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SUMARIO

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THE MULTIFUNCTIONALITY OF AQUATIC EXERCISE: MEDICINE, TRAINING, FITNESS, AND REHABILITATION

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The modality of Aquatic exercise (practiced in shallow water or deep water), also known as Water Aerobics, can be defined as a set of exercises performed in water, predominantly in the vertical position, with or without the use of music and with or without the use of additional equipment. Over the past 30 years, there has been a significant increase in the availability of water aerobics/exercise programs and interest in scientific research in this area, both in the realm of prevention, through programs promoting improved physical fitness, as well as in sports training (physical conditioning and in phases of athlete regeneration/recovery) and also in rehabilitation/hydrotherapy programs.

Although lacking specific guidelines for its prescription, the modality of Water Aerobics has become part of medical prescriptions, being one of the most recommended activities by healthcare professionals in the context of non-pharmacological treatment for various chronic diseases (Dai et al., 2023; Doyenart et al., 2023; Heidari et al., 2023; Scheer et al., 2023; Xu et al., 2022). There is scientific evidence of its positive effects on improving aerobic fitness, strength, flexibility (Borreani et al., 2014; Mercer et al., 2014; Silvers et al., 2014; Yoo et al., 2013), body composition (Zhu et al., 2023), balance, ability to perform daily activities, relief of symptoms of musculoskeletal diseases (Xu et al., 2022, 2023), health-related quality of life, and mental health (especially in cases of mild depression, anxiety, and self-esteem) (Doyenart et al., 2023; Tang et al., 2022).

The buoyancy force, opposite to the action of gravity, reduces the mechanical load on the body, minimizing the impact of movements on the axial axis, which is especially advantageous for groups such as pregnant women, obese individuals, or those with musculoskeletal pain (Alberton et al., 2015). Additionally, hydrostatic pressure improves peripheral circulation and acts on pain receptors, which combined with the muscle relaxation provided by buoyancy and water temperature, contributes to pain control and reduction of edema and swelling (Yazigi et al., 2013).

In an era where "Exercise is Medicine" and the "Feel Good factor" are considered important pillars for exercise practice and health promotion, it is essential to conduct more studies with controlled protocols to validate water aerobics programs and methodologies, as well as to investigate the acute effects of different patterns of water exercises in various conditions, such as exercise cadence, depth, water temperature, additional equipment, and different populations.

This edition of the RIAA (International Journal of Aquatic Activity) aims to contribute to the promotion and dissemination of scientific research in the field of water aerobics, aiming to valorize this practice and provide stronger support for its prescription in quality professional practice.

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HEART RATE DEFLECTION POINT CORRESPONDS TO VENTILATORY THRESHOLD DURING WATER-BASED MAXIMAL TEST IN UNTRAINED WOMEN

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Funciones de los autores:
SSP, CLA, ACK y LFMK conceptualizaron y diseñaron el estudio SSP, CLA y GBD escribirán el programa deseado y interpretarán los datos. GBD y BEBX prepararon el primer borrador del documento y SSP, ACK, LFMK y CLA lo revisaron críticamente. Todos los autores han aprobado esta versión final del texto.

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Background: The research problem addresses the investigation of the correlation and accuracy of the Heart Rate Deflection Point (HRDP) method compared to the Ventilatory Threshold (VT) method in predicting the Anaerobic Threshold (AT) during water-based stationary running maximal tests performed by untrained women.
Goals: This study compared heart rate (HR), oxygen uptake (VO_2), percentage of maximal heart rate ($\%HR_{max}$), percentage of maximal oxygen uptake ($\%VO_{2max}$), and cadence (CAD) related to the anaerobic threshold (AT) during a water-based stationary running maximal test performed by untrained women between HRDP and VT methods. In addition, the correlations between both methods were assessed for all variables.
Method: Fifty-six untrained women (40.2 ± 16.3 years) started the protocol at a cadence of 85 beats per minute (b.min^{-1}) for 3 min with subsequent increments of 15 b.min^{-1} every 2 min until exhaustion.
Results: There was no difference in the HR, VO_2, $\%HR_{max}$, $\%VO_{2max}$, and CAD related to AT between the HRDP and the VT methods. Moreover, significant relationships were found between the methods to determine the AT (r=0.61-0.95).
Conclusions: In conclusion, the HRDP method may accurately predicting AT in untrained women performing the water-based stationary running maximal test.
Keywords: Aquatic exercise, anaerobic threshold, cardiorespiratory responses, exercise test, ventilatory threshold.

El punto de deflexión de la frecuencia cardíaca corresponde al umbral ventilatorio durante la prueba máxima basada en agua en mujeres no entrenadas.

Resumen
Antecedentes: El problema de investigación aborda la correlación y precisión del método del Punto de Deflexión de la Frecuencia Cardíaca (HRDP) comparado con el método del Umbral Ventilatorio (VT) en la predicción del Umbral Anaeróbico (AT) durante pruebas máximas de carrera estacionaria en agua realizadas por mujeres no entrenadas.
Objetivos: Este estudio comparó la frecuencia cardíaca (HR), el consumo de oxígeno ($\dot{V}O_2$), el porcentaje de la frecuencia cardíaca máxima ($\%HR_{max}$), el porcentaje del consumo máximo de oxígeno ($\%VO_{2max}$) y la cadencia (CAD) relacionados con el AT durante una prueba máxima de carrera estacionaria en agua por mujeres no entrenadas entre los métodos HRDP y VT. Además, se evaluaron las correlaciones entre ambos métodos para todas las variables.
Método: Cincuenta y seis mujeres no entrenadas (40,2 ± 16,3 años) iniciaron el protocolo con una cadencia de 85 latidos por minuto (b.min^{-1}) durante 3 min, con incrementos subsiguientes de 15 b.min^{-1} cada 2 min hasta el agotamiento.
Resultados: No hubo diferencia en la HR, VO_2, $\%HR_{max}$, $\%VO_{2max}$ y CAD relacionados con el AT entre los métodos HRDP y VT. Además, se encontraron relaciones significativas entre los métodos para determinar el AT (r=0.61-0.95).
Conclusiones: El método HRDP puede ser un predictor preciso del AT en mujeres no entrenadas realizando la prueba máxima de carrera estacionaria en agua. Palabras clave: ejercicio acuático, umbral anaeróbico, respuestas cardiorrespiratorias.
Palabras clave: Terapia Acuática, Umbral Anaerobio, Capacidad Cardiovascular, Prueba de Esfuerzo, Umbral Ventilatorio.

O ponto de deflexão da frequência cardíaca corresponde ao limiar ventilatório durante o teste máximo baseado em água em mulheres não treinadas.

Resumo
Introdução: O problema de pesquisa aborda a investigação da correlação e precisão do método do Ponto de Deflexão da Frequência Cardíaca (HRDP) em comparação com o método do Limiar Ventilatório (VT) na predição do Limiar Anaeróbio (AT) durante testes máximos de corrida estacionária em água realizados por mulheres não treinadas.
Objetivos: Este estudo comparou a frequência cardíaca (HR), o consumo de oxigênio (VO_2), a porcentagem da frequência cardíaca máxima ($\%HR_{max}$), a porcentagem do consumo máximo de oxigênio ($\%VO_{2max}$) e a cadência (CAD) relacionados ao AT durante um teste máximo de corrida estacionária em água por mulheres não treinadas entre os métodos HRDP e VT. Além disso, as correlações entre ambos os métodos foram avaliadas para todas as variáveis.
Método: Cinquenta e seis mulheres não treinadas (40,2 ± 16,3 anos) iniciaram o protocolo com uma cadência de 85 batimentos por minuto (b.min^{-1}) por 3 min, com incrementos subsequentes de 15 b.min^{-1} a cada 2 min até a exaustão.
Resultados: Não houve diferença na HR, $\dot{V}O2$, $\%HR_{max}$, $\%VO_{2max}$ e CAD relacionados ao AT entre os métodos HRDP e VT. Além disso, foram encontradas relações significativas entre os métodos para determinar o AT (r=0.61-0.95).
Conclusões: O método HRDP pode ser um preditor preciso do AT em mulheres não treinadas realizando o teste máximo de corrida estacionária em água.
Palavras chaves: Exercício aquático, limiar anaeróbio, aptidão cardiorrespiratória, teste de esforço, limiar ventilatório.

Introduction

Water-based aerobic exercises have been practiced by different populations, including healthy individuals (Colado et al., 2009; Pinto et al., 2014), older individuals (Pinto et al., 2015; Tsourlou et al., 2006), and people with special needs (Adsett et al., 2015). It is well documented in the literature that the lower maximal and submaximal physiological parameters (i.e., heart rate, oxygen uptake, lactate concentration) during aerobic exercise performed in the aquatic in comparison to dry land environment (Alberton et al., 2009; Alberton et al., 2014; Barbosa et al., 2007; Benelli et al., 2004; Kruel et al., 2013). Thus, it is important to acknowledge the pattern of cardiorespiratory parameters in water-based aerobic exercises to prescribe the intensity during water-based programs.

The anaerobic threshold (AT) has been used to prescribe the aerobic training intensity in different water-based activities performed by young and elderly populations (Kanitz et al., 2015; Pinto et al., 2014). The determination of the AT is important since the use of a pre-selected percentage of maximal heart rate or oxygen uptake may represent different intensities for the practitioners (i.e., aerobic vs. anaerobic intensity). However, the gold standard methods to determine the AT, spirometer, or lactate concentration are expensive and/or invasive. Thus, Conconi et al. (1982) established that the AT could be determined by a noninvasive test based on the relationship of incremental running speed with HR. The HR, corresponding to the breakpoint at which the linearity of the HR-speed relationship was broken, is defined as the heart rate deflection point (HRDP).

In the aquatic environment, there have been a few studies investigating the HRDP compared to gold standard methods (Alberton et al., 2013; Cellini et al., 1986; Kruel et al., 2013; Pinto et al., 2016). Kruel et al. (2013) reported similar HR and VO_2 corresponding to the AT between ventilatory (VT) (ventilation vs. intensity) and HRDP methods (HR vs. intensity) during maximal protocols in stationary running performed on land and in water by active young women. Analyzing three water-based aerobic exercises, Alberton et al. (2013) verified a significant relationship in the HR and VO_2 corresponding to the AT determined by the HRDP and VT methods during maximal protocols performed by active young women. However, the unique focus of our study on untrained women, who engage in water-based aerobic exercises across a wide age range and with varying physical fitness levels, is a novel and important contribution to the field, as it provides insights into the occurrence of the HRDP during water-based maximal tests in women with low aerobic conditioning, thereby aiding in the prescription of the adequate target training zone.

Therefore, this study was designed to assess the relationship between HRDP and the VT methods to determine the HR, VO_2, percentage of maximal HR ($\%HR_{max}$), percentage of maximal VO_2 ($\%VO_{2max}$), and cadence corresponding to the AT obtained during water-based stationary running maximal test performed by untrained women. It was hypothesized that cardiorespiratory variables related to AT would be similar between HRDP and VT methods. The data from the present study could be helpful for the prescription based on the AT in water-based setting training since there is limited information regarding the intensity during this activity in untrained women.

Methods

Participants

The inclusion criteria for the participants were 18–60 years old and not engaged in any regular and systematic training program in the previous six months. Exclusion criteria included any history of neuromuscular, hormonal, and cardiovascular diseases. Participants were not taking any medication that influenced on hormonal and neuromuscular metabolism. All participants were recruited from Porto Alegre, Brazil, by sending flyers, by e-mail, and through the local media (announcements in the daily newspaper). The announcement provided a contact (i.e., telephone number) for the study and the inclusion and exclusion criteria. Fifty-six healthy women (n=56, age: 40.2 ± 16.3 years; body mass: 67.2 ± 12.1 kg; height: 162.3 ± 6.4 cm; body fat: 34.0 ± 5.7%) contacted the research team and were recruited to the initial screening. Informed consent was also read and signed during the initial screening, and the participants were carefully informed about the study's design and the possible risks and discomforts related to the measurements. All recruited women met the inclusion and exclusion criteria and were included in this study. The sample size was calculated using the GPower version 3.1.9 program for T-tests. We adopted a power of 95%, an alpha level of 5%, and an effect size of d=0.51 based on data from Kruel et al. (2013). It resulted in a total sample size of 44 participants. Considering a dropout of 25%, a minimum of 55 participants would be necessary. The project was approved by the Local Research Ethics Committee, and all procedures were in accordance with the Helsinki Declaration of 1975 as revised in 1996.

Experimental procedure

To investigate the AT determined by the HRDP and VT methods, a maximal test was carried out in a shallow swimming pool with a depth between 0.95 and 1.30 m. For this purpose, volunteers participated in two different sessions. In the first session, the participants were familiarized with the protocol in the water environment. In the second session, they performed the water-based stationary running maximal test with the data collection of cardiorespiratory variables.

The sessions consisted of familiarization and experimental protocol. The first session occurred 48–72 hours before data collection during the experimental protocol. The following instructions were given to the participants before the test: fast for 3–4 hours before the test session, do not ingest stimulants, hydrate freely, and avoid intense exercise in the last 24 hours.

Familiarization session

In this session, body mass and height were measured using an analogic scale and a stadiometer (Asimed, Camarate, Portugal). Body composition was assessed using the skin fold technique. A 7-site skin fold equation was used to estimate body density (Jackson et al., 1980), and body fat was subsequently calculated using the Siri equation (Siri, 1993). Afterward, the participants performed the water-based stationary running exercise at different progressive cadences while wearing the gas collection mask. In addition, all the care details (e.g., hip and knee flexion maintainance at 90°), which would need to be taken when performing the exercise, were explained.

Experimental protocol session

A maximal test was applied in the aquatic environment to determine the HR, VO_2, $\%HR_{max}$, $\%VO_{2max,}$ and cadence corresponding to the AT,. The maximal test with stationary running was conducted with an initial cadence of 85 $b.min^{-1}$ for three minutes, with 15 $b.min^{-1}$ increases in cadence every two minutes until maximal effort was obtained. The participants were required to perform each phase of the exercise (i.e., hip flexion or extension) in one beat. A compact disc was used to reproduce the cadences employed during the test. The maximal test was stopped when the participants indicated their exhaustion using a hand signal. In addition, the assessment was considered valid when some of the following criteria were met at the end of the test: estimated maximal heart rate was reached (220 age), a respiratory exchange ratio (RER) greater than 1.15 was reached, and a maximal respiratory rate of at least 35 breaths per minute (Howley et al., 1995). Moreover, the average time to reach exhaustion ranged from 8 to 10 minutes, which is considered optimal for the validity of the maximal test performed. Similarly, the RER was also analyzed, and the result confirmed that the protocol is within the proper value needed to accept the test.

During the exercise, participants were connected to a mixing-box-type portable gas analyzer to evaluate the ventilatory data (VO2000, MedGraphics, Ann Arbor, USA). This equipment had been previously calibrated according to the manufacturer's specifications. The HR was measured using a Polar monitor (FS1, Shangai, China). The sampling rate of the collected HR and ventilatory data was one sample every 10 seconds, and the data were acquired using the Aerograph software. Throughout the experiment, the water temperature was maintained at 31.0 ± 0.1 °C, and the water depth for each subject was controlled between the xiphoid process and shoulders.

Data Treatment

Based on the cardiorespiratory data obtained during exercise, the AT was determined from the HRDP (HR-by-intensity) (Alberton et al., 2013; Kruel et al., 2013) and by the VT (V E-by-intensity), which was confirmed using CO_2 ventilatory equivalent (VE/VCO_2) (Wasserman et al., 1973). The breakpoint of the curves was visually inspected by two independent, blinded, experienced exercise physiologists. In the present study, determining the AT by the VT is considered the gold standard method.

