active Questionnaire, metabolic equivalent of task (IPAQ met), strength results, and

sarcopenia. The International Physical Active Questionnaire Seated (IPAQ sit) had a negative correlation with the SARC-F and a significant correlation with the handgrip, demonstrating that the number of hours of sitting influences low levels of strength. Table 2 shows the values of the anthropometric variables and the screening questionnaires.

Table 1.

Descriptive analysis of total sample physical fitness at baseline

	HTG (N = 26)	AEC (N = 25)	TOTAL (N = 51)
SARC-F	1,8 ± 1,3	1,6 ± 1,5	1,7 ± 1,4
IPAQ met	1508 ± 944	1343 ± 616	1277 ± 785
IPAQ Sit (min)	312 ± 100	298 ± 140	305 ± 120
TUG (sec)	5,8 ± 1,2	5,8 ± 1,5	5,8 ± 1,3
Handgrip (Kg)	23,4 ± 6,0	22,8 ± 6,2	23,1 ± 6,0
CST (sec)	17,2 ± 3,7	18,9 ± 6,9	18,0 ± 5,5
BST right (cm)	13,5 ± 8,7	-14,8 ± 10,7	-14,1 ± 9,6
BST left (cm)	10,7 ± 11,8	-10,3 ± 10,5	-10 ± 11,1
CSRT right (cm)	-0,3 ± 9,3	1,2 ± 11,7	0,4 ± 10,4
CSRT left (cm)	0,0 ± 9,3	0,0 ± 11,6	0,0 ± 10,3

Values are expressed as mean ± standard deviation. SARC-F= Simple Questionnaire to Rapidly Diagnose Sarcopenia; IPAQ = International Physical Active Questionnaire; TUG = Time Up and Go Test; CST: Stand to Sit Test; BST= Back Scratch Test; CSRT= Chair Sit and Reach Test.

Table 2.

Pearson's Correlations for the variables at baseline

	SARC-F	TUG	Handgrip	CST
Age	0,322*	0,432*	-0,245	-0,230
Weight	0,059	0,219	0,234	-0,245
BMI	0,155	0,325*	-0,049*	-0,241
Fat mass	0,389*	0,298*	-0,488*	-0,297*
IPAQ met	-0,015	-0,164	0,105	-0,114
IPAQ sit	-0,217	0,026	0,342*	0,042

(\*): Significant difference  $p < 0,05$ . BMI: Body Mass Index; SARC-F= Simple Questionnaire to Rapidly Diagnose Sarcopenia; IPAQ met = International physical active questionnaire, Metabolic equivalent of the task; IPAQ Sit = International physical active questionnaire Seated; TUG = Time Up and Go Test; CST: Stand to Sit Test.

The chronic results regarding the strength and sarcopenia indicators of the intervention groups are presented in Table 3.

Table 3.

Analysis of the group effect of physical function tests and Sarcopenia indicators for physical fitness tests (Before and After interventions).

	HTG			AEC			ANCOVA	
	Before	After	Changes <sup>d</sup>	Before	After	Changes <sup>d</sup>	F	p-value
TUG (sec)	5,8 ± 1,2	5,1 ± 0,9	-0,68 ± 0,11	5,8 ± 1,5	5,9 ± 1,5	0,7 ± 0,12	10,82	0,002*
Handgrip (Kg)	23,4 ± 6,0	26,0 ± 8,0	2,61 ± 0,52	22,8 ± 6,2	22,8 ± 6,5	0,01 ± 0,53	3,51	0,07
CST	17,2 ± 3,8	21,0 ± 4,6	3,73 ± 0,62	18,9 ± 6,9	18,2 ± 7,0	0,56 ± 0,63	1,39	0,244
BST right (cm)	-13,5 ± 8,7	-10,7 ± 8,4	2,93 ± 1,01	-14,8 ± 10,7	-14,6 ± 10,3	0,37 ± 1,03	6,06	0,017*
BST left (cm)	-10,7 ± 11,8	-9,3 ± 10,3	1,31 ± 1,18	-10,3 ± 10,5	-9,0 ± 10,8	1,40 ± 1,21	8,29	0,006*
CSRT right (cm)	-0,3 ± 9,3	1,8 ± 8,5	2,00 ± 0,91	1,2 ± 11,7	1,3 ± 11,4	2,40 ± 0,93	6,19	0,016*
CRST left (cm)	0,0 ± 9,3	1,9 ± 9,2	2,12 ± 0,94	0,0 ± 11,6	0,8 ± 10,7	1,20 ± 0,96	3,1	0,09

Values are expressed as mean ± standard deviation. (\*) Significant difference  $p < 0,05$ . SARC-F= Simple questionnaire to Rapidly Diagnose Sarcopenia; IPAQ met = International physical active questionnaire, Metabolic equivalent of the task; IPAQ Sit = International physical active questionnaire Seated; TUG = Time Up and Go Test; CST: Stand to Sit Test; BST= Back Scratch Test; CSRT= Chair Sit and Reach Test.