Statistical Analysis

Data are presented as mean ± standard deviation. The normality of distribution was assessed by a Kolmogorov–Smirnov test. A paired two-tailed Student's t-test was used to compare all variables between the HRDP and the VT methods. The Pearson product-moment correlation coefficient was used to assess the relationship between the methods. The differences were plotted against the average value, as suggested by Bland and Altman (1995). Significance was accepted when α=0.05, and the SPSS statistical software package (version 20.0) was used to analyze all data.

Results

All participants completed the test. No adverse effects or any safety concerns were found during the exercise protocol. The descriptive values regarding the maximal and AT variables obtained during the water-based stationary running maximal test are presented in Table 1.

Table 1. Descriptive statistics (mean ± SD) of maximal and submaximal variables during water-based stationary running maximal test.

	Mean	±SD
HR_{max} (bpm)	175	±15
VO_{2max} (ml.kg^{-1}.min^{-1})	23.09	±5.20
RER_{max}	1.38	±0.19
RER_{AT}	1.12	±0.13
TE (min)	9.91	±1.86

Note: HR_{max} - maximal heart rate; VO_{2max} - maximal oxygen uptake; RER_{max} - maximal respiratory exchange ratio; RER_{AT} - respiratory exchange ratio at anaerobic threshold; TE - time to exhaustion.

Heart rate deflection point was successfully determined in 51 of the 56 participants analyzed (91.07%). Thus, the results from five participants were excluded from the remaining analyses. There was no difference in the HR, VO_2, $\%HR_{max}$, $\%VO_{2max,}$ and cadence corresponding to AT between the HRDP and VT methods (Table 2). In addition, significant relationships were found between the methods to determine the AT for all variables analyzed. Figure 1 shows the relationship between HRDP and VT for HR, VO_2, $\%HR_{max}$, $\%VO_{2max,}$ and cadence. In addition, a Bland-Altman plot with estimated mean bias and 95% limits of agreement for differences in HR, $\%HR_{max}$ (%), $VO_{2,}$ and $\%VO_{2max}$ data between HRDP and VT, as plotted against the mean value, are presented in Figure 2.

Table 2. Comparison between VT and HRDP methods during water-based stationary running maximal test.

	VT		HRDP		
	Mean	±SD	Mean	±SD	p
HR (bpm)	152	±16	152	±15	0.095
VO_2 (ml.kg^{-1}.min^{-1})	17.46	±4.00	16.98	±3.81	0.073
$\%HR_{max}$ (%)	86.92	±5.09	86.27	±5.06	0.076
$\%VO_{2max}$ (%)	75.16	±10.69	74.10	±10.49	0.431
CAD (b.min^{-1})	120	±12	120	±13	0.766

Note: HR - heart rate; VO_2 - oxygen uptake; $\%HR_{max}$ - percentage of maximal HR; $\%VO_{2max}$ - percentage of maximal VO_2; CAD – cadence; VT - ventilatory threshold; HRDP - heart rate deflection point.

Figure 1. Relationship between HRDP and VT for HR, VO_2, $\%HR_{max}$, $\%VO_{2max}$ and cadence

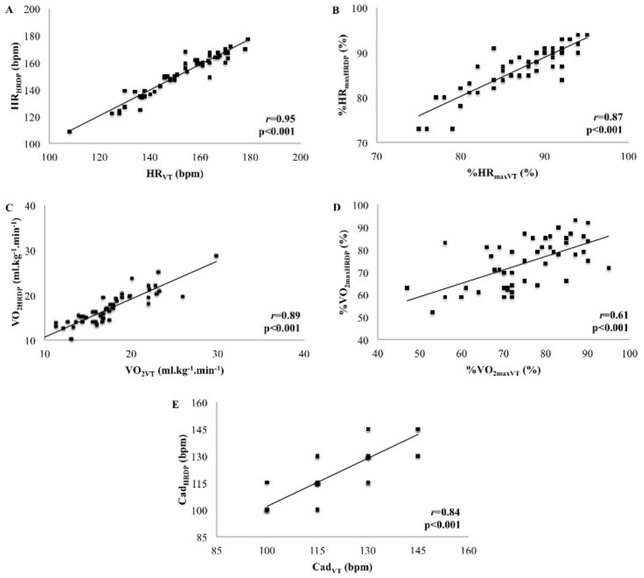
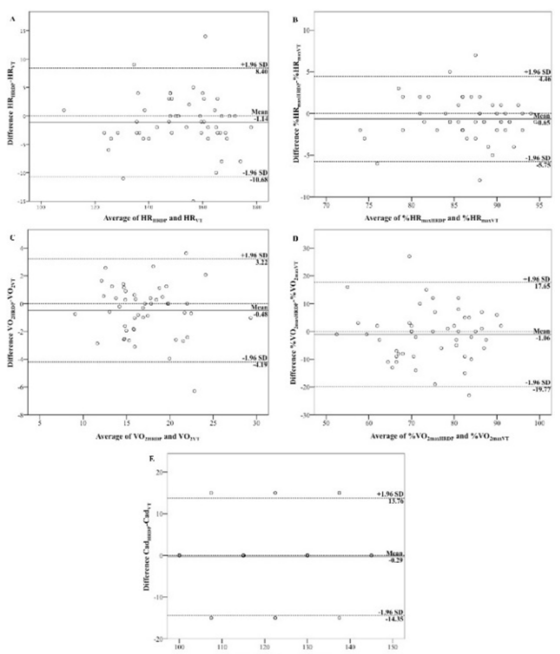


Figure 2. Evaluation of the agreement between HR, $\%HR_{max}$, VO_2, and $\%VO_{2max}$ Measurements Between HRDP and VT.



Discussion

The results of this study indicate a strong relationship between HRDP and VT methods for HR, VO_2, $\%HR_{max}$, $\%VO_{2max}$, and cadence (r=0.61-0.95; p<0.001). In addition, similar values were found between the methods for these variables. Thus, the HRDP method may be applied to determine the AT in untrained women during a maximal test performed with the widely used water-based stationary running exercise. By determining the AT through this noninvasive measurement, which is relatively simple to implement without costly materials, it is possible to precisely prescribe the intensity of this water-based exercise in untrained women in a wide age range.

Recent studies analyzed the relationship between HRDP and VT methods in water-based aerobic exercises. Kruel et al. (2013) investigated nine active women during a maximal test with stationary running performed in a water environment. They found similar HR (168 ± 13 bpm vs. 173 ± 8 bpm) and VO_2 (26.3 ± 4.7 $ml.kg^{-1}.min^{-1}$ vs. 26.2 ± 6.0 $ml.kg^{-1}.min^{-1}$) values at AT between the two methods mentioned above. To investigate the relationship between HRDP and VT methods, Alberton et al. (2013) analyzed 20 young active women performing three water-based aerobic exercises (stationary running, frontal kick, and cross-country skiing) and reported no differences in HR (155-160 bpm vs. 155-159 bpm) and VO_2 (21-22 $ml.kg^{-1}.min^{-1}$ vs. 21-23 $ml.kg^{-1}.min^{-1}$) responses between the methods. This study also verified the relationship between the methods on HR and VO_2 and observed significant correlations ranging from 0.67 to 0.97 for all evaluated exercises. In our study, the HR (152 ± 15 bpm vs. 152 ± 16 bpm) and VO_2 (16.98 ± 3.81 $ml.kg^{-1}.min^{-1}$ vs. 17.46 ± 4 $ml.kg^{-1}.min^{-1}$) values at the AT were similar and showed significant correlations (HR: r=0.95; VO_2: r=0.89) between HRDP and VT methods in a large sample (n=51) comprised by untrained women.

Regarding the relative HR values corresponding to AT, in our study, the percentage achieved was 86 and 87% of the HRmax in HRDP and VT methods, respectively. This result agrees with the findings of other authors who verified a mean HR ranging from 88 to 94% of HR_{max} (Bodner et al., 2002; Bourgois and Vrijens, 1998; Hofmann et al., 2007; Mikulic et al., 2011). The relative VO_2 values corresponding to the AT determined by HRDP and VT methods were achieved at 74 and 75% of VO_{2max}, respectively. In the study developed by Fabre et al. (2008), the VO_2 values corresponding to the AT were achieved at 87% of $VO_{2\,max}$ in both HRDP and VT methods during continuous incremental field tests involving roller-skiing performed by well-trained cross-country skiers. Regarding the percentage of maximal cardiorespiratory variables corresponding to the AT (i.e., $\%HR_{max}$ and $\%VO_{2max}$), the studies in water and on dry land mentioned above did not present a relationship between the methods.

In the present study, the cadence corresponding to the AT during the water-based stationary running maximal test was similar between the HRDP (120 ± 13 $b.min^{-1}$) and VT (120 ± 12 $b.min^{-1}$) methods. In addition, we observed a significant correlation between them (r=0.84). Alberton et al. (2014) determined the cadence equivalent to AT by the gold standard VT method in the performance of the water-based stationary running maximal test and found a mean value of 134 ± 12 $b.min^{-1}$ for a group of active young women (i.e., 24.0 ± 2.5 years). Investigating the relationship between HRDP and VT methods on running speed in trained runners, Petit et al. (1997) demonstrated similar and correlated (r=0.95) values between the methods (16.3 ± 2.1 $km.h^{-1}$ vs. 16.4 ± 2.3 $km.h^{-1}$).

The HRDP was determined in most of the cases of untrained women (91%) in the present study. In addition, the Bland-Altman analysis suggests an acceptable concordance with the HRDP method for measuring the AT during water-based stationary running maximal tests performed by untrained women. The analysis of the Bland-Altman plots reveals that, in 95% of cases, HRHRDP may range from 10.7 bpm to less and from 8.4 bpm to greater than the original estimate, and VO_2HRDP may range from 4.2 $ml.kg^{-1}.min^{-1}$ to less and from 3.2 $ml.kg^{-1}.min^{-1}$ to greater than the original estimate, which can be considered a moderate difference. These results are following previous studies, which analyzed the agreement between HRDP and VT methods for these variables (Baiget et al., 2015; Mikulic et al., 2011). Moreover, the Bland-Altman plots were also investigated for the $\%HR_{max}$, $\%VO_{2max}$, and cadence. The results revealed that $\%HR_{max}$HRDP may range from 5.7% to less and from 4.5% to greater, the $\%VO_{2max}$HRDP may range from 19.8% to less and from 17.7% to greater, and the cadence may range from 14.3 $b.min^{-1}$ to less and 13.8 $b.min^{-1}$ to greater than the original estimate.

It is important to highlight that the HRDP method is simple, low-cost, and noninvasive. The time necessary to conduct the test is relatively short (approximately 10 minutes), which means it can be incorporated within or as part of a water-based training session. Additionally, attention is necessary when HRDP detection is based on visual analysis since experienced observers should perform this procedure. One possible limitation of our study is the sample size, which may have been small, and it could not detect modest but meaningful differences as statistically significant. Thus, future studies should explore the analysis of the HRDP method in a large sample that includes a wide age range.

Conclusions

The present study's findings showed that the HRDP and VT methods were strongly correlated for HR, VO_2, $\%HR_{max}$, $\%VO_{2max}$, and cadence. In addition, the agreement between methods was verified by the Bland-Altman plots for all analyzed variables. Thus, the HRDP method may accurately predict AT in untrained women performing the water-based stationary running maximal test.

Contribution and practical implications

This study significantly contributes to the existing literature by providing a comparative analysis of the HRDP and VT methods in assessing AT in untrained women during maximal aquatic tests. It deepens our understanding of physiological responses to aquatic exercise and offers a practical, less complex alternative for aerobic fitness assessment. The potential application of these methods by health and sports professionals for prescribing aquatic training further underscores the value of our research, expanding the tools available for physical assessment and developing effective interventions in the aquatic context.

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EFFECTS OF AQUATIC INTERVAL AEROBIC TRAINING ON FUNCTIONAL FITNESS AND CARDIOVASCULAR HEALTH OF MIDDLE-AGED ADULTS: A PILOT STUDY

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Abstract
Bachground: Aquatic training can improve the health of adults and seniors. However, it still lacks elucidation about the controlled and periodized prescription.
Goal: To verify the effect of 12 weeks of structured and monitored aerobic interval training on functional and cardiovascular outcomes in middle-aged adults.
Methods: A pilot study, with 12 weeks of intervention, 3 weekly sessions of 50 minutes duration. Participants of both sexes, between 30 and 80 years old, were recruited. Was collected the 30-s arm curl test, 30-s chair stand test, 8-foot Up and Go test (8UG) and 6-minute walk (6MWT), blood pressure (BP), heart rate rest (HRR) and quality of life (WHOQOL-8). Training was prescribed with 4 mesocycles of 3 weeks each, with linear progression in volume (duration), density (relation stimulus: recuperation) and intensity (rating perceived effort).
Results: Participated od this study thirteen middle-aged adults (58.54±4.67 years old) with 56.50 ± 17.29% adherence to training. After 12 weeks, was found improvement in the 30-s arm curl test (Δ%: 19.13), 8UG (Δ%: 6.9), diastolic BP (Δ%: 11.5) and HRR (Δ%: 12.2).
Conclusion: The practice of 12 weeks of aerobic interval training were able to improve upper limb strength, functional cardiorespiratory fitness and generate cardiovascular changes in middle-aged adults.
Keywords: Aquatic exercise, Middle aged, Physical fitness, Blood pressure, Exercise.

Resumen
Antecedentes: El entrenamiento acuático puede mejorar la salud de adultos y personas mayores. Sin embargo, todavía falta dilucidación sobre la prescripción controlada y periodizada.
Objetivo: verificar el efecto de 12 semanas de entrenamiento interválico aeróbico estructurado y monitorizado sobre los resultados funcionales y cardiovasculares en adultos de mediana edad.
Métodos: Un studio piloto, con 12 semanas de intervención, 3 sesiones semanales de 50 minutos de duración. Se reclutaron participantes de ambos sexos, entre 30 y 80 años. Se recogieron las pruebas de flexión de brazos de 30 s, prueba de reposo en silla de 30 s, prueba de 8 pies Up and Go (8UG) y caminata de 6 minutos (6MWT), presión arterial (PA), frecuencia cardíaca en reposo (FCR) y calidad. de vida (WHOQOL-8). El entrenamiento se prescribió con 4 mesociclos de 3 semanas cada uno, con progresión lineal en volumen (duración), densidad (relación estímulo: recuperación) e intensidad (calificación del esfuerzo percibido).
Resultados: Participaron de este estudio trece adultos de mediana edad (58,54±4,67 años) con 56,50±17,29% de adherencia al entrenamiento. Después de 12 semanas, se encontró mejoría en la prueba de curl de brazos de 30 s (Δ%: 19,13), 8UG (Δ%: 6,9), PA diastólica (Δ%: 11,5) y HRR (Δ%: 12,2).
Conclusión: La práctica de 12 semanas de entrenamiento interválico aeróbico logró mejorar la fuerza de los miembros superiores, la aptitud cardiorrespiratoria funcional y generar cambios cardiovasculares en adultos de mediana edad.
Palabras clave: Ejercicio acuático, Edad media, Aptitud física, Presión arterial, Ejercicio.