Significant differences were identified in all muscle strength and power variables before and after the HTG and between the HTG and AEC. There were significant

increases in muscle strength, power, flexibility, agility, and balance for participants in the HTG, while the AEC showed reductions or no change in variables related to

strength and power. The Student's t-test was used to compare continuous variables based on the intervention group to compare the HTG and AEC in all quantitative variables collected.

The results demonstrate no significant differences between the groups for one of the variables, as shown in Table 3. Since the assumption of variance homogeneity was not met, the Student's t-test with Welch's correction was used.

Table 4.

ANCOVA anthropometry questionnaire of mismatches adjusted to the baseline value.

	HTG			AEC			ANCOVA	
	Before	After	Changes <sup>d</sup>	Before	After	Changes <sup>d</sup>	F	p-value
Weight (kg)	71,5 ± 16,8	69,8 ± 16,7	-1,7 ± 0,7	70,2 ± 12,5	69,8 ± 12,9	-0,4 ± 0,7	0,448	0,507
BMI (kg/m)	27,6 ± 5,7	26,9 ± 5,6	-0,6 ± 0,3	28,0 ± 4,4	27,9 ± 4,8	-0,1 ± -0,7	0,16	0,691
Fat mass (%)	37,3 ± 7,4	34,7 ± 7,5	-2,4 ± -0,6	35,5 ± 7,3	33,1 ± 6,6	-2,1 ± -0,6	3,9	0,54
SARC-F	1,8 ± 1,3	1,4 ± 1,2	-0,27 ± 0,4	1,6 ± 1,5	2,0 ± 2,1	0,36 ± 0,3	10,09	0,003*
IPAQ met	1508 ± 944	1778,92 ± 499	440 ± 106	1037 ± 490	1343 ± 616	130 ± 108	541	0,001*
IPAQ sit	312 ± 100	308 ± 96	-662 ± 17	298 ± 140	310 ± 108	7,9 ± 17	27	0,001*

Values are expressed as mean ± standard deviation. (\*) Significant difference  $p < 0,05$ . IPAQ met = Internacional physical active questionnaire, Metabolic equivalent of the task; IPAQ Sit = Internacional physical active questionnaire Seated; SARC-F = Simple questionnaire to rapidly diagnose sarcopenia; BMI = Body Mass Index.

## Discussion

This study aims to verify the effect of the aquatic program on sarcopenia indicators in healthy people. An essential indicator of the patient's health is the level of physical activity, which, unlike sedentary behavior, is associated with the reduction of health risk factors (Avelar, Bastone, Alcântara, & Gomes, 2010; Guerra, Mielke, & Garcia, 2014; Horacio, de Avelar, & Danielewicz, 2021).

Physically active individuals have a greater degree of functional autonomy compared to more inactive individuals (Ciprandi, Bertozzi, Zago, Sforza, & Galvani, 2018), as well as cognitive and physical functions preserved in the development process (Araújo-Gomes et al., 2023). This highlights the importance of investigating the effects of physical exercise programs using diverse practice methods and systematizing their prescriptions.

The results found in this study show a significant improvement in muscle strength indices, a variable that is related to and impacted by the deleterious effects of development (Scartoni et al., 2020; Scudese et al., 2018), which corroborates the studies by Cruz-Jentoft et al. (2019), and Reis, Vianna, Colugnati, Novaes, and Mansur (2020), when stating that neuromuscular degeneration in this age group is characterized by muscle damage rooted in adverse changes that accumulate throughout life, reducing functional autonomy (Dantas., 2014; Scartoni et al., 2021; Vale, Pernambuco, & Dantas, 2016) and balance (Borba-Pinheiro et al., 2015; Borges et al., 2018; Ribeiro, Nunes, & Schoenfeld, 2020), increasing the dependence on movements, risk of seizures and sarcopenia that occurs mainly due to the progressive loss of motor units, accompanied by atrophy of muscle fibers (Ortega & Cuartas, 2020).