Resumo
Introdução: O treinamento aquático pode melhorar a saúde de adultos e idosos. Contudo, ainda faltam esclarecimentos sobre a prescrição controlada e periodizada.
Objetivo: Verificar o efeito de 12 semanas de treinamento aeróbico intervalado estruturado e monitorado sobre os resultados funcionais e cardiovasculares em adultos de meia-idade.
Métodos: Um estudo piloto, com 12 semanas de intervenção, 3 sessões semanais de 50 minutos de duração. Foram recrutados participantes de ambos os sexos, com idade entre 30 e 80 anos. Foram coletados os testes de flexão de cotovelo, sentar e levantar, 8-foot Up and Go test (8UG) e caminhada de 6 minutos (TC6), pressão arterial (PA), frequência cardíaca de repouso (FCR) e qualidade de vida. O treinamento foi prescrito com 4 mesociclos de 3 semanas cada, com progressão linear em volume (duração), densidade (relação estímulo:recuperação) e intensidade (classificação deesforço percebido)
Resultados: Participaram deste estudo treze adultos de meia idade (58,54±4,67 anos) com 56,50±17,29% de aderência o ao treinamento. Após 12 semanas, foi encontrada melhora significativa no teste de flexão de cotovelo em 30 segundos (Δ%: 19,13), 8UG (Δ%: 6,9), PA diastólica (Δ%: 11,5) e FCR (Δ%: 12,2).
Conclusão: A prática de 12 semanas de treinamento aeróbio intervalado foi capaz de melhorar a força de membros superiores, a aptidão cardiorrespiratória funcional e gerar alterações cardiovasculares em adultos de meia-idade.
Palavras-chave: Exercício aquático, Meia idade, Aptidão física, Pressão arterial, Exercício.

Introduction

For successful aging, promoting physical exercise during middle age is important (Szychowska & Drygas, 2022). The physical behavior adopted during this period may reflect on the behavior during the next phase of life. This was observed in the study of Chen et al. (2022), who followed men and women for 20 years and reported that physically active middle-aged individuals tend to remain in the practice of physical activity during old age.

However, several barriers can compromise a healthy lifestyle (Herazo-Beltrán et al., 2017), as well, as preferences need to be taken into account (Amireault et al., 2019). In this perspective, different possibilities are offered, among them, aquatic activities in upright position have gained popularity, due to their thermal and mechanical properties, which allow mitigating articulation overload and providing beneficial changes in the cardiac, respiratory, renal and hormonal systems (Carregaro & Toledo, 2008; Pendergast et al., 2015), in addition to being recommended for individuals with different clinical conditions (Bailly et al., 2022; Faíl et al., 2022).

Several meta-analyses have demonstrated the positive impacts of the aquatic training on adults and elderly people with and without pre-established chronic diseases, generating improvements in muscle strength (Prado et al., 2022), functional capacity (Waller et al., 2016), and aerobic capacity and flexibility (Saquetto et al., 2022), in addition to significant reductions in the lipid and glycemic profile (Delevatti et al., 2015), with improvements in the worsening of cardiometabolic diseases in aging (Leonel et al., 2023; Reichert et al., 2018), making the aquatic environment an important alternative for carrying out physical training.

Aquatic exercise programs in upright position have been popular and sought after by middle-aged and elderly audiences for decades, however, these programs are sometimes just a set of exercises performed in water, with or without music, in shallow or deep water which involves any type of physical exercise performed immersed, without suitable structuring and control of training variables (Moreira et al., 2019; Neiva et al., 2018; Silva et al., 2019; Waller et al., 2016). Althought there are increasing advances in scientific studies in this área, there is still a lack in the prescription, monitoring of internal and external load in periodization models that modulate volume and intensity, in a pragmatic perspective. It is necessary a movement of transfer the important scientific findings of aquatic exercise area for reality of gyms aquatic, being important studies performed in a “real world”, which consider the practical challenges in several income situations, as lack of equipment to evaluate participants and for monitoring the intensity prescription during the classes. Given this, the present work aims to verify the effect of 12 weeks of structured and monitored aerobic interval training on functional and cardiovascular outcomes in middle-aged adults.

Methods

Study design

This is a pilot study, with the aim of verifying the effect of an aerobic training program in an aquatic environment in upright position.

Participants

Participants in the extension program of aquatic activities in an upright position, linked to the Universidade Federal de Santa Catarina (UFSC) enrolled in the 2022.1 semester, were invited to participate in this work. As eligibility criteria, participants had to be between 30 and 80 years of age, of both sexes and have medical authorization to practice physical exercise and not have musculoskeletal limitations that could aggravate any physical condition or compromise the proper performance of the exercises. All participants signed the free and informed consent form and the study was approved by the Research Ethics Committee for Human Beings (5.510.243) and registered in the Brazilian Registry of Clinical Trials (RBR-2txw8zy).

Intervention

Given the scenario in which the participants of this study found themselves, coming from a post-pandemic period and after long detraining (more than 3 months), 3 familiarization sessions with the aquatic environment were carried out prior to the training program, with the aim of understanding the technique performing the exercises and using the Borg Perceived Exertion Scale (6 to 20). The training was carried out for 12 weeks, with three weekly sessions, on non-consecutive days (Monday, Wednesday and Friday). All sessions were taught and supervised by physical education professionals or by a student specifically selected for the training program.

Each training session lasted 50 minutes, divided into a warm-up period (5-10 minutes), followed by the main part (30 to 36 minutes) and ended with relaxation and/or stretching (5 minutes). The main part consisted of interval aerobic exercise in the upright position, through hydrogymnastics and/or walking/running in a deep pool. The training intensity was prescribed according to the Subjective Perceived Exertion (RPE) from 6 to 20 (Borg, 1982).

Regardless of the modality (hydrogymnastics and jogging) the training program was structured with 4 mesocycles of 3 weeks each. The first two mesocycles consisted of 1 minute of execution at higher intensity and 1:30 minutes at a lower intensity (1:1.5), with a total duration of 30 minutes. From the third mesocycle onwards, there was an increase in training density and volume, with a total duration of the session lasting 36 minutes and with a stimulus:recovery ratio of 1 minute each (1:1). In the last mesocycle, the training intensity was also increased. In the jogging, the movement technique remained the same, details in Table 1.

Table 1. Periodization characteristics of interval aerobic training in jogging.

Mesocycle	Week	Training sessions	Duration (main part)
1	1-3	12 x (1min 30s RPE 11 and 1 min RPE 13)	30 min
2	4-6	12 x (1min 30s RPE 11 and 1 min RPE 15)	30 min
3	7-9	18 x (1 min RPE 11 and 1min RPE 15)	36 min
4	10-12	18 x (1 min RPE 13 and 1min RPE 15)	36 min

Note: min= minutes; RPE: Rating of perceived effort; s= seconds.

In the sessions in which the hydrogymnastics modality was prescribed, 6 exercises were performed in the following order: stationary running, posterior elevation, frontal kick, hip adduction and abduction, frontal sliding and posterior running. Each exercise was performed at stimulus and recovery intensity to move on to the next exercise. The execution of the 6 exercises was counted as a block, more details prescription (Table 2).

Table 2. Periodization characteristics of interval aerobic training in hydrogymnastics.

Series block	Exercise	Execution time	RPE
Mesocycle I (Week 1-3)			
2x	Stationary running	1 min 30s	11 (light)
		1 min	13 (somewhat hard)

	Posterior elevation	1 min 30s	11 (light)
		1 min	13 (somewhat hard)
	Frontal Kick	1 min 30s	11 (light)
		1 min	13 (somewhat hard)
	Hip adduction and abduction	1 min 30s	11 (light)
		1 min	13 (somewhat hard)
	Frontal sliding	1 min 30s	11 (light)
		1 min	13 (somewhat hard)
	Posterior running	1 min 30s	11 (light)
		1 min	13 (somewhat hard)
Mesocycle II (Week 4-6)			
2x	Stationary running	1 min 30s	11 (light)
		1 min	15 (hard/heavy)
	Posterior elevation	1 min 30s	11 (light)
		1 min	15 (hard/heavy)
	Frontal Kick	1 min 30s	11 (light)
		1 min	15 (hard/heavy)
	Hip adduction and abduction	1 min 30s	11 (light)
		1 min	15 (hard/heavy)
	Frontal sliding	1 min 30s	11 (light)
		1 min	15 (hard/heavy)
	Posterior running	1 min 30s	11 (light)
		1 min	15 (hard/heavy)
Mesocycle III (Week 7-9)			
3x	Stationary running	1 min	11 (light)
		1 min	15 (hard/heavy)
	Posterior elevation	1 min	11 (light)
		1 min	15 (hard/heavy)
	Frontal Kick	1 min	11 (light)
		1 min	15 (hard/heavy)
	Hip adduction and abduction	1 min	11 (light)
		1 min	15 (hard/heavy)
	Frontal sliding	1 min	11 (light)
		1 min	15 (hard/heavy)
	Posterior running	1 min	11 (light)
		1 min	15 (hard/heavy)
Mesocycle IV (Week 10-12)			
3x	Stationary running	1 min	13 (somewhat hard)
		1 min	15 (hard/heavy)
	Posterior elevation	1 min	13 (somewhat hard)
		1 min	15 (hard/heavy)
	Frontal Kick	1 min	13 (somewhat hard)
		1 min	15 (hard/heavy)
	Hip adduction and abduction	1 min	13 (somewhat hard)
		1 min	15 (hard/heavy)
	Frontal sliding	1 min	13 (somewhat hard)
		1 min	15 (hard/heavy)
	Posterior running	1 min	13 (somewhat hard)
		1 min	15 (hard/heavy)

Note: min= minutes; RPE: Rating of perceived effort Borg Scale 6-20; s= seconds; x: series.

Sample characterization measures

To characterize the participants, an initial anamnesis with sociodemographic information, health conditions and physical activity practice was applied. The collects of anthropometric characteristics followed the procedures reported by Lohman et al. (1988). Body mass and height were collected using a digital scale with a precision of 100 grams (Marte®, modelo PP 180), and a stadiometer with a precision of 1 millimeter (AlturaExata®), respectively. The ratio between total body mass and height squared was used to calculate the Body Mass Index (BMI) represented by kg/m². In addition, the waist-to-height ratio was also calculated using the ratio between waist circumference (cm) and height (cm).

Outcome measures

Functional fitness, quality of life, capillary blood glucose, blood pressure and resting heart rate were evaluated before and after 12 weeks of training. Training control parameters were also collected through internal and external load.

As primary result, functional fitness was assessed using the Rikli and Jones battery of tests (Rikli & Jones, 2013). In summary, the resistance and strength of the dominant upper limb was evaluated through a 30-s arm curl (4 kg for men and 2 kg for women), the resistance and strength of the lower limbs was performed through the 30-s chair stand, functional mobility was assessed using the 8-foot Up and Go test (8UG), and cardiorespiratory endurance through the 6-minute walk test (6MWT). For the evaluations, the participants were instructed to wear suitable clothes and received instructions on how to perform each test. Once familiarized, the evaluation was performed following the sequence mentioned above.

To assess the quality of life, the instrument was used WHOQOL-8 (Fleck et al., 2000). This instrument is self-administered, cross-culture translated and validated into Portuguese, consisting of 8 questions. Its score varies between zero and 32 points, with questions about the global quality of life and general perception of health, in addition to questions related to the physical, psychological, social relationships and environment domains.

In the collection of capillary blood glucose, a digital puncture procedure was performed with a clinical glucometer (Accu-CheckPerforma, Roche, Portugal), with the aid of disposable lancets (Accu-Check Safe-T-Pro Uno, Roche, Portugal) and a drop of capillary blood, which made it possible to assess the concentration of blood glucose at the moment. Resting systolic (SBP) and diastolic (DBP) blood pressure were measured using automatic equipment (OMRON, model HEM-7113, Brazil) after the participants remained at rest, sitting in a calm environment, for 10 minutes. Resting heart rate was measured after 10 minutes of rest, using a portable heart rate meter (Polar®, S810i) positioned on the wrist of the participants.

Training load measures were collected at the end of the first and last session of the training program. Internal load (IL) was collected using the modified Borg CR10 scale (Foster et al., 2017) in order to evaluate the intensity individually. For this evaluation, each participant had to answer, individually, the following question: “How was your training today?”. The answer was given through the descriptor in the table, linked to a numerical value from zero to 10 (zero corresponding to no effort and 10 to maximum exertion). The internal training load was calculated by multiplying the RPE score by the total duration of the session expressed in minutes (including warm-up, cool-down and rest between efforts) expressed in arbitrary units (AU) (Nakamura et al., 2010). The external load (EL) was given by the number of repetitions performed in the last exercise (Posterior running) of the last session of the training block, in hydrogynastics and in jogging, the distance covered in the pool. These repetitions were counted by the students themselves, who at the end of the series, individually, passed on the information to the coaches.

Statistical analysis

The sample was characterized with variables of age, sex, BMI, Waist-to-Height Ratio and health status with presence of systemic arterial hypertension and dyslipidemia. Continuous variables were expressed as mean and standard deviation and categorical variables as absolute and relative frequency.

For the analysis of the study outcomes, the Shapiro-Wilk test was applied to assess the normality of the data. Once normality was identified, the paired Student's t test was applied for pre- and post-intervention comparisons. The effect size was calculated using the Cohens'd (Cohen, 1988) and classified as: 0.20 > d < 0.50 – small; 0.50 > d <0.80, mean and; d ≥ 0.80 – large. The significance level adopted was 0.05. All these analyzes were performed using SPSS, version 21.0 (IBM Corp., Armonk, NY, EUA).

Results

Started the training program 21 participants of both sexes, however, after some withdrawals due to personal reasons, only 13 participants completed the intervention. Of these participants, 5 reported using some medication, such as diuretics, beta-blockers and angiotensin-converting enzyme (ACE) inhibitors.

Thirty-five training sessions were planned, in which participants completed 19.61±6.18 sessions. Adherence to the training program was 56.50±17.29%, however, it is worth mentioning that 4 participants achieved adherence equal to or greater than 70%. No adverse effects to training were reported, although some participants complained of pain and/or musculoskeletal limitation, which disappeared during training. In Table 3 are the sociodemographic and health characteristics of the participants.

Table 3. Characteristics of the participants (n=13).

Variables	$\bar{X}$ (±sd)
Age (years)	58.54±4.67
BMI (kg/m²)	28.46±4.44
Waist-to-Height Ratio	0.55±0.06
	n (%)
Sex (female)	10 (76.9%)
Presence of systemic arterial hypertension	5 (38.5%)
Presence of dyslipidemia	5 (38.5%)

Note: BMI= body mass index; $\bar{X}$ = average; sd= standard deviation; n= absolute frequency; %= relative frequency.

After a period of 12 weeks of aerobic training in the aquatic environment, there was a significant improvement in the 30-s arm curl and 6MWT scores, as well as a significant reduction in DBP and heart rate resting (HRR) of the participants. Table 4 describes all functional fitness, quality of life and cardiometabolic measures.

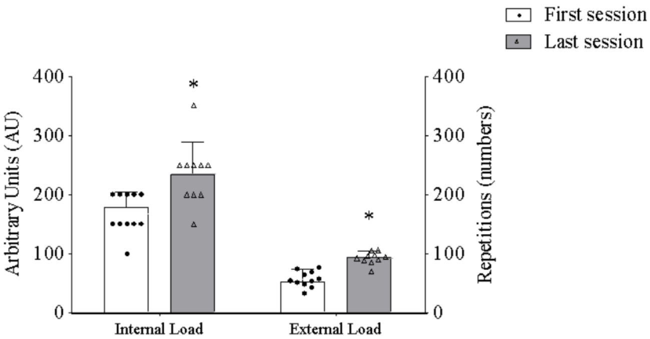
Table 4. Effects of aquatic training in upright position before and after 12 weeks of intervention (n=13).

Variables	Before $\bar{X}$ (±sd)	After $\bar{X}$ (±sd)	*Cohen's d*	p value
30-s chair stand (reps)	14.81±3.21	16.81±3.25	0.61	0.073
30-s arm curl (reps)	16.46±4.33	19.61±4.50	0.71	0.007*
8UG (s)	6.02±1.32	5.69±8.15	0.05	0.213
6MWT (meters)	563.07±90.36	601.90±66.18	0.49	0.016*
WHOQOL-8 (points)	29.14±2.90	31.00±2.28	0.71	0.095
Capillary blood glucose (mg/dl)	111.10±16.15	103.10±7.66	0.63	0.190
SBP (mmHg)	118.60±12.35	114.21±9.39	0.40	0.261
DBP (mmHg)	78.86±9.44	70.25±9.98	0.88	0.001*
HRR (bpm)	79.38±9.48	69.69±11.42	0.92	0.006*

Note: 8UG= 8-foot Up and Go test; 6MWT= 6-minute walk test; bpm=beats per minute; DBP= diastolic blood pressure; HRR= heart hate resting; reps=repetitions; s=seconds; SBP= systolic blood pressure; $\bar{X}$ = average; sd= standard deviation; *= p<0.05

In Figure 1 are expressed the means and standard deviation in group and individual values of the internal and external training load. Both types of loads showed a significant increase after 12 weeks of aquatic training (IL = First session: 177.78±26.35 AU; last session: 233.33±55.90 AU; p=0.030/ EL =First session: 51.10±22.27 repetitions; last session: 93.30±10.33 repetitions; p<0.001).

Figure 1. Participants averages and individual values of internal and external load of the first and last training session.



Note: Internal training load represented by the left y-axis in arbitrary measures; External training load is represented by the right y-axis in number of repetitions of the posterior running exercise; *= p<0.05 pre vs post.

Discussion

The aim of the present polit study was to verify the effect of 12 weeks of structured and monitored aerobic interval training on functional and cardiovascular outcomes in middle-aged adults. As main findings, despite the low dose of exercise, there was an improvement in the muscular resistance of the upper limbs and cardiorespiratory conditioning, as well as a reduction in the participants' DBP and HRR.

Although adherence to the training program was approximately 56%, it is worth highlighting that these improvements in different functional and cardiovascular outcomes have great clinical relevance, given the natural decline of organic functions in the continuous aging process (Valenzuela et al., 2019). The reduction of physical capacity, for example, leads to the impossibility of performing activities of daily living (Gomes et al., 2020), increased blood pressure exposes individuals to the risk of cardiovascular events (Kokkinos, 2014), while increased HRR is associated with heart failure in the general population (Böhm, Bewarder, et al., 2020).

In this scenario, interventions that promote the improvement of different body functions are important and necessary (Valenzuela et al., 2019). In our study, we observed an improvement of 19.13% in the performance of the 30-s arm curl, which demonstrates the influence of the training in gaining strength and muscular endurance of the upper limbs. This result is of great clinical relevance, since in our study the upper limbs only accompanied the movement, and no specific training was prescribed for gains in this muscle group. In addition, in the land environment, it is necessary to prescribe specific training in order to have significant improvements in the upper limbs (Wu et al., 2023). This positive effect found in our study is related to the increase in resistance created by the water in upper limb movements, together with an increase in intensity, which contributed to generate positive neuromuscular adaptations, improving the strength and functional capacity of the participants.

In studies that prescribed interval aerobic training in an aquatic environment, where the upper limbs accompanied the movements, they also obtained relevant improvements in the strength and resistance of the upper limbs, with gains of 15.5% (Farinha et al., 2021) and 42.44% (Reichert et al., 2016). The difference in values found in these studies compared to ours may be related to training prescription and intervention time. In the study by Farinha et al. (2021) the authors used the predicted HR as a parameter to control the intensity, however, properties such as water temperature and immersion depth reduce the HR values and this may have underestimated the actual intensity performed by the participants (Graef & Kruel, 2006). In the study by Reichert et al. (2016), we understand that the training time provided the expressive magnitude of gains for the resistance of the upper limbs. The observed gains are important, as the function of the upper limbs is crucial for realization out activities such as carrying groceries and performing household chores. Therefore, the maintenance or improvement of its function contributes positively to the individual's ability to perform activities of daily living (Dunsky et al., 2011).

Although no significant change was observed, an average effect size was observed in the result of the 30-s chair stand test, with an average increase of 2 repetitions in a group with already satisfactory baseline values. This increase in repetitions becomes relevant considering that in aging the increase of 2 repetitions corroborates in improvement for activities in daily life, in addition, this increase is found with specific strength training on land (Lemos et al., 2020). We can infer that the aerobic aquatic training performed contributes to the maintenance of lower limb strength and resistance in middle-aged adults. In the same sense, in the functional mobility test (8UG) there was no significant change, however, the participants had values below those evidenced with aerobic training in an aquatic environment (Delevatti et al., 2018; Reichert et al., 2016).

Regarding the 6MWT, we observed an increase of 6.9% in the distance covered by the participants in our study, indicating greater displacement speed for the same time. In this context, the importance of the observed results is emphasized, since the distance covered after training is in accordance with the values considered clinically relevant in clinical populations (Bohannon & Crouch, 2017).In addition, based on the assumption of increased speed in the execution of the test, we can infer that the proposed training model provided a protective functional gain, since the reduction in walking speed is associated with an increased risk of cardiovascular diseases and premature mortality (Veronese et al., 2018).

Our findings for the walk test differ from some findings in the literature. Reichert et al. (2016), for example, after 28 weeks, they observed gains of 11.96%, however, the sample of this study was composed of elderly people, who generally present greater amplitude for improvement. Also in this study, it is worth mentioning that the weekly frequency was two sessions per week, representing 20 sessions more than in our study, however, even with a more expressive improvement, our participants ended the intervention with 18 m more in distance covered.

In the study by Kargarfard et al. (2018), participants with multiple sclerosis underwent 8 weeks of training in the aquatic environment and experienced gains of 11.52% in the distance covered in the walk test. This clinical condition of the participants in the study by Kargarfard et al. (2018) may be the main factor for the difference between our findings. This is because, in this study, the participants started the training program by walking 451 m and ended the intervention with 503 m. However, the pre-training value in our study was 563 m, which is greater than the post-training values by Kargarfard et al. (2018). Therefore, we can infer that the functional condition of the participants before the training program may have been determinant for the greater gains observed by Kargarfard et al. (2018).

As well as functional fitness, training in an aquatic environment can positively influence cardiovascular aspects, given the significant reduction in DBP (11.5%) accompanied by a non-significant reduction in SBP (3.7%) observed in our study. Although relevant, it is worth mentioning that these results differ from those reported by Delevatti et al. (2016), which observed a significant reduction only in SBP (4.6%), without significant reduction in DBP (2.3%). Our findings, especially in DBP, confirm the findings of an important meta-analysis (Reichert et al., 2018) who found a reduction in both SBP (-10.58 mmHg) and DBP (-4.40 mmHg). Discussing more specifically, our findings obtained lower reductions than this study in SBP (-4.39 mmHg) and higher in DBP (-8.61 mmHg).

Despite the particularities of the prescription of training in the study by Delevatti et al. (2016), the baseline DBP reported by these authors was lower than that recorded in our study. Interestingly, the opposite was observed for SBP, which was higher in the study Delevatti et al. (2016). In this scenario, according to Wilder's principle (Messerli et al., 2015), the possibility of greater reductions was observed in those whose basal blood pressure values were higher, which corroborates the scientific literature, as it has been reported that pre-training values are determinant in the BP response to physical exercise (Sardeli et al., 2020).

Overall, the reduction in all studies was beneficial to participants' cardiovascular function. Jeffers et al. (2015) reported that small reductions in blood pressure reduce the risk and mortality from cardiovascular events. Clinically, a decrease of 2 mmHg in DBP can reduce the risk of stroke by 15% (Cook et al., 1995), as well as, a 5 mmHg reduction in SBP can reduce the risk of cardiovascular events by 10% (Canoy et al., 2022). In this perspective, we observed reductions of 8.6 mmHg and 4.4 mmHg in DBP and SBP, respectively, which leads us to believe that the practice of training applied in our study seems to have good clinical relevance.

This positive impact on the cardiovascular health of the participants can also be seen in the reduction in HRR, which corroborates the findings of Delevatti et al. (2016). Even with findings in the same direction, the magnitudes of change differ, possibly due to differences in drug use and baseline HR values. However, regardless of the magnitude, the reduction in HRR is extremely important for the clinical context, indicating, among other alterations, a possible sympathetic suppression (Fu & Levine, 2013).

High HRR values have been associated with poor physical fitness, disease development and mortality, and although the ideal HRR may vary from individual to individual, average values that exceed 70 bpm are considered to be of concern (Böhm, Schumacher, et al., 2020; Olshansky et al., 2022). In our findings, there was a decrease of 10 bpm, going from 80 bpm to 70 bpm and, in this context, they seem to reinforce even more the possible cardiovascular clinical benefit that 12 weeks of aerobic training in an aquatic environment provided to the participants.

Although no significant changes were observed, it is noteworthy that a medium effect size was observed in the quality of life and capillary blood glucose results. The improvements in these parameters need to be highlighted, as they corroborate several studies in the literature. The systematic review of Delevatti et al.(2015), for example, describes that glycemia and lipid profile can improve with the practice of aquatic training in the upright position, as well as, in the meta-analysis of Faíl et al. (2022) aquatic training has been reported to be effective in improving health and physical fitness in healthy adults and adults with chronic diseases.

The control of the internal and external load carried out in this work contributes to infer that these increases are consistent with the proposed training progression that we proposed, with a significant increase of 23.29% in the internal load and 45% in the external load, which denotes that the training prescribed, performed and perceived by the participants progressed over the 12 weeks. The control, the correct application and distribution of loads in the training prescription is necessary to generate physiological changes and improvements in the performance and health of practitioners (Impellizzeri et al., 2019). With the records of internal and external load, we can infer that the beneficial effects found are associated with the capacity of the training to generate adaptations and changes in the body of the participants.

In this sense, our study presents benefits provided by the applied training, however, some limitations were observed and need to be reported. As this is a pilot study linked to a community-oriented project, it was not possible to previously determine a sample size and the period of the day that the training was applied may have hindered the presence and participation of more volunteers. In addition, due to the small number of participants, it was not possible to design an intervention that included a control group, making certain comparisons difficult. The use of medication by some participants may have influenced cardiovascular measurements. Structural and temperature problems in the pool, corroborated the low adherence to the training program, and due to logistical issues of scheduling pools and the problems reported above, they made it difficult to practice the jogging modality. Randomized clinical studies should be encouraged, as this type of study offers the possibility of controlling other variables that may influence the outcome variable.

Conclussion

The pilot study of twelve weeks of aerobic interval training showed improvements in upper limb strength, functional cardiorespiratory fitness and generate cardiovascular changes in middle-aged adults.

Clinical relevance

- Aerobic aquatic training with intensity and volume progression improves upper limb strength and walking distance.
- Twelve weeks of aquatic aerobic exercise with intensity and volume modulation reduce diastolic blood pressure and heart rate resting.

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EL IMPACTO DEL ENTRENAMIENTO DE AQUAGYM EN LAS VARIABLES DE APTITUD FÍSICA Y FUNCIONAL (PROTOCOLO DE ESTUDIO)

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1 conceptualizaron y diseñaron el estudio y 1 escribió el programa deseado. 1 interpretó los datos. 1 y 2 prepararon el primer borrador del documento y 1 y 2 lo revisaron críticamente. Todos los autores han aprobado esta versión final del texto.

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Resumen
Antecedentes: Los cambios asociados al proceso de envejecimiento comprometen la funcionalidad y respectiva autonomía de las personas mayores, conduciendo al surgimiento de comorbilidades, incluyendo enfermedades reumáticas, dolores crónicos, obesidad, sarcopenia, Alzheimer, demencia, entre otras.
Objetivo: Este protocolo fue desarrollado específicamente con el objetivo de estudiar el impacto del entrenamiento de aeróbic acuático en la aptitud física y la salud musculoesquelética de los practicantes de edad avanzada. Incluye validar los niveles de aptitud física e indicadores de sarcopenia en personas mayores que participan en programas de aeróbic acuático y posteriormente presentar una propuesta de intervención e implementar el Programa "Hidroentrenamiento".
Método: Todos los participantes del proyecto estarán sujetos a dos momentos de evaluación (línea de base y después de 14 semanas). Instrumentos: batería de pruebas sugeridas por Rickley y Jones, 1999, que son: Standing and Sitting 30'', Time up and go, Reaching Behind the Back, Sitting and Reaching y Handgrip Test. Los inventarios: Inventario de Depresión de Beck, IPAQ y SARC-F. Criterios de inclusión: personas mayores de 65 años que practican entrenamiento acuático, dos veces por semana durante 45 minutos. La muestra se organiza en dos grupos: Grupo de Ejercicio Acuático (GEA) que se someterá al programa "Hidroentrenamiento." y Grupo Control (CG), que permanecerá en el programa de aeróbic acuático, sin sufrir interferencia alguna.
Resultados: El protocolo de ejercicios de GEA tiene como objetivo mejorar la fuerza y la potencia con movimientos específicos que maximicen la resistencia que ofrece el agua, en una periodización con un aumento paulatino y progresivo de la carga a través del volumen. El programa GC es de carácter comunitario e incluye ejercicios de movimiento general, sin organización y control de la carga de entrenamiento.
Conclusiones: Se espera que el Programa "Hidroentrenamiento" sea diferenciador y promueva la mejora de la fuerza y la condición física de sus practicantes.
Palabras clave: Ejercicios Acuáticos, Aquagym, Sarcopenia, Ejercicios funcionales, Personas mayores

Abstract: The impact of aquatic exercise training on physical and functional fitness variables (Study protocol).
Background: The changes associated with the aging process compromise the functionality and respective autonomy of the elderly, leading to the emergence of comorbidities, including rheumatic diseases, chronic pain, obesity, sarcopenia, Alzheimer's, dementia, among others.
Goal: This protocol was specifically developed with the aim of studying the impact of water aerobics training on the physical fitness and musculoskeletal health of elderly practitioners. It includes validating physical fitness levels and sarcopenia indicators in elderly people participating in water aerobics programs and subsequently presenting an intervention proposal and implementing the "Hydrotraining" Program. All project participants will be subject to two assessment moments (baseline and after 14 weeks). Instruments: battery of tests suggested by Rickley and Jones, 1999, which are: Standing and Sitting 30'', Time up and go, Reaching Behind the Back, Sitting and Reaching, and Handgrip Test. The inventories: Beck Depression Inventory, IPAQ and SARC-F. Inclusion criteria: individuals over 65 years old who practice Aquatic Exercise, twice a week for 45 minutes. The sample is organized into two groups: Aquatic Exercise Group (GEA) which will be subjected to the "Hydrotraining" program and Control Group (CG), which will remain in the water aerobics program, without suffering any interference. The GEA exercise protocol aims to improve strength and power with specific movements that maximize the resistance offered by the water, in a periodization with a gradual and progressive increase in load through volume. The GC program is of a community nature and includes fferentiating and promote the improvement of strength and physical fitness of its practitioners.
Keywords: Aquatic Exercises, Hydrogymnastics, Sarcopenia, Functional Exercises, Periodization

Resumo: O impacto do treino de hidroginástica nas variáveis da aptidão física e funcionais.(Protocolo de Estudo).
As alterações associadas ao processo de envelhecimento comprometem a funcionalidade e respetiva autonomia do idoso, levando ao surgimento de comorbidades, entre elas doenças reumáticas, dor cronica, obesidade, sarcopenia, Alzheimer, demência, entre outras. Este protocolo foi especificamente desenvolvido com o objetivo de estudar o impacto do treino de hidroginástica na aptidão física e na saúde músculo-esquelética dos idosos praticantes. Contempla a validação dos níveis de aptidão física e indicadores de sarcopenia em idosos participantes de programas de hidroginástica e posterior apresentar uma proposta de intervenção e implementar o Programa "Hidrotreinamento". Todos os participantes do projeto estarão sujeitos à dois momentos de avaliação (*baseline* e após 14 semanas). **Instrumentos:** bateria de Testes sugerido por Rickley e Jones, 1999, que são: de Levantar e Sentar 30'', Time up and go, Alcançar Atrás das Costas, Sentar e Alcançar e Teste de preensão manual. Os inventários: Inventário de Depressão de Beck, IPAQ e SARC-F. Critérios de inclusão: indivíduos com mais 65 anos praticantes de hidroginástica, com frequência de 2x semana por 45 minutos. A amostra está organizada em dois grupos: Grupo Exercício Aquático (GEA) que serão submetidos ao programa "Hidrotreinamento" e Grupo Controlo (GC), que vai se manter no programa de hidroginástica, não sofrendo qualquer interferência. O protocolo de exercício do GEA pretende melhorar a força e potência com movimentos específicos que maximizam a resistência oferecida pela a água, numa periodização com aumento de carga gradual e progressiva através do volume. O programa GC é de caráter comunitário e inclui exercícios de movimentos gerais, sem organização e controlo da carga de treino. Espera-se que o Programa "Hidrotreinamento" seja diferenciador e promotor da melhoria de força e da aptidão física dos seus praticantes.
Palavras chaves: Exercício Aquático, Hidroginástica, Sarcopenia, Força, Idosos.