Therefore, when selecting two exercise programs for more mature people, primary attention should be given to strengthening the lower body muscles (Ribeiro et al., 2020). Muscle strength related to capacity and mass

The comparisons between HTG and AEC participants were repeated for all collected quantitative variables. The results indicate that there are significant differences between the variables TUG after for AEC ( $5.850 \pm 1.452$ ) in comparison to TUG after in AEG ( $5.118 \pm 0.903$ ). This shows that the HTG demonstrated superior muscle strength and power gains for the lower limbs compared to the AEC.

reduction tends to be more pronounced in the lower limbs than in the upper limbs (Janssen, Heymsfield, Wang, & Ross, 2000), which is why we found two aspects of the present study.

Many studies on aquatic exercise are focused on older people, suggesting that this population is the largest group that practices water aerobics worldwide Aboarrage Junior et al., 2018; Kim et al., (2020). However, some scholars claim that the positive effects of training in an aquatic environment are similar to exercises on land and can be influenced by factors such as size, speed of movement, and use of devices, as shown (Prado et al., 2022).

As the muscle power observed in the study was not increased after training in water, both for HTG and AEC, it is proven that this result is based on the adaptation that occurs due to the physical characteristics of the aquatic environment, such as more excellent resistance to movement (Kanitz et al., 2015), which corroborates the results of the meta-analysis by Fail et al. (2022) by showing that aquatic training is practical, improving several parameters such as balance, cardiorespiratory fitness, and mainly muscular strength during exercise (Hall-López et al., 2017; Marcos-Pardo et al., 2019; Martínez-Carbonell Guillaumon et al., 2019; Pöyhönen et al., 2002; Tsourlou, Benik, Dipla, Zafeiridis, & Kellis, 2006).

However, despite aquatic training generating a positive increase in the variables studied for both intervention groups, HTG participants showed significant increases in muscular strength, power, flexibility, agility, and balance compared to AEC, which can be justified for some points below.

Systematizing two exercises and periodizing training is fundamental to asserting training objectives in the water (Fail et al., 2022; López, Martínez, Monzon, & de Souza Vale, 2018). For example, aquatic programs commonly use plyometric training to increase muscular strength and power (Jurado-Lavanant et al., 2018; Stemm & Jacobson,

2007; Wertheimer, Antekolovic, & Matkovic, 2018). In a study by Robinson, Devor, Merrick, and Buckworth (2004), Plyometric training was used in water for 8 weeks, and the results indicated better strength levels in women, showing that systematic control of the classroom structure made a difference in the results. This exciting fact contradicts suggestions that the aquatic environment provides little tension to muscles and bones (Bento, Lopes, Cebolla, Wolf, & Rodacki, 2015; Jurado-Lavanant et al., 2018).

The control of intensity in the central part of the training focused on the "all out" method, in which the practitioner is required to execute movements at maximum intensity at the moment of stimulus (Machado et al., 2018) and was used to quantify and determine the intensity of the load. Periodization was controlled based on the progression of this load through the volume of stimuli, gauged through the subjective perception of effort proposed by Borg (G. Borg, 1970; Gunnar Borg, 1998).

Strategies for producing a high-quality aquatic exercise intervention were structured according to AEA guidelines (AEA, 2018), including overload assessment and management, impact level control, exercise cadence control, and appropriate music selection aligned with exercise goals.

The movement speed required for aquatic exercise practice increases exercise intensity, enhancing force production (Reichert et al., 2019). Two other variables influencing force production are movement amplitude and the area of contact with water resistance, which should be considered during prescription (AEA, 2018).

There has been a belief that aquatic training is not the most reliable way to improve muscle strength (Wertheimer et al., 2018). However, some recent studies have found that aquatic resistance training increases maximal dynamic strength (Reichert et al., 2019).

Gobi et al. (2020) observed that due to the protective effect on joints, movements performed in water can be done vigorously, potentially leading to increases in maximal oxygen consumption (VO<sub>2</sub> max) over relatively short periods. They employ the high-intensity interval training (HIIT) method to achieve this. This approach proves particularly suitable for older people, obese, and individuals with joint pathologies, for whom land-based exercise may not be recommended. The authors suggest that short-term, low-volume aquatic HIIT is an effective and time-efficient strategy for improving body composition, muscular oxidative capacity, fasting glycemia, triglyceride levels, blood pressure, and physical fitness, compared to prolonged moderate-intensity steady-state exercise.

By improving muscle strength and power, the likelihood of an older adult being affected by sarcopenia decreases significantly (Grgic, Schoenfeld, Orazem, & Sabol, 2022), increasing balance, gait performance, and functional autonomy of movement, comfort for older adults, more outstanding quality of life and well-being (Araújo-Gomes et al., 2023; Scartoni et al., 2021).

It is worth noting that the aquatic environment is different due to more excellent resistance to movement, the

maximum force exerted throughout the range of movement at a consistent speed, changes in balance due to reduced plantar support, and changes in the motor scheme (Gobbi, Aquiri, Monoli, Cau, & Capodaglio, 2020), factors that are in line with the present study when we refer to the systematic control that Hidrotreinamento<sup>®</sup> proposes. The protective effect on the joint load of the immersed individual helps practice exercises vigorously, producing positive increments to combat sarcopenia.

Despite the studies mentioned, there is still a gap in the guidelines for prescribing these exercises, as there are few studies on the acute effects of different aquatic movement patterns, which generally constitute a training or rehabilitation session. The movement pattern in the aquatic environment is an essential variable for physiological and metabolic responses, mainly for developing muscular strength and functional fitness.

## Conclusion

The Hidrotreinamento<sup>®</sup> program and community aquatic exercises effectively develop muscle strength and power in older adults. It is essential to highlight that. When a specific, periodized, supervised training protocol is applied and carefully adapted to the needs of older adults, the results are more significant and better, as demonstrated in the present study. Careful monitoring of movement execution and effective implementation of this periodization highlight that aquatic exercises are suitable for improving physical fitness in healthy older people.

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## Referências

- Aboarrage Junior, A. M. (2021). *A Evolução da Hidroginástica* (Vol. 1). São Paulo Bazil: Lura Editora.
- Aboarrage Junior, A. M., Teixeira, C. V. S., Dos Santos, R. N., Machado, A. F., Evangelista, A. L., Rica, R. L., . . . Bocalini, D. S. (2018). A High-Intensity Jump-Based Aquatic Exercise Program Improves Bone Mineral Density and Functional Fitness in Postmenopausal Women. *Rejuvenation Res*, 21(6), 535-540. doi:10.1089/rej.2018.2069