Introdução

Entre as alterações associadas ao processo de envelhecimento podemos citar, o aumento de peso e da gordura corporal, a redução de massa muscular, a perda de equilíbrio, a redução da capacidade aeróbia, da mobilidade, da flexibilidade e diminuição da densidade mineral óssea. Tais alterações caracterizam o declínio progressivo do sistema musculosquelético (Cruz-Jentoft et al., 2019; Jang et al., 2020) e comprometem a funcionalidade e respetiva autonomia do idoso (Shiotsu & Yanagita, 2018), levando ao surgimento de comorbidades como doenças reumáticas, dor crónica, obesidade, sarcopenia, quedas, Alzheimer e demência, entre outras. (Iolascon et al., 2018; Lee et al., 2011; Lim et al., 2013; Rezaeipour, 2021). Como agravante, o sentimento de improdutividade, incapacidade, diminuição das relações sociais, a dificuldade de adaptação ao processo de envelhecimento e a dor crónica podem levar à perda de autoestima, ao aumento da ansiedade e à instalação de sintomas depressivos; quadro muito característico ao avançar da idade, acabando por comprometer ainda mais o ciclo de comorbidades e respetiva qualidade de vida do idoso (Beck & Clapp, 2011; De Beurs et al., 2005; Marcellini et al., 2006; Murrell & Meeks, 2002; Nitschke & Müller, 2004; Ryff et al., 2006).

Entre as comorbidades associadas ao envelhecimento, a sarcopenia é uma doença muscular caracterizada pela alteração do tecido muscular, identificada pela redução de força muscular e com diminuição da quantidade ou qualidade muscular, associada ao comprometimento do desempenho físico. Este termo tem sido usado para descrever aspectos micro e macroscópicos da arquitetura e composição muscular. Devido aos limites tecnológicos, a quantidade e a qualidade muscular permanecem problemáticas como parâmetros primários para definir a sarcopenia (Cruz-Jentoft et al., 2019).

Na sua definição operacional é um distúrbio muscular esquelético progressivo e generalizado que está associado ao aumento da probabilidade de resultados adversos, incluindo quedas, fraturas, incapacidade física e mortalidade (Cruz-Jentoft et al., 2019). O *European Working Group on Sarcopenia in Older People* (EWGSOP2) destaca como principais causas da sarcopenia a interação complexa de distúrbios da inervação, desequilíbrio hormonal, o aumento de mediadores inflamatórios e alterações da ingestão protéico-calórica e estabelece os seguintes critérios de diagnóstico da sarcopenia: uma ou mais medidas de força muscular, massa muscular e desempenho físico, além de um questionário de rastreio inicial denominado SARC-F (Ramirez et al., 2022). O desempenho físico que anteriormente era considerado parte da definição central de sarcopenia, agora esta a ser usado para categorizar a gravidade da sarcopenia (Morley et al., 2011). Keller (2019), cita que sarcopenia está ligada à atrofia e perda de fibras musculares e unidades motoras, o que afeta principalmente as fibras musculares de contração rápida e as suas unidades motoras, pois parecem ser mais propensas à falha de função e perda ao longo do tempo.

Entre as recomendações para a prevenção e tratamento da sarcopenia, destacam-se o treino de força e uma ingestão nutricional adequada. O exercício físico associado a cargas mecânicas e de alto impacto tem sido sugerido como estratégia de treino que causa um efeito positivo na remodelação óssea, força e potência muscular (Hoffmann et al., 2022). No entanto, esse tipo de exercícios pode não ser sempre apropriado para adultos de meia-idade e idosos devido ao declínio físico ou a distúrbios crónicos com dor incapacitante como a osteoartrite (Daly et al., 2019; Kemmler & Von Stengel, 2019; Rodrigues et al., 2017). Ainda, o risco de queda e o medo que frequentemente prevalece nesta população durante a realização dos exercícios em ambiente terrestre, têm desencorajado os idosos a iniciar ou a manter-se em um programa de exercícios (Rodrigues et al., 2017).

Entre os diferentes programas de exercício, a hidroginástica tem crescido e está a ganhar muitos praticantes em diferentes contextos (opinativo. É necessário incluir evidencia, que pode ser um indicador estatístico ou uma referencia). Estudos têm demonstrado que os exercícios aquáticos/hidroginástica têm efeito positivo nas componentes da aptidão física, no controle da dor Crónica e no risco de fratura traumática e oferecem uma sobrecarga mecânica mais reduzida (Faíl et al., 2023; Pinto et al., 2013; Prado et al., 2022; Schinzel et al., 2023; Silva et al., 2022; Tsourlou et al., 2006; Xu et al., 2023; Yazigi et al., 2013).

Tendo como base a exploração das propriedades hidrostáticas e hidrodinâmicas, verifica-se que os benefícios crónicos do exercício aquático causam melhoria geral da aptidão física em diferentes perfis de praticantes, seja em contextos de prevenção, reabilitação ou treino (Fuentes-Lopez et al., 2021; Ha et al., 2018; Irandoust et al., 2019; Kim et al., 2020; Martinez-Carbonell Guillamon et al., 2019). Específicamente, a literatura reporta efeitos positivos desta prática na força geral, resistência cardiorrespiratória, potência muscular, flexibilidade, equilíbrio, agilidade e no controlo de sintomas de patologias do foro musculo-esquelético e de saúde mental (Aboarrage Junior et al., 2018; Alberton, Antunes, et al., 2011; Alberton, Cadore, et al., 2011; Colado & Garcia-Masso, 2009; Colado et al., 2010; Colado, Tella, et al., 2009; Colado, Triplett, et al., 2009). Complementarmente, além da água ter um efeito relaxante, sendo a Hidroginástica uma aula de grupo de carácter predominantemente aeróbio pode ser um excelente contributo para a saúde psicológica, no âmbito da autoimagem, autoestima e controlo da ansiedade (Jackson et al., 2022; Tang et al., 2022).

No âmbito do efeito crónico de programas de hidroginástica e do treino de força, Reichert et al. (2019), compararam os efeitos a curto e longo prazo (8 e 16 semanas) de três treinamentos realizados em meio aquático (treinamento aeróbio, treinamento combinado de força com uso de equipamento resistido e treinamento combinado com séries múltiplas) nas respostas neuromusculares e cardiorrespiratórias de mulheres idosas. Avaliaram a força dinâmica máxima e a resistência muscular de extensão e flexão do joelho, flexão de cotovelo e supino, bem como a capacidade funcional. Os resultados mostraram ganhos semelhantes na força dinâmica máxima de extensão e flexão do joelho e flexão do cotovelo e aumentos na resistência muscular e na capacidade funcional. Num estudo de Schoenell et al. (2016) sobre adaptações neuromusculares em mulheres jovens sedentárias, após 10 semanas de treino aquático observaram-se melhorias significativas em todas variáveis avaliadas, independente do volume de treino.

Avelar et al. (2010), avaliaram o impacto de um programa estruturado de exercícios aquáticos e não aquáticos para desenvolvimento da resistência muscular de membros inferiores no equilíbrio estático e dinâmico de idosos. Os sujeitos foram divididos em três grupos: grupo de exercícios aquáticos, grupo de exercícios não aquáticos e grupo controle. Os grupos de exercícios foram submetidos a um programa de resistência muscular de membros inferiores que consistiu em sessões de 40 minutos duas vezes por semana durante seis semanas. O programa de resistência muscular de membros inferiores aumentou significativamente o equilíbrio ($p<0,05$) e essa melhoria foi independente do ambiente, ou seja, aquático ou não aquático.

Moreira et al. (2019), compararam os efeitos de duas metodologias de aulas de hidroginástica na capacidade funcional e flexibilidade de idosas em um período de 12 semanas. Noventa mulheres, com idades entre 55-70 anos, foram divididas em três grupos, um que não se exercitava, um que realizava aulas de hidroginástica com ênfase em exercícios de membros inferiores e um que realizava aulas de hidroginástica convencional. Utilizaram, para avaliação, testes funcionais. Os resultados encontrados na comparação intragrupo, demonstraram que houve melhorias significativas no desempenho nos testes e direcionaram para a conclusão que de a prática de hidroginástica melhorou a capacidade funcional e a flexibilidade das idosas. Não foram encontradas diferenças entre os dois tipos de metodologia utilizados. Katsura et al. (2010) avaliaram a eficácia do treinamento com exercícios aquáticos com equipamento resistidos em idosos. Os indivíduos foram divididos em dois grupos e foram submetidos a um treinamento de força: um grupo usando equipamentos para a aumentar a resistência à água e um grupo sem o equipamento. Cada a sessão durou 90 minutos e foi realizado três vezes por semana durante 8 semanas. Melhorias significativas foram observadas na força muscular em flexão plantar e no teste *time up* and *go* (TUG) em ambos os grupos. O grupo com equipamentos teve um melhor desempenho nos testes de equilíbrio e de capacidade de caminhar, que estão associados à prevenção de quedas.

Prado et al. (2022) realizaram uma revisão sistemática e meta-análise de estudos randomizados sobre as respostas de força muscular após um programa de exercícios aquáticos. Os resultados demonstraram que o treinamento em ambiente aquático pode ser dependente de fatores como idade, velocidade do movimento e uso de equipamentos. Exercícios terrestres e aquáticos parecem levar a ganhos de força muscular semelhantes. O exercício aquático deve ser recomendado como estratégia para melhorar a força muscular, mas novos estudos com melhor qualidade metodológica devem ser realizados.

Apesar de já haver vários estudos tendo a hidroginástica como foco, são poucos os estudos que têm como objetivo a validação do treino de força na água para pessoas idosas e que apresentem protocolos detalhados no que se refere à periodização e progressão da carga, e respetivo controlo, de modo a serem reprodutíveis e a fornecerem suporte às recomendações gerais e específicas para a prescrição do exercício na água (Prado et al., 2022).

Face a este cenário, esta proposta de estudo baseia-se nas seguintes questões:

Os padrões de movimento executados na hidroginástica são suficientes para gerar uma adaptação neuromuscular? A organização dos exercícios executados nas aulas de hidroginástica podem gerar ganho de força? O programa aquático estruturado promove a melhoria da força e da funcionalidade de idosos? Qual será a dose-resposta do exercício aquático no treino de força? No intuito de responder às questões formuladas estabeleceu-se o objetivo geral do estudo: apresentar uma proposta de intervenção de um programa de treinamento aquático, o “Hidrotreinamento”, para o desenvolvimento da força e aptidão funcional de pessoas idosas. São objetivos específicos: (1) Avaliar e comparar a força e potência muscular (2) Avaliar e comparar o nível de aptidão funcional e (3) Avaliar e comparar os indicadores de sarcopenia, entre dois grupos que praticam Hidroginástica com protocolos diferentes.

Material e métodos

O protocolo do estudo foi submetido para aprovação pela Comissão de Ética da Faculdade de Motricidade Humana da Universidade de Lisboa, em conformidade com as diretrizes nacionais e internacionais para investigação científica que envolve seres humanos. (Número:13/2013). Todos os participantes serão previamente informados sobre os procedimentos e riscos potenciais do estudo e assinarão um termo de consentimento livre.

Desenho experimental

O programa “Hidrotreinamento” terá duração de 14 semanas e frequência bi-semanal, seguindo as orientações prescritas no estudo de Yazigi et al. (2013). Será baseado nas Diretrizes da Associação de Exercício Aquático (AEA, 2018), no ACSM Diretrizes para Prescrição de Exercícios (ACSM, 2017) e na análise de protocolos de estudo anteriores (Yazigi et al., 2016). Será constituído por 28 sessões sendo que cada sessão terá a duração de 45 minutos, assim distribuídos: 10 a 15 minutos de aquecimento, 10 a 20 minutos do treino principal e 5 minutos finais para relaxamento. O Ambiente da piscina a ser utilizada tem a temperatura do ar a rondar os 28º ± 1°C, e a temperatura da água será controlada a 30,5 ± 0,5°C.

Os treinos serão organizados seguindo uma periodização segundo a qual uma sobrecarga será incrementada progressivamente todas as semanas, sendo a água o principal elemento de resistência (tabelas 1, 2 e 3). O protocolo do GEA terá como objetivos específicos a melhoria da qualidade de vida e o condicionamento físico. Terá como objetivos principais a adaptação aquática, flexibilidade, treino da mobilidade e estabilidade, treino da marcha, socialização e saúde mental. Serão objetivos secundários deste grupo o desenvolvimento do sistema cardiorrespiratório e o treino de força e de potência muscular.

Outro aspecto que será considerado é o nível de habilidade aquática de cada participante, bem como a organização dos padrões motores adequados à respiração na qual o praticante expira no momento da aplicação da força (Gosselink, 2004; Linsenbardt et al., 1992). Para garantir uma compreensão clara dessa situação, será fornecida uma orientação prévia aos participantes, visando minimizar a possibilidade de erros na execução dos movimentos. Nas suas primeiras semanas os alunos farão as aulas para aprendizagem e adaptação dos exercícios propostos, onde toda a qualidade técnica será valorizada. Neste período, os participantes também serão treinados para entender como utilizar a tabela de Borg (Borg, 1970; Borg, 1998) que será usada para monitorar a intensidade e a perceção subjetiva do esforço, de acordo com as diretrizes para a gestão da intensidade do exercício (ACSM, 2017).Para facilitar a compreensão optou-se para esta população pela escala adaptada de 1 a 10 valores.

A música terá uma cadência de 128 batimentos por minuto (BPM), no aquecimento e em todas sessões. Isso permitirá uma melhor amplitude de movimento com baixa aceleração dos segmentos corporais. Na parte principal da sessão, a cadência mudará para 132 BPM, o que exigirá um maior esforço por parte dos participantes, principalmente na estabilização do corpo e na capacidade de manter a amplitude de movimento. Isso também resultará em uma aceleração dos segmentos corporais, à medida que os participantes aplicam força contra a resistência da água.