- ACSM, A. C. S. o. M. (2017). *Diretrizes do ACSM para teste de esforço e prescrição* (L. W. e. Wilkins Ed. 10ª edição ed.).
- AEA, A. E. A. (2018). *Aquatic Fitness Professional Manual* (Seventh Edition ed.): Human Kinetics.
- Alberton, C. L., Antunes, A. H., Pinto, S. S., Tartaruga, M. P., Silva, E. M., Cadore, E. L., & Martins Krueel, L. F. (2011). Correlation between rating of perceived exertion and physiological variables during the execution of stationary running in water at different cadences. *J Strength Cond Res*, 25(1), 155-162. doi:10.1519/JSC.0b013e3181bde2b5
- Alberton, C. L., Cadore, E. L., Pinto, S. S., Tartaruga, M. P., da Silva, E. M., & Krueel, L. F. (2011). Cardiorespiratory, neuromuscular and kinematic responses to stationary running performed in water and on dry land. *Eur J Appl Physiol*, 111(6), 1157-1166. doi:10.1007/s00421-010-1747-5
- Araújo-Gomes, R. C., Leite, C. L., Miranda, F. B., Portela, B. O., Moreira, C. H., & Scartoni, F. R. (2023). Efeitos do Treinamento de Força Muscular, Aeróbico e de Resistência Muscular Sobre a Autonomia Funcional e Qualidade de Vida de Idosos. *Matricidade*, 19(3).
- Assembly, W. M. A. G. (2004). World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. *Journal international de bioethique= International journal of bioethics*, 15(1), 124-129.
- Association, W. M. (2000). Declaration of Helsinki: ethical principles for medical research involving human subjects. *Jama*, 284, 3043-3045.
- Avelar, N. C., Bastone, A. C., Alcântara, M. A., & Gomes, W. F. (2010). Effectiveness of aquatic and non-aquatic lower limb muscle endurance training in the static and dynamic balance of elderly people. *Rev Bras Fisioter*, 14(3), 229-236.
- Balogun, J. A., Akomolafe, C. T., & Amusa, L. O. (1991). Grip strength: effects of testing posture and elbow position. *Arch Phys Med Rehabil*, 72(5), 280-283.
- Barry, E., Galvin, R., Keogh, C., Horgan, F., & Fahey, T. (2014). Is the Timed Up and Go test a useful predictor of risk of falls in community dwelling older adults: a systematic review and meta-analysis. *BMC Geriatr*, 14, 14. doi:10.1186/1471-2318-14-14
- Beck, A. T., Steer, R. A., Ball, R., & Ranieri, W. (1996). Comparison of Beck Depression Inventories -IA and -II in psychiatric outpatients. *J Pers Assess*, 67(3), 588-597. doi:10.1207/s15327752jpa6703\_13
- Bento, P. C. B., Lopes, M. d. F. A., Cebolla, E. C., Wolf, R., & Rodacki, A. L. (2015). Effects of water-based training on static and dynamic balance of older women. *Rejuvenation research*, 18(4), 326-331.
- Bondi, D., Jandova, T., Verratti, V., D'Amico, M., Kinel, E., D'Attilio, M., . . . Pietrangelo, T. (2021). Static balance adaptations after neuromuscular electrical stimulation on quadriceps and lumbar paraspinal muscles in healthy elderly. *Sport Sciences for Health*, 1-12.
- Borba-Pinheir, C. J., Dantas, E. H. M., da Rocha-Júnior, O. R. M., Walsh-Monteiro, A., de Alencar Carvalho, M. C. G., Drigo, A. J., & Figueiredo, N. M. A. (2015). Fuerza muscular e independencia funcional de mujeres mayores después de un programa de entrenamiento de Karate adaptado. *Revista Ciencias de la Actividad Física*, 16(1), 9-17.
- Borg, G. (1970). [Physical training. 3. Perceived exertion in physical work]. *Lakartidningen*, 67(40), 4548-4557. Retrieved from <https://www.ncbi.nlm.nih.gov/pubmed/5477775>
- Borg, G. (1998). *Borg's Perceived Exertion and Pain Scales* (H. Kinetics Ed.).