Amostra

O estudo do efeito do programa “Hidrotreinamento” requer uma amostra mínima de 25 participantes por grupo. Foi calculada a potência com o programa *G Power* 3.1, para uma potência de 0,95 para comparar dois grupos independentes com nível de significância (α) P<0,05 A amostra do estudo será considerada como não probabilística intencional, selecionada por conveniência e terá. Para o estudo recrutaremos os praticantes de hidroginástica que já frequentam um programa comunitário e praticantes de um programa de hidroginástica num ginásio privado, constituindo assim dois grupos.

Grupo controlo (GC) com 25 participantes que continuarão a cumprir o programa de hidroginástica comunitário que já frequentavam. (2) Grupo Experimental (GEA) com 26 participantes que deixará de cumprir o antigo programa de hidroginástica e será submetido ao “Hidrotreinamento”, programa estruturado e periodizado com o objetivo de qualificar os padrões motores visando um aumento da força muscular.

Critérios de inclusão:

- ter idade igual ou superior a 55 anos;

- ser autónomo;
- não ter contraindicação para exercício aquático;
- estar a frequentar um programa bisemanal de exercício aquático/hidroginástica
- ter autonomia para a realização dos testes;
- ter conhecimentos básicos de leitura e escrita

Serão critérios de exclusão::

- artroplastia de quadril ou joelho ou cirurgia de joelho nos seis meses anteriores ao estudo;
- injeções no joelho nos últimos três meses.
- condições médicas instáveis;
- patologias dermatológicas.

Os dois grupos de idosos exercício aquático (GEA) e grupo controlo (GC), serão avaliados em dois momentos distintos. Os sujeitos serão selecionados através dos programas comunitários existentes no concelho de Oeiras e num ginásio privado, segundo os seguintes

Protocolo de exercício

Protocolo Hidrotreinamento (Grupo Exercício Aquático - GEA).

O programa de "Hidrotreinamento" consiste em treinos aquáticos projetados para desenvolver a força muscular, incorporando uma série de exercícios realizados na posição vertical. Estes exercícios são baseados em movimentos neuro motores fundamentais, tanto básicos quanto específicos, e são padronizados de acordo com as diretrizes estabelecidas por Aboarrage Junior (2021). Os grupos musculares são categorizados entre parte superior e inferior do corpo, bem como entre parte anterior e posterior. Cada sessão de treino segue uma estrutura consistente, composta por três momentos distintos: aquecimento, parte principal e relaxamento.

Na parte inicial, é crucial destacar que todas sessões seguem um padrão estrutural semelhante. O aquecimento é projetado com base na combinação de exercícios destinados a recrutar grandes grupos musculares e promover movimentos fundamentais básicos que são 8: corrida, chutes, twist, ski, pêndulo, cavalo, polichinelo e balanço. Este aquecimento visa elevar a temperatura corporal, mobilizar as principais articulações, corrigir possíveis erros de execução e enfatizar o componente motor através de exercícios de coordenação (Aboarrage Junior, 2021; AEA, 2018). A intensidade, direção e trajetória dos movimentos, bem como a cadência do exercício, serão progressivamente ajustados de acordo com o nível de habilidade aquática dos participantes. Para tal, o professor que lidera estas aulas deve ter uma capacidade de observação e de ensino, de modo a identificar as dificuldades de cada participante e ajustar a proposta de modo a que todos tenham sucesso na sua prática.

Na parte fundamental do treino, serão realizados movimentos destinados a recrutar diversos grupos musculares, incluindo quadríceps, isquiotibiais, adutores/abdutores do quadril, glúteos, abdominais e eretores da coluna. Serão implementados protocolos com método intervalado de alta intensidade, conforme sugerido por Aboarrage Junior et al. (2018). As séries serão realizadas de forma intervalada, alternando entre exercícios para treinar a força resistida e estímulos de aceleração, com pausas para recuperação. A estratégia "all out", na qual os praticantes executam os movimentos com máxima intensidade durante os estímulos (Machado et al., 2018), determinará a carga de trabalho. A periodização será cuidadosamente controlada, ajustando o volume de estímulos de acordo com a progressão da carga, conforme as diretrizes estabelecidas pela AEA (2018).Para tal, o número de séries, repetições, intensidade e até a cadencia musical será controlado e desenvolvida de modo progressivo.

Na parte final do treino, além da implementação de diferentes estratégias e propostas pré-definidas a cada semana, será incorporada uma forte componente motivacional. Para maximizar a adesão ao programa, serão incluídos elementos e técnicas comportamentais que incentivam o contato social entre os participantes, promovem interações frequentes durante todas as fases da intervenção, estabelecem objetivos comportamentais claros com feedback regular, auxiliam os participantes na automonitorização da intensidade dos exercícios e desafiam os participantes a superar as métricas coletadas nas avaliações, estabelecendo um compromisso pessoal para cada um (Tabelas 1, 2 e 3).

Figura ou quadro 1 – Periodização semanal do protocolode Hidrotreinamento do grupo GEA(semana 1 a 7).

	Semana		semana 1	semana 2	semana 3	semana 4	semana 5	semana 6	semana 7
	BPM música		128	128	132	132	132	132	132
Aquecimento	Mobilidade articular/estabilidade	Duração	10	10	10	10	10	10	5
		Padrão de movimento	Movimentos articulares com grande amplitudes e pequena área de superfifie de contato	Movimentos articulares com grande amplitudes e pequena área de superfifie de contato	Movimentos articulares com grande amplitudes e pequena área de superfifie de contato	Movimentos articulares com grande amplitudes e pequena área de superfifie de contato	Movimentos articulares com grande amplitudes e pequena área de superfifie de contato	Movimentos articulares com grande amplitudes e pequena área de superfifie de contato	Movimentos articulares com grande amplitudes e pequena área de superfifie de contato
Parte Fundamental	Componente cardiorrespiratória: Padrões Básicos	Duração	10	10	10	10	10	10	5
		Intensidade (Tabela Borg)	10 - 12	10 - 12	10 - 12	10 - 12	10 - 12	10 - 12	10 - 12
		Padrão de movimento	8 Elementos Básicos: Corrida, chute, balanço, polichinelo, ski, twist, cavalo e pêndulo.	8 Elementos Básicos: Corrida, chute, balanço, polichinelo, ski, twist, cavalo e pêndulo.	8 Elementos Básicos: Corrida, chute, balanço, polichinelo, ski, twist, cavalo e pêndulo.	8 Elementos Básicos: Corrida, chute, balanço, polichinelo, ski, twist, cavalo e pêndulo.	8 Elementos Básicos: Corrida, chute, balanço, polichinelo, ski, twist, cavalo e pêndulo.	8 Elementos Básicos: Corrida, chute, balanço, polichinelo, ski, twist, cavalo e pêndulo.	8 Elementos Básicos: Corrida, chute, balanço, polichinelo, ski, twist, cavalo e pêndulo.
	Treino de Força/Potência	Duração	20'	20	20	20	20	20	30
		Intensidade (Tabela Borg)	15 - 17	15 - 17	15 - 17	15 - 17	15 - 17	15 - 17	15 - 17
		Padrão de movimento	MODELO 1 BLOCO 1	MODELO 1 BLOCO 2	MODELO 2 BLOCO 1	MODELO 2 BLOCO 2	MODELO 3 BLOCO 1	MODELO 3 BLOCO 2	MODELO 1 BLOCO 1/2
			MODELO 1 BLOCO 2	MODELO 2 BLOCO 2	MODELO 3 BLOCO 2	MODELO 3 BLOCO 1	MODELO 2 BLOCO 2	MODELO 2 BLOCO 1	MODELO BLOCO 2/1
			MODELO 1 BLOCO 3	MODELO 3 BLOCO 2	MODELO 1 BLOCO 1	MODELO 1 BLOCO 2	MODELO 1 BLOCO 1	MODELO 1 BLOCO 2	MODELO 3 BLOCO 1/2
Parte Final		Duração	5	5	5	5	5	5	5
	Alongamentos	Padrão de movimento	Alongamento estático com grande aplitude e pequena área de superfifie de contato.	Alongamento estático com grande aplitude e pequena área de superfifie de contato.	Alongamento estático com grande aplitude e pequena área de superfifie de contato.	Alongamento estático com grande aplitude e pequena área de superfifie de contato.	Alongamento estático com grande aplitude e pequena área de superfifie de contato.	Alongamento estático com grande aplitude e pequena área de superfifie de contato.	Alongamento estático com grande aplitude e pequena área de superfifie de contato.
	Componete lúdica/ descontração		componente ludico/social	Jogos cognitivos	componente ludico/social	Jogos cognitivos	componente ludico/social	Jogos cognitivos	componente ludico/social

Figura ou quadro 2 – Periodização semanal do protocolo de Hidrotreinamento do grupo GEA, (semana 8 a 14).

	Semana		semana 8	semana 9	semana 10	semana 11	semana 12	semana 13	semana 14
	BPM música		132	132	132	132	132	132	132
Aquecimento	Mobilidade articular/estabilidade	Duração	5	5	5	5	5	5	5
		Padrão de movimento	Movimentos articulares com grande amplitudes e pequena área de superfífie de contato	Movimentos articulares com grande amplitudes e pequena área de superfífie de contato	Movimentos articulares com grande amplitudes e pequena área de superfífie de contato	Movimentos articulares com grande amplitudes e pequena área de superfífie de contato	Movimentos articulares com grande amplitudes e pequena área de superfífie de contato	Movimentos articulares com grande amplitudes e pequena área de superfífie de contato	Movimentos articulares com grande amplitudes e pequena área de superfífie de contato
Parte Fundamental	Componente cardiorrespiratória: Padrões Básicos	Duração	5	5	5	5	5	5	5
		Intensidade (Tabela Borg)	10 - 12	10 - 12	10 - 12	10 - 12	10 - 12	10 - 12	10 - 12
		Padrão de movimento	8 Elementos Básicos: Corrida, chute, balanço, polichinelo, ski, twist, cavalo e pêndulo.	8 Elementos Básicos: Corrida, chute, balanço, polichinelo, ski, twist, cavalo e pêndulo.	8 Elementos Básicos: Corrida, chute, balanço, polichinelo, ski, twist, cavalo e pêndulo.	8 Elementos Básicos: Corrida, chute, balanço, polichinelo, ski, twist, cavalo e pêndulo.	8 Elementos Básicos: Corrida, chute, balanço, polichinelo, ski, twist, cavalo e pêndulo.	8 Elementos Básicos: Corrida, chute, balanço, polichinelo, ski, twist, cavalo e pêndulo.	8 Elementos Básicos: Corrida, chute, balanço, polichinelo, ski, twist, cavalo e pêndulo.
	Treino de Força/Potência	Duração	30	30	30	30	30	30	30
		Intensidade (Tabela Borg)	15 - 17	15 - 17	15 - 17	15 - 17	15 - 17	15 - 17	15 - 17
		Padrão de movimento	MODELO 2 BLOCO 2/1	MODELO 3 BLOCO 1/2	MODELO 1 BLOCO 2/1	MODELO 2 BLOCO 1/2	MODELO 3 BLOCO 2/1	MODELO 1 BLOCO 1/2	MODELO 2 BLOCO 2/1
			MODELO 3 BLOCO 1/2	MODELO 1 BLOCO 2/1	MODELO 3 BLOCO 1/2	MODELO 1 BLOCO 2/1	MODELO 2 BLOCO 1/2	MODELO 3 BLOCO 2/1	MODELO 1 BLOCO 1/2
			MODELO 1 BLOCO 2/1	MODELO 2 BLOCO 1/2	MODELO 2 BLOCO 2/1	MODELO 3 BLOCO /21	MODELO 1 BLOCO 2/1	MODELO 2 BLOCO 1/2	MODELO 3 BLOCO 2/1
Parte Final		Duração	5	5	5	5	5	5	5
	Alongamentos	Padrão de movimento	Alongamento estático com grande aplitude e pequena área de superfífie de contato.	Alongamento estático com grande aplitude e pequena área de superfífie de contato.	Alongamento estático com grande aplitude e pequena área de superfífie de contato.	Alongamento estático com grande aplitude e pequena área de superfífie de contato.	Alongamento estático com grande aplitude e pequena área de superfífie de contato.	Alongamento estático com grande aplitude e pequena área de superfífie de contato.	Alongamento estático com grande aplitude e pequena área de superfífie de contato.
	Componete lúdica/ descontração		Jogos cognitivos	componente ludico/social	Jogos cognitivos	componente ludico/social	Jogos cognitivos	componente ludico/social	Jogos cognitivos

Tabela 3 - Organização dos blocos e séries da periodização do grupo GEA

BLOCO DE TREINO	
SÉRIE 1	4 x o mesmo exercício e depois muda para o próximo seguindo modelos abaixo.
SÉRIE 2	1 x o exercício depois troca para próximo seguindo os modelos abaixo, fazendo 4 voltas em forma de circuito.
MODELO 1	
BLOCO 01	
ANCORADO	Adução/abdução horizontal dos ombros com base Antero posterior.
REBOTE	Salto com Extensão do quadril.
ANCORADO	Flexão/extensão dos cotovelos com base Antero posterior.
REBOTE	Salto com flexão de quadril e joelhos.
BLOCO 02	
REBOTE	Salto com Extensão do quadril.
ANCORADO	Flexão/extensão dos cotovelos com base Antero posterior.
REBOTE	Salto com flexão de quadril e joelhos.
ANCORADO	Adução/abdução dos ombros com base latero lateral.
MODELO 2	
BLOCO 01	
ANCORADO	Adução/abdução dos ombros com base latero lateral
REBOTE	Salto com abdução e adução do quadril.
ANCORADO	Flexão/extensão dos cotovelos com base Antero posterior.
REBOTE	Salto com flexão posterior dos joelhos.
BLOCO 02	
REBOTE	Salto com abdução e adução do quadril.
ANCORADO	Adução/abdução horizontal dos ombros com base antero posterior.
REBOTE	Salto com flexão posterior dos joelhos.
ANCORADO	Flexão/extensão dos cotovelos com base Antero posterior.
MODELO 03	
BLOCO 01	
ANCORADO	Adução/abdução horizontal dos ombros com base Antero posterior
REBOTE	Chute frontal alternado com ênfase na extensão dos joelhos.
ANCORADO	Adução/abdução dos ombros com base latero lateral
REBOTE	Elevação dos calcanhares alternados.
BLOCO 02	
REBOTE	Chute frontal unilateral com ênfase na extensão do joelho*
ANCORADO	Flexão/extensão dos cotovelos com base Antero posterior.
REBOTE	Extensão do quadril unilateral com ênfase na flexão do joelho*
ANCORADO	Adução/abdução dos ombros com base latero lateral.
* Realizar 2 para direita e dois para esquerda	

Protocolo Hidroginástica (Grupo Controlo)

O grupo controlo será de caráter comunitário e terá uma forte componente social e lúdica, com um programa de exercícios aquáticos de movimentos gerais e sem organização e controlo da carga de treino. Não terá um plano específico de treino para a força ou componente cardiorrespiratório e os grupos musculares não serão organizados para que haja um equilíbrio na distribuição dos estímulos para todo o corpo. Os indivíduos deste grupo manterão a sua prática, de acordo com o que já faziam anteriormente, no entanto, serão avaliados na mesma altura e com o mesmo intervalo de tempo do grupo Hidrotreinamento, ou seja, antes e após 28 sessões distribuídas ao longo de 14 semanas consecutivas, com frequência de duas sessões semanais. A duração de cada sessão é de 45 minutos com a seguinte estrutura:

-5 a 10 minutos de aquecimento: serão utilizados movimentos variados como: corrida, chute, polichinelo, ski, balanço, pêndulo, cavalo, twist, juntamente com deslocamentos laterais e frontais.

-20 a 30 minutos de treino principal: não terá uma sequência para sobrecarregar os grupos musculares, trocando de exercícios a cada 1 minuto.

-5 a 10 minutos parte final: denominada de relaxamento, onde serão utilizados movimentos com baixa velocidade e alongamentos variados.

O Ambiente da piscina será registado e controlado (humidade e temperatura), sendo que a temperatura da água é controlada a 30,5 ± 0,5°C.

Testes, Instrumentos e Procedimentos

-Cálculo do peso e da altura – o peso será medido com uma balança Tanita BF 550 para a composição corporal, com a pessoa a olhar para frente, mantendo o corpo em posição ortostática. Para medir a altura será usado um estadiómetro.

-Teste levantar e sentar na cadeira (LS) – durante 30’’ o indivíduo realizará o número máximo de repetições do movimento de levantar e sentar de uma cadeira. Os braços permaneceram cruzados ao nível do peito e os pés não poderão perder o contacto com o chão (Jones et al., 1999).

-Teste de agilidade levantar e caminhar (TUG) - o teste será iniciado com o participante totalmente sentado na cadeira (postura ereta), mãos sobre as coxas, e pés totalmente assentes no solo. Ao sinal de “partida” o participante levanta da cadeira, caminha o mais rápido que puder em linha reta, em direção ao cone que está posicionado a 3 metros, dá a volta ao cone e retorna à cadeira. A pontuação refere-se ao tempo percorrido (Barry et al., 2014; Podsiadlo & Richardson, 1991).

-Teste de sentar e alcançar o pé na cadeira (SA) - este teste será alternativa segura e socialmente aceitável aos testes tradicionais de sentar e alcançar no chão, e é uma medida razoavelmente precisa e estável da flexibilidade dos isquiotibiais (Jones et al., 1998). O sujeito, sentado numa cadeira, encolhe uma perna e estica a outra. O corpo inclina-se sobre a perna esticada, na direção do pé e, com os polegares sobrepostos, deve permanecer no seu limite máximo (até a perna conseguir permanecer esticada). A posição deve ser mantida durante 2’’, sem se recorrer a movimentos balísticos ou insistências. A medição do teste será feita com uma régua (de que tipo, marca e modelo?), da seguinte forma: se os dedos estiverem antes da ponta do pé o *score* é negativo, se estiverem na linha da ponta do pé o *score* é 0, e se os dedos ultrapassarem a ponta do pé, o *score* é positivo. Os sujeitos terão três tentativas para cada membro, e a melhor dessas pontuações será registada com precisão de centímetros.

-Teste de alcançar as costas (AC) - É uma medida da amplitude de movimento geral do ombro que envolve a medição da distância entre os dedos médios atrás das costas de acordo com o protocolo de Rikli & Jones, 2013. Após uma tentativa de familiarização a esse teste, o participante será avaliado duas vezes, alternadamente, em cada ombro.

-Teste de força de preensão manual (FPM) - este teste avalia a força isométrica máxima dos músculos da mão e do antebraço. O protocolo adotado para este projeto é o mesmo que foi utilizado para adultos portugueses no observatório nacional (Baptista F, 2011). Antes do teste, o dinamômetro de preensão manual Jamar digital será ajustado ao tamanho da mão de cada sujeito. O sujeito ficará de pé, com os braços ao longo do corpo, sem contacto com o tronco, e com os cotovelos flexionados a 20. O teste será realizado primeiro na mão dominante, seguido pela mão não dominante. A força será realizada durante a fase expiratória, sem manobra de Valsalva. Após três tentativas, se a diferença entre cada valor estiver dentro de 3 kg, o teste será considerado completo. Se uma diferença maior for observada, o teste terá de ser repetido após um tempo de descanso de, no mínimo, xx minutos. A melhor repetição será escolhida para análise posterior.

Para complementar, conhecer e entender melhor a amostra, especialmente em relação ao controle da atividade física, rastreamento de sarcopenia e avaliação da gravidade da depressão em idosos serão aplicados questionários em formato de entrevista individual com todos os participantes. Durante essa entrevista, o avaliador fará as perguntas e preencherá os questionários junto com os participantes. A aplicação desses questionários proporcionará uma compreensão mais abrangente do perfil físico e emocional dos participantes, contribuindo para uma intervenção personalizada e eficaz. Os questionários a utilizar serão:

-Inventário de Depressão de Beck (BDI-II) - Este instrumento, desenvolvido por Beck e colaboradores (Beck et al., 1996), inclui 21 itens usados para classificar a gravidade da depressão de acordo com a definição clínica. É um dos instrumentos mais populares e amplamente utilizados para avaliar a gravidade da sintomatologia depressiva. A versão portuguesa (Campos et al., 2009) apresenta uma boa consistência interna, uma estrutura fatorial muito semelhante à versão original (Beck & Steer, 1984; Beck et al., 1996), e uma validade convergente adequada. Todos os participantes serão informados sobre a forma de preencher o inquérito e as suas respostas serão confirmadas durante as entrevistas.

-Questionário Internacional de Atividade Física (IPAQ-SF) - A forma resumida do IPAQ foi escolhida por ser de fácil aplicação. Apesar da sua confiabilidade ter sido verificada em muitos países e com diferentes populações (Craig et al., 2003; Rütten & Abu-Omar, 2004), alguns estudos mostram que o IPAQ-SF normalmente superestima a atividade física (Lee et al., 2011). No entanto, este instrumento será utilizado para controlar a quantidade de atividade física ao longo do estudo em METS e o “tempo sentado” e não para classificar de modo qualitativo se é muito ou pouco ativo. Embora este questionário seja preenchido com auxílio da equipa de investigadores, todos receberão toda a informação necessária sobre o conteúdo, objetivos e procedimentos. Os dados serão processados de acordo com as diretrizes do IPAQ -SF(Lee et al., 2011).

-Questionário (SARC-F) - É uma ferramenta de triagem rápida e objetiva para identificar uma provável sarcopenia. O questionário rastreia sinais autorrelatados sugestivos de sarcopenia, que incluem deficiências de força, caminhada, levantar de uma cadeira, subir escadas e sofrer quedas. Cada um dos parâmetros autorrelatados recebe uma pontuação mínima e máxima de 0 e 2, respetivamente (Malmstrom et al., 2016). Todos os participantes serão informados sobre como preencher o questionário, e as suas respostas serão confirmadas durante as entrevistas. Outra vez em não concordância com o descrito acima Importa referir que para a familiarização com os inquéritos são questionários ou inquèritos?? todos os avaliadores serão submetidos a uma semana de treino para a sua aplicação, com pessoas recrutadas aleatoriamente no Conselho de Oeiras, sem nenhuma relação com o estudo. Continuo a referir que a menção ao conselho não deveria constar no texto por questões de confidencialidade e anonimato.

Análise de dados

Todos os dados deste estudo serão tratados com recurso ao software SPSS, versão 25.0 (IBM Co., Armonk, NY, EUA). Para alcançar os objetivos propostos, os dados serão analisados separadamente por estudos. Todos os pressupostos estatísticos serão verificados para decisão sobre o método a ser utilizado, paramétricos ou não paramétricos. Inicialmente será feita a análise descritiva da amsotra e a análise de variância bidirecional será realizada por medidas repetidas para verificar o efeito do exercício aquático de 14 semanas. O nível de significância (α) dos testes estatísticos será estabelecido em $P<0{,}05$. Será utilizada estatística descritiva, incluindo frequências para variáveis categóricas e médias com desvio padrão (DP) para variáveis contínuas. A distribuição normal das variáveis contínuas será testada pelo teste de *Kolmogorov-Smirnov.* A correlação entre as variáveis contínuas na *baseline* será analisada pelo coeficiente de correlação de Pearson (r) interpretado como forte ($r \geq 0{,}7$), moderado ($0{,}5<r<0{,}7$) e fraco ($0{,}3<r<0{,}5$), e o coeficiente de determinação será usado melhor compreensão de como a alteração numa variável terá impacto em outra variável e será obtido pelo quadrado do coeficiente de correlação r (r2) (Taylor, 1990). As diferenças pós-intervenção (*baseline* menos pós-intervenção) serão comparadas entre os grupos através da análise de covariância, ajustada pelos valores basais do desfecho. As comparações das alterações entre os grupos (GEA e GC) serão realizadas como análise primária por análises uni-variadas de covariância (ANCOVA), nas quais as variáveis dependentes serão ajustadas. As diferenças médias dentro dos grupos serão calculadas como Mom1 (*baseline*) menos Mom2 (após a intervenção). O *effect size* será verificado por eta quadrado parcial, se forem cumpridos os pressupostos de cada test.

Contribuições e implicações prácticas

A contribuição para a literatura científica e a disseminação dos achados são aspectos cruciais para a continuidade do impacto do Projeto Segue Fit. Acredita-se que os resultados obtidos vão reforçar a importância do treinamento de força na água para a saúde e aptidão funcional dos idosos.

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AQUATIC EXERCISES FOR WOMEN: PHYSIOLOGICAL INTENSITY PRESCRIPTION AND HEALTH-RELATED BENEFITS

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Abstract
Background: Physical exercise has a fundamental role in promoting health, and the characteristics of the aquatic environment favor its practice for achieving health-related benefits across all age groups. Nevertheless, it is crucial to understand the physiological alterations induced by immersion and their implications for regulating exercise intensity.
Goals: This article provides a perspective on the possibilities of intensity monitoring in water aerobics, considering the physiological shifts resulting from immersion. Additionally, a practical framework is proposed for aquatic instructors to tailor exercise intensity, thereby optimizing health outcomes among adult and older women.
Results: Evidence supporting intensity control through heart rate and ratings of perceived exertion is presented, contextualizing the health benefits derived from water-based exercise programs prescribed by these parameters for women.
Conclusions: Based on such aspects, the authors recommend using heart rate and/or rating of perceived exertion as parameters for intensity monitoring during water aerobics since both allow the training load to be individualized and easy to implement in groups of adults and older women.
Keywords: aquatic environment, water-based exercise, heart rate, rating of perceived exertion.

Resumen: Ejercicio acuático para mujeres: prescripción por intensidades fisiológicas y beneficios para la salud.
Antecedentes: La actividad física juega un papel fundamental en la promoción de la salud, y las características del medio acuático favorecen su práctica para obtener beneficios relacionados con la salud en individuos de todas las edades. Sin embargo, es crucial comprender las alteraciones fisiológicas inducidas por la inmersión y sus implicaciones para el control de la intensidad del ejercicio.
Objetivos: Este artículo ofrece una perspectiva sobre las posibilidades de monitorear la intensidad en la hidrogimnasia, teniendo en cuenta las alteraciones fisiológicas resultantes de la inmersión. Además, se propone una estructura práctica para que los instructores de actividades acuáticas adapten la intensidad del ejercicio, optimizando así los resultados de salud en mujeres adultas y mayores.
Resultados: Se presentan evidencias que respaldan el control de la intensidad a través de la frecuencia cardíaca y el índice de esfuerzo percibido, contextualizando los beneficios para la salud derivados de programas de hidrogimnasia prescritos según estos parámetros para mujeres.
Conclusiones: Basados en estos aspectos, los autores recomiendan la utilización de la frecuencia cardíaca y/o la percepción subjetiva de esfuerzo como parámetros para monitorear la intensidad durante la hidrogimnasia, ya que ambos permiten personalizar la carga de entrenamiento y son de fácil implementación en sesiones en grupos de adultos y mujeres mayores.
Palabras clave: ambiente acuático, aeróbic acuático, frecuencia cardíaca, índice de esfuerzo percibido.

Resumo: Exercício Aquático para mulheres: prescrição por intensidades fisiológicas e benefícios relacionados a saúde
Introdução: O exercício físico tem um papel fundamental na promoção da saúde, e as características do meio aquático favorecem sua prática para o alcance de benefícios relacionados à saúde em indivíduos de todas idades. No entanto, é crucial compreender as alterações fisiológicas induzidas pela imersão e suas implicações para o controle da intensidade do exercício.
Objetivos: este artigo traz uma perspectiva sobre as possibilidades de monitoramento da intensidade na hidroginástica, considerando as alterações fisiológicas decorrentes da imersão. Além disso, uma estrutura prática é proposta para os instrutores de atividades aquáticas adaptarem a intensidade do exercício, otimizando assim os desfechos de saúde entre mulheres adultas e idosas.
Resultados: São apresentadas evidências que dão suporte para o controle da intensidade por meio da frequência cardíaca e do índice de esforço percebido, contextualizando os benefícios à saúde derivados de programas de hidroginástica prescritos por esses parâmetros para mulheres.
Conclusões: Baseados nesses aspectos, os autores recomendam a utilização da frequência cardíaca e/ou percepção subjetiva de esforço como parâmetros para monitoramento da intensidade durante a hidroginástica, visto que ambos permitem que a carga de treinamento seja individualizada e são de fácil implementação em sessões em grupos de adultos e mulheres idosas.
Palavras-chaves: ambiente aquático, hidroginástica, frequência cardíaca, índice de esforço percebido.

Introduction

Physical exercise promotes health, reduces the risk of major non-communicable diseases development, and can be a non-pharmacological therapy in selected diseases. The definition of the optimal type and dose of exercise is essential for reaching these benefits (Garber et al., 2011; Pedersen & Saltin, 2015). In this scenario, healthcare professionals have widely indicated aquatic exercises for individuals of all ages and different physical fitness and health statuses. ACSM's guidelines, for example, recommend this type of exercise for endurance training of older individuals, considering it is advantageous for this population (ACSM, Chodzko-Zajko et al., 2009). Among their characteristics are the low impact exercises (Alberton et al., 2015; Alberton et al., 2021b), high neuromuscular demand (Alberton et al., 2011; Alberton et al., 2014b), and the possibility of reaching high physiological intensities (Andrade et al., 2020c; Schaun et al., 2018) due to the water's physical characteristics.

Several studies have investigated water aerobics and its health-related benefits in the current literature. We highlight that most of them developed water-based programs for women, who are the primary practitioners of aquatic exercises (Andrade et al., 2020c; Costa et al., 2018a; Costa et al., 2018b; Häfele et al., 2022; Pinto et al., 2015; Reichert et al., 2020; Takeshima et al., 2002). Nevertheless, it is well-established that water immersion causes physiological alterations, which have important implications in the intensity monitoring during water-based exercises (Pendergast et al., 2015). Accordingly, the correct intensity prescription, considering the physiological alterations from the aquatic environment and the population at hand, is a crucial factor for the success of the exercise program.

Hence, this article provides a perspective on the possibilities of intensity control during water aerobics for women, considering the physiological changes from immersion. In addition, the aim is to propose a practical framework for aquatic instructors to prescribe tailored intensity and obtain health-related benefits in adult and older women.

Intensity prescription during water aerobics

Water aerobics is a modality composed of several exercises, such as running, kicking, jumping, rocking, sliding, and scissors, usually performed stationary. Tailoring exercise by varying frequency, duration, and, most importantly, intensity is crucial to maximizing health-related benefits. Intensity control is achieved by using both objective or subjective parameters of intensity control; however, their choice should take into consideration the mode of exercise (e.g., water versus land-based exercises) and the population (e.g., healthy versus individuals with cardiovascular disorders).