- Borges, E. G. d. S., Vale, R. G. d. S., Pernambuco, C. S., Cader, S. A., Sá, S. P. C., Pinto, F. M., . . . Dantas, E. H. M. (2018). Efeitos da dança no equilíbrio postural, na cognição e na autonomia funcional de idosos. *Revista brasileira de enfermagem*, 71, 2302-2309.
- Ciprandi, D., Bertozzi, F., Zago, M., Sforza, C., & Galvani, C. (2018). Associations between objectively measured physical activity levels and physical fitness and health-related quality of life in elderly women. *Sport Sciences for Health*, 14, 183-191.
- Cipriani, N. C. S., Meurer, S. T., Benedetti, T. R. B., & Lopes, M. A. (2010). Aptidão funcional de idosas praticantes de atividades físicas. *Revista Brasileira de Cineantropometria & Desempenho Humano*, 12, 106-111.
- Colado, J. C., & Garcia-Masso, X. (2009). Technique and safety aspects of resistance exercises: a systematic review of the literature. *Phys Sportsmed*, 37(2), 104-111. doi:10.3810/psm.2009.06.1716
- Colado, J. C., Garcia-Masso, X., González, L. M., Triplett, N. T., Mayo, C., & Merce, J. (2010). Two-leg squat jumps in water: an effective alternative to dry land jumps. *Int J Sports Med*, 31(2), 118-122. doi:10.1055/s-0029-1242814
- Colado, J. C., Triplett, N. T., Tella, V., Saucedo, P., & Abellan, J. (2009). Effects of aquatic resistance training on health and fitness in postmenopausal women. *Eur J Appl Physiol*, 106(1), 113-122. doi:10.1007/s00421-009-0996-7
- Cruz-Jentoft, A. J., Bahat, G., Bauer, J., Boirie, Y., Bruyere, O., Cederholm, T., . . . the Extended Group for, E. (2019). Sarcopenia: revised European consensus on definition and diagnosis. *Age Ageing*, 48(4), 601. doi:10.1093/ageing/afz046
- Dantas, E. H. M., de Oliveira Sant'Ana, L., Vianna, J. M., Machado, S., Bezerra, J. C. P., Corey, M. T., & Scartoni, F. R. (2022). Chronic Effects of Different Types of Neuromuscular Training on Hemodynamic Responses Estimated VO2max, and Walking Performance in Older People. *International Journal of Environmental Research and Public Health*, 20(1), 640.
- Dantas, E. H. M. (2014). *A prática da preparação física*. (Vol. sexta edição).
- dos Reis, N. R., de Oliveira Sant'Ana, L., da Costa, F. F., de Souza Ribeiro, A. A., Campos, Y. d. A. C., Scartoni, F. R., . . . da Silva Novaes, J. (2020). Indicadores de adesão, fatores motivacionais e benefícios percebidos por idosos da academia da terceira idade. *Revista Brasileira de Fisiologia do Exercício*, 19(3), 202-208.
- Fail, L. B., Marinho, D. A., Marques, E. A., Costa, M. J., Santos, C. C., Marques, M. C., . . . Neiva, H. P. (2022). Benefits of aquatic exercise in adults with and without chronic disease—A systematic review with meta-analysis. *Scandinavian Journal of Medicine & Science in Sports*, 32(3), 465-486.
- Ferreira, J. P., Teixeira, A., Serrano, J., Farinha, C., Santos, H., Silva, F. M., . . . Luis, P. (2020). Impact of Aquatic-Based Physical Exercise Programs on Risk Markers of Cardiometabolic Diseases in Older People: A Study Protocol for Randomized-Controlled Trials. *Int J Environ Res Public Health*, 17(22). doi:10.3390/ijerph17228678
- Ferreira, O. G. L., Maciel, S. C., Costa, S. M. G., Silva, A. O., & Moreira, M. A. S. P. (2012). Envelhecimento ativo e sua relação com a independência funcional. *Texto & Contexto Enfermagem*, 21, 513-518.
- Fletcher, G. F., Landolfo, C., Niebauer, J., Ozemek, C., Arena, R., & Lavie, C. J. (2018). Promoting physical activity and

- exercise: JACC health promotion series. *Journal of the American College of Cardiology*, 72(14), 1622-1639.
- Fraga, M. J., Cader, S. A., Ferreira, M. A., Giani, T. S., & Dantas, E. H. (2011). Aerobic resistance, functional autonomy and quality of life (QoL) of elderly women impacted by a recreation and walking program. *Archives of Gerontology and Geriatrics*, 52(1), e40-e43.
- Fuentes-Lopez, J., Vidal-Espinoza, R., Alvear-Vasquez, F., Sanchez-Macedo, L., Mamani Velasquez, D., Rivera Pacco, W., . . . Gomez Campos, R. (2021). Systematic review of aquatic physical exercise programs on functional fitness in older adults. *Eur J Transl Myol*, 31(4). doi:10.4081/ejtm.2021.10006
- Gobbi, M., Aquiri, A., Monoli, C., Cau, N., & Capodaglio, P. (2020). Aquatic exercise. *Rehabilitation interventions in the patient with obesity*, 35-50.
- Grgic, J., Schoenfeld, B. J., Orazem, J., & Sabol, F. (2022). Effects of resistance training performed to repetition failure or non-failure on muscular strength and hypertrophy: A systematic review and meta-analysis. *Journal of sport and health science*, 11(2), 202-211.
- Guerra, P. H., Mielke, G. I., & Garcia, L. M. T. (2014). Comportamento sedentário. *Corpoconsciência*, 23-36.
- Ha, G. C., Yoon, J. R., Yoo, C. G., Kang, S. J., & Ko, K. J. (2018). Effects of 12-week aquatic exercise on cardiorespiratory fitness, knee isokinetic function, and Western Ontario and McMaster University osteoarthritis index in patients with knee osteoarthritis women. *J Exerc Rehabil*, 14(5), 870-876. doi:10.12965/jer.1836308.154
- Hall-López, J., Ochoa-Martínez, P., Alarcón Meza, E., Moncada-Jiménez, J., García Bertruy, O., & Martín Dantas, E. (2017). Hydrogymnastics training program on physical fitness in elderly women. *Rev. Int. Med. Cienc. Act. Fis. Deporte*, 17, 283-298.
- Hoffmann, I., Shojaa, M., Kohl, M., von Stengel, S., Becker, C., Gosch, M., . . . Clausen, J. (2022). Exercise reduces the number of overall and major osteoporotic fractures in adults. does supervision make a difference? Systematic Review and Meta-Analysis. *Journal of Bone and Mineral Research*, 37(11), 2132-2148.
- Horacio, P. R., de Avelar, N. C. P., & Danielewicz, A. L. (2021). Comportamento sedentário e declínio cognitivo em idosos comunitários. *Revista Brasileira de Atividade Física & Saúde*, 26, 1-8.
- Irlandoust, K., Taheri, M., Mirmoezzi, M., H'Mida, C., Chtourou, H., Trabelsi, K., . . . Knechtel, B. (2019). The Effect of Aquatic Exercise on Postural Mobility of Healthy Older Adults with Endomorphic Somatotype. *Int J Environ Res Public Health*, 16(22). doi:10.3390/ijerph16224387
- Janssen, I., Heymsfield, S. B., Wang, Z., & Ross, R. (2000). Skeletal muscle mass and distribution in 468 men and women aged 18–88 yr. *Journal of applied physiology*.
- Jones, C. J., Rikli, R. E., & Beam, W. C. (1999). A 30-s chair-stand test as a measure of lower body strength in community-residing older adults. *Research quarterly for exercise and sport*, 70(2), 113-119.
- Jones, C. J., Rikli, R. E., Max, J., & Noffal, G. (1998). The reliability and validity of a chair sit-and-reach test as a measure of hamstring flexibility in older adults. *Res Q Exerc Sport*, 69(4), 338-343. doi:10.1080/02701367.1998.10607708
- Jurado-Lavanant, A., Alvero-Cruz, J., Pareja-Blanco, F., Melero-Romero, C., Rodríguez-Rosell, D., & Fernandez-García, J. (2018). The effects of aquatic plyometric training on repeated jumps, drop jumps and muscle damage. *International journal of sports medicine*, 39(10), 764-772.
- Kanitz, A. C., Delevatti, R. S., Reichert, T., Liedtke, G. V., Ferrari, R., Almada, B. P., . . . Kruel, L. F. M. (2015). Effects of two deep water training programs on cardiorespiratory and muscular strength responses in older adults. *Experimental gerontology*, 64, 55-61.
- Kim, Y., Vakula, M. N., Waller, B., & Bressel, E. (2020). A systematic review and meta-analysis comparing the effect of aquatic and land exercise on dynamic balance in older adults. *BMC Geriatr*, 20(1), 302. doi:10.1186/s12877-020-01702-9
- Kuzala, E. A., & Vargo, M. C. (1992). The relationship between elbow position and grip strength. *Am J Occup Ther*, 46(6), 509-512. doi:10.5014/ajot.46.6.509
- Lee, P. H., Macfarlane, D. J., Lam, T. H., & Stewart, S. M. (2011). Validity of the International Physical Activity Questionnaire Short Form (IPAQ-SF): a systematic review. *Int J Behav Nutr Phys Act*, 8, 115. doi:10.1186/1479-5868-8-115
- López, J. A. H., Martínez, P. Y. O., Monzon, C. O. L., & de Souza Vale, R. G. (2018). Effects of four months of periodized aquatic exercise program on functional autonomy in post-menopausal women with parkinson's disease. *Retos: nuevas tendencias en educación física, deporte y recreación*(33), 217-220.
- Machado, A. F., Evangelista, A. L., Miranda, J. M. Q., Teixeira, C. V., Rica, R. L., Lopes, C. R., . . . Bocalini, D. S. (2018). Description of training loads using whole-body exercise during high-intensity interval training. *Clinics*, 73.
- Malmstrom, T. K., Miller, D. K., Simonsick, E. M., Ferrucci, L., & Morley, J. E. (2016). SARC-F: a symptom score to predict persons with sarcopenia at risk for poor functional outcomes. *J Cachexia Sarcopenia Muscle*, 7(1), 28-36. doi:10.1002/jcsm.12048
- Marcos-Pardo, P. J., Orquin-Castrillón, F. J., Gea-García, G. M., Menayo-Antúnez, R., González-Gálvez, N., Vale, R. G. d. S., & Martínez-Rodríguez, A. (2019). Effects of a moderate-to-high intensity resistance circuit training on fat mass, functional capacity, muscular strength, and quality of life in elderly: A randomized controlled trial. *Scientific reports*, 9(1), 7830.
- Marfell-Jones, M., Stewart, A., & Olds, T. (2006). *Kinanthropometry IX: Proceedings of the 9th International Conference of the International Society for the Advancement of Kinanthropometry*: Routledge.
- Martinez-Carbonell Guillamon, E., Burgess, L., Immins, T., Martinez-Almagro Andreo, A., & Wainwright, T. W. (2019). Does aquatic exercise improve commonly reported predisposing risk factors to falls within the elderly? A systematic review. *BMC Geriatr*, 19(1), 52. doi:10.1186/s12877-019-1065-7
- Ortega, J. A. F., & Cuartas, L. A. H. (2020). Efectos de la velocidad de entrenamiento en fuerza sobre diversas manifestaciones de la fuerza en mujeres adultas mayores. *Retos: nuevas tendencias en educación física, deporte y recreación*(38), 325-332.
- Oxford, K. L. (2000). Elbow positioning for maximum grip performance. *J Hand Ther*, 13(1), 33-36. doi:10.1016/s0894-1130(00)80050-2
- Podsiadlo, D., & Richardson, S. (1991). The timed "Up & Go": a test of basic functional mobility for frail elderly persons. *J Am Geriatr Soc*, 39(2), 142-148. doi:10.1111/j.1532-5415.1991.tb01616.x



- Pöyhönen, T., Sipilä, S., Keskinen, K. L., Hautala, A., Savolainen, J., & Mälkiä, E. (2002). Effects of aquatic resistance training on neuromuscular performance in healthy women. *Medicine & Science in Sports & Exercise*, 34(12), 2103-2109.
- Prado, A. K. G., Reichert, T., Conceição, M. O., Delevatti, R. S., Kanitz, A. C., & Kruehl, L. F. M. (2022). Effects of Aquatic Exercise on Muscle Strength in Young and Elderly Adults: A Systematic Review and Meta-Analysis of Randomized Trials. *J Strength Cond Res*, 36(5), 1468-1483. doi:10.1519/jsc.0000000000001595
- Reis, N., Vianna, J., Colugnati, F., Novaes, J., & Mansur, H. (2020). Sensitivity and specificity of SARC-F in the classification of sarcopenia in the elderly: preliminary results. *Revista Brasileira de Fisiologia do Exercício*, 19, 258. doi:10.33233/rbfex.v19i4.3895
- Ribeiro, A. S., Nunes, J. P., & Schoenfeld, B. J. (2020). Selection of resistance exercises for older individuals: the forgotten variable. *Sports Medicine*, 50, 1051-1057.
- Robinson, L. E., Devor, S. T., Merrick, M. A., & Buckworth, J. (2004). The effects of land vs. aquatic plyometrics on power, torque, velocity, and muscle soreness in women. *The Journal of Strength & Conditioning Research*, 18(1), 84-91.
- Sant'Ana, L. d. O., Machado, S., Ribeiro, A. A. d. S., Reis, N. R. d., Campos, Y. d. A. C., Silva, J. G. V. d., . . . Novaes, J. d. S. (2020). Effects of cardiovascular interval training in healthy elderly subjects: a systematic review. *Frontiers in Physiology*, 11, 739.
- Scartoni, F. R., Sant'Ana, L. d. O., Murillo-Rodriguez, E., Yamamoto, T., Imperatori, C., Budde, H., . . . Machado, S. (2020). Physical exercise and immune system in the elderly: implications and importance in COVID-19 pandemic period. *Frontiers in psychology*, 11, 593903.
- Scartoni, F. R., Sant'Ana, L. O., Vianna, J. M., Machado, S., Dantas, E. H. M., & Budde, H. (2021). Chronic effects of different neuromuscular training on hemodynamic responses estimated vo2max and walking performance in the elderly. Scudese, E., Brandão, P. P., Senna, G. W., de Oliveira, C. Q., Stantzer, M., Rodrigues Scartoni, F., . . . Dantas, E. H. M. (2018). Active vs. Passive Inter-Set Recovery in Lower Limbs Strength Performance. *Journal of Exercise Physiology Online*, 21(5).
- Silva, S. R. d. (2018). *Incidência da hipertensão arterial sistêmica e prevalência de seus fatores de risco em idosos do grupo Renascer*.
- Stemm, J. D., & Jacobson, B. H. (2007). Comparison of land- and aquatic-based plyometric training on vertical jump performance. *The Journal of Strength & Conditioning Research*, 21(2), 568-571.
- Strath, S. J., Kaminsky, L. A., Ainsworth, B. E., Ekelund, U., Freedson, P. S., Gary, R. A., . . . Swartz, A. M. (2013). Guide to the assessment of physical activity: clinical and research applications: a scientific statement from the American Heart Association. *Circulation*, 128(20), 2259-2279.
- Tsourlou, T., Benik, A., Dipla, K., Zafeiridis, A., & Kellis, S. (2006). The effects of a twenty-four-week aquatic training program on muscular strength performance in healthy elderly women. *The Journal of Strength & Conditioning Research*, 20(4), 811-818.
- Vale, R. G. d. S., Pernambuco, C. S., & Dantas, E. H. M. (2016). *Manual de avaliação do idoso. Ícone, São Paulo*.
- Wertheimer, V., Antekolovic, L., & Matkovic, B. R. (2018). Muscle damage indicators after land and aquatic plyometric training programmes. *Montenegrin Journal of Sports Science and Medicine*, 7(1), 13-19.
- Who, J., & Consultation, F. E. (2003). Diet, nutrition and the prevention of chronic diseases. *World Health Organ Tech Rep Ser*, 916(i-viii), 1-149.
- Yazigi, F., Carnide, F., Espanha, M., & Sousa, M. (2016). Development of the Knee OA Pre-Screening Questionnaire. *Int J Rheum Dis*, 19(6), 567-576. doi:10.1111/1756-185X.12447

#### Datos de los/as autores/as:

Antonio Michel Aboarrage junior  
 Fabiana Rodrigues Scartoni  
 Alexandre Fernandes Machado  
 Danilo Sales Bocalini  
 Flavia Giovanetti Yazigi  
 Fabiana Rodrigues Scartoni

ninousa@hotmail.com  
 scartonifabiana@gmail.com  
 xdmachado@gmail.com  
 bocaliniht@hotmail.com  
 fyazigi@fmh.ulisboa.pt  
 fabiana.scartoni@ucp.br

Autor/a  
 Autor/a  
 Autor/a  
 Autor/a  
 Autor/a  
 Traductor/a