For adequate intensity control in the aquatic environment, we should consider that immersion exposes the individuals to profound physiological stresses, leading to several acute cardiovascular and renal adjustments. During immersion, the hydrostatic pressure action results in a translocation of blood from the dependent limbs to the chest and increased plasma volume due to transcapillary autotransfusion of fluid from the cells (Arborelius et al., 1972; Watenpaugh et al., 2000). Moreover, water's high heat conductivity can significantly influence human function in the aquatic environment (McArdle et al., 1976; Srámek et al., 2000). These mechanisms augment intrathoracic blood volume, which increases cardiac end-diastolic volume, stroke volume, and cardiac output due to increased end-diastolic cardiac fiber length, and reduces the heart rate and total peripheral resistance (Pendergast et al., 2015). In addition, the increased venous return and atrial stretch lead to the attenuated secretion of anti-natriuretic hormones and vasopressin, which results in diuresis and natriuresis (Pendergast et al., 2015).

Therefore, intensity monitoring during water-based exercises must consider all these physiological alterations, and the prescription cannot be based on the same parameters used for land aerobic training because training loads may be overestimated. Hence, we will present the characteristics of the main types of physiological intensity prescription during water aerobics: heart rate (HR) and rating of perceived exertion (RPE) for adult and older women.

Intensity controlled by HR

The HR is recommended as a feasible physiological parameter to prescribe the training intensity during water aerobics (Alberton et al., 2014a). HR during water-based exercises is directly related to oxygen consumption (VO_2), not only when expressed in absolute values but also when expressed in percentages of maximal values obtained in aquatic graded maximal tests in women (David et al., 2017; Andrade et al., 2020b). Nevertheless, lower HR and VO_2 values during maximal and anaerobic threshold intensities are reported in women during graded maximal tests employing water-based exercises compared to a land treadmill (Alberton et al., 2013a; Alberton et al., 2014a). The aquatic HR may also be affected by the water temperature. For example, HR during different aquatic exercises was shown to be significantly greater in water at 36°C compared to water at 28°C (Hall et al., 1998; Bergamin et al., 2015), but no significant difference was observed between temperatures of 31 and 27°C (Yázigi et al., 2013). Therefore, for a precise prescription, the intensity control by HR needs to use values measured in the aquatic environment considering the water temperature and exercise characteristics, such as body position and water depth (Alberton & Kruel, 2009).

Therefore, a graded maximal test is necessary for obtaining the maximal HR (HR_{max}) in the aquatic environment. Protocols with water-based exercises (usually stationary running) were proposed in previous studies performed in women. Intensity increases of 15 b.min^{-1} every 2 min (Alberton et al., 2013a; Andrade et al., 2020a; Kruel et al., 2013) or 10 b.min^{-1} every 1 min (Alberton et al., 2014a) are recommended, with the initial cadence adjusted for the assessed population (young women: 80-85 b.min^{-1}; older women: 70 b.min^{-1}). The resulting HR_{max} may be used as a reference, and the target intensity may be calculated according to the program's purpose.

On the other hand, it is known that a pre-selected percentage of training based on HR_{max} (regardless of the environment) does not accurately represent the metabolic stress and may result in different training zones for different individuals (Wolpern et al., 2015). Therefore, determining the anaerobic threshold may be a more precise and tailored alternative for intensity monitoring, which has also been employed in water aerobics studies for young and older women (Costa et al., 2018a; Pinto et al., 2015; Reichert et al., 2020). In practical terms, studies have shown that during the aquatic graded maximal tests aforementioned is possible to determine the anaerobic threshold in young and older women by using the HR deflection point (Alberton et al., 2013b; Andrade et al., 2020a; Kruel et al., 2013), which is a non-invasive and easy procedure (Conconi et al., 1982). Based on this parameter, percentage values below, at, or above the anaerobic threshold may be calculated according to progression and target training zones.

Although aquatic instructors may have difficulties applying this type of prescription in large groups when an apart physical fitness evaluation is not a routine, it is indispensable for personalized training (individual or small groups). Notwithstanding, alternative procedures for training prescription are recommended for conditions in which individuals are not allowed to perform a graded maximal test or physician supervision is needed.

Intensity controlled by RPE

Subjective parameters are possibilities of intensity control widely recommended for endurance training in adult and older individuals (ACSM, Chodzko-Zajko et al., 2009; Garber et al., 2011). RPE may be applied for monitoring intensity during water-based exercises because it is a low-cost and straightforward tool, easily adapted for use in the aquatic environment. Among different scales, Borg's RPE 6-20 is the most investigated during water aerobics in adult and older women (Alberton et al., 2016; Andrade et al., 2020b; David et al., 2017).

Recent studies performed with young and older women showed that RPE during water-based exercises is directly related to the percentages of maximal VO_2 and HR obtained in aquatic graded maximal tests (Alberton et al., 2016; Andrade et al., 2020b; David et al., 2017). In addition, RPE at maximal and anaerobic threshold intensities seems to be similar between aquatic graded maximal tests (employing water-based exercises) and a land treadmill protocol in young women (Alberton et al., 2013a; Alberton et al., 2014a). Table 1 presents RPE values (6-20) corresponding to different training zones determined for the water-based stationary running exercise in young (Alberton et al., 2016) and older women (Andrade et al., 2020b).

Moreover, the knowledge of the RPE corresponding to the anaerobic threshold in the aquatic environment may help aquatic instructors more accurately prescribe intensity considering the metabolic stress. RPE value corresponding to ≈16 (between hard and very hard) was observed at the anaerobic threshold for the water-based stationary running in young (Alberton et al., 2013a; Alberton et al., 2016) and older women (Andrade et al., 2020a). Therefore, RPE may be used to individualize training loads during water aerobics based on these reference data. We may use it for individuals of any age and health condition since it has been widely used during water aerobics in realistic conditions or scientific and controlled settings, resulting in health-related benefits (Andrade et al., 2020c, Costa et al., 2018b).

This type of intensity control requires only a banner with identical reproduction of the selected scale, positioned in a visible place, and a suitable familiarization procedure (Borg, 1990). Furthermore, RPE is recommended for particular populations on medications whose cardiovascular responses may be affected during the exercise (Mitchell et al., 2019). However, time and effort are necessary to provide enough instructions about its use and appropriate familiarization so that this subjective method may be considered valid and accurate for reaching the target intensity.

Health-related benefits in women

The reduced joint impact and lower cardiovascular responses give the aquatic environment interesting characteristics for women, especially climacteric and older women. Once during these periods, there is a greater propensity for developing cardiovascular diseases and weight gain, which, as a consequence, can lead to an increase in joint and muscle damage. The benefits of water aerobics training for women in different age groups are well elucidated, demonstrating, for example, reductions in resting blood pressure values (Reichert et al., 2018), improvement in the lipid profile (Costa et al., 2018b), and glycemic (Delevatti et al., 2016), as well as improvements in physical fitness components, such as muscle strength, balance, and cardiorespiratory capacity (Costa et al., 2018a; Häfele et al., 2022).

Older women, particularly climacteric women who are going through a series of hormonal changes, can benefit from water aerobics training and the acute physiological effects of immersion. A reduction in female sex hormones, such as estrogen and progesterone, can negatively affect a women's health. Estrogen, for example, has an essential cardioprotective role, and its reduction can lead to sympathetic hyperactivity, increased release of vasoconstrictor hormones, and, consequently, an increase in the activity of the renin-angiotensin system. These changes can lead to cardiometabolic complications. The scientific literature is already quite clear on the role of exercise in improving women's health during menopause (Zanesco & Zaros, 2009). Exercise in an aquatic environment can have additional beneficial effects, as immersion leads to physiological adjustments due to hydrostatic pressure and greater thermoconductivity. Among these adjustments, we have a lower sympathetic activation and several hormonal changes, for example, a reduction in vasoconstrictor hormones. As a result, the renin-angiotensin system is suppressed (Coruzzi et al., 1984; Gabrielsen et al., 2002). These effects of immersion are contrary to those observed by the estrogen production reduction, which can enhance the effects of exercise when performed in this environment.

In addition, these physiological changes, especially after menopause, can lead to greater chances of developing metabolic diseases, such as obesity, dyslipidemia, diabetes, among others. Therefore, aquatic exercise also has an additional benefit, as the physiological adjustments arising from immersion also lead to an increased release of atrial natriuretic peptide (Shiraishi et al., 2002). This response contributes to the increase in the oxidative capacity of lipids, especially in the breakdown of triglycerides, which may help treat dyslipidemia and obesity (Akahoshi et al., 2001).

Future directions in this research area are randomized clinical trial designs in which aquatic aerobic training is used as the central intervention (not combined with resistance exercises or multicomponent exercises) compared to traditional control groups in different populations. Water aerobics interventions prescribed by one of the main types of physiological intensity (HR or RPE) on health outcomes with high methodological quality and low risk of bias are still scarce in the literature. Comparative studies could also be developed as a sequence to compare different intensity prescription models during water aerobics on health outcomes (HR versus RPE; $\%HR_{max}$ versus HR deflection point).

Table 1. Rating of perceived exertion (RPE) values corresponding to different percentages of maximal oxygen consumption ($\%VO_{2max}$) during water-based stationary running exercise.

$\%VO_{2max}$	RPE (Borg's 6-20 Scale)	
	Young women	Older women
50-59%	13	10
60-69%	15	11
70-79%	16-17	13-14
80-89%	18	17
90-99%	19	17-18

*Note: Adapted from Alberton et al. (2016) and Andrade et al. (2020b) for young and older women, respectively.

Final Considerations

The present opinion article recommends using HR and RPE as parameters for intensity monitoring during water aerobics because both allow the training load to be individualized and easy to implement in groups of adults and older women. Both HR and RPE have high relationships with VO_2 and have been used in studies that verified positive gains in physical fitness and health-related outcomes. The physiological changes during immersion should be considered regardless of the intensity control choice. Reference values for HR or RPE suitable for the aquatic environment should be adopted, considering their positive and negative points, as shown in Figure 1. In addition, we showed that aquatic training promotes remarkable health-related benefits for women of all ages, especially in climacteric and older ones. Among such benefits, we highlight the acute physiological adjustments from water immersion and the chronic metabolic improvements arising from water aerobics training.

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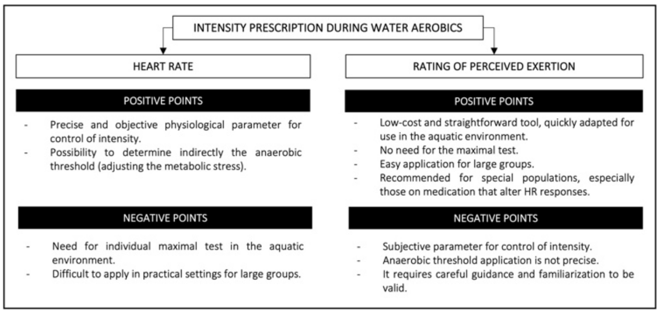
Figure 1. Intensity prescription during water aerobics: summary of positives and negatives points.



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Fuerza de reacción vertical del suelo en el ejercicio acuático de patada frontal realizado por mujeres: efectos de la edad

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Resumen
Antecedentes: Aumentar el conocimiento sobre las fuerzas que actúan en diferentes ejercicios acuáticos en mujeres de diferentes edades es importante para una prescripción más eficaz e individualizada.
Objetivos: comparar la fuerza de reacción del suelo durante el ejercicio aeróbic acuático de patada frontal realizado a diferentes cadencias entre mujeres jóvenes y posmenopáusicas.
Método: la muestra estuvo compuesta por 24 mujeres, 12 mujeres jóvenes (23,7 ± 3,6 años) y 12 mujeres posmenopáusicas (57,3 ± 2,6 años). Para determinar la fuerza de reacción vertical del suelo de pico y el impulso, las voluntarias realizaron el ejercicio de patada frontal a diferentes cadencias (80, 100 y 120 b.min^{-1}). Para el análisis de datos, se utilizó una ANOVA de dos vías (α = 0,05).
Resultados: se observó un aumento en la fuerza de reacción del suelo de pico de la cadencia de 80 b.min-1 para las cadencias más altas (p < 0,001). Las mujeres jóvenes tenían valores de fuerza de reacción del suelo de pico más altos en comparación con las mujeres posmenopáusicas (p = 0,012), lo que demuestro que las mujeres posmenopáusicas tenían valores de fuerza de reacción del suelo de pico de 78-82% en comparación con las mujeres jóvenes. Además, se observó una reducción del impulso a cadencias más altas (p < 0,001), con valores similares entre grupos (p = 0,835).
Conclusiones: las mujeres posmenopáusicas presentaron valores más bajos de fuerza de reacción del suelo de pico (0,65-0,75 PC) e impulso similar (94-133 N·s) en comparación con las mujeres jóvenes, por lo tanto, el ejercicio evaluado puede considerarse de baja probabilidad de lesiones musculoesqueléticas, independientemente de la cadencia de ejecución.
Palabras clave: ambiente acuático; hidroterapia; envejecimiento; cinética.

Abstract: Vertical ground reaction force of the water-based exercise frontal kick performed by women: age effects
Background: Increasing knowledge about the forces that act in different aquatic exercises in women of different ages is important for a more effective and individualized prescription.
Goals: To compare the vertical ground reaction force during the water-based frontal kick exercise performed at different cadences between young and postmenopausal women.
Method: Twenty-four participants, twelve young (23.7 ± 3.6 years) and 12 postmenopausal women (57.3 ± 2.6 years), voluntarily completed a session with frontal kick performance in the aquatic environment (cadences 80, 100, and 120 b.min^{-1}) to determine peak and impulse of vertical ground reaction force. Repeated measures two-way ANOVA was used (α = 0.05).
Results: The peak vertical ground reaction force increased from 80 b.min-1 to the higher cadences (p < 0.001). In addition, young showed greater peak vertical ground reaction values than the postmenopausal women (p = 0.012), revealing that postmenopausal women presented 78-82% of peak vertical ground reaction values observed for young women during water-based frontal kick exercise. Moreover, it was observed a reduction in impulse with the increasing cadence (p < 0.001), with similar values between young and postmenopausal women (p = 0.835).
Conclusions: These findings highlight the safety of the water-based exercise for postmenopausal women since lower peak vertical ground reaction (0.65-0.75 BW) and similar impulse (94-133 N·s) values were observed in comparison to the young ones, considered as low odds for musculoskeletal injuries, regardless the cadence of performance.
Keywords: aquatic environment; hydrotherapy; aging; kinetics.

Resumo: Força de reação do solo vertical do exercício de hidroginástica chute frontal realizado por mulheres: efeitos da idade
Introdução: Aumentar o conhecimento sobre as forças que atuam em diferentes exercícios aquáticos em mulheres de diferentes idades é importante para uma prescrição mais eficaz e individualizada.
Objetivos: comparar a força de reação do solo durante o exercício de hidroginástica chute frontal realizado em diferentes cadências entre mulheres jovens e na pós-menopausa.
Método: a amostra foi composta por 24 mulheres, 12 mulheres jovens (23,7 ± 3,6 anos) e 12 mulheres na pós-menopausa (57,3 ± 2,6 anos). Para determinar a força de reação do solo vertical de pico e o impulso, as voluntárias realizaram o exercício de hidroginástica chute frontal em diferentes cadências (80, 100 e 120 b.min^{-1}). Para análise dos dados foi utilizada uma ANOVA de dois caminhos (α = 0,05).
Resultados: Foi observado um aumento da força de reação do solo de pico da cadência de 80 b.min-1 para as maiores cadências (p < 0.001). As mulheres jovens apresentaram maiores valores de força de reação do solo de pico em comparação as pós-menopáusicas (p = 0,012), com valores para as pós-menopáusicas correspondentes a 78-82% dos observados para as jovens durante o exercício chute frontal. Além disso, foi observada uma redução do impulso nas maiores cadências (p < 0,001), com valores semelhantes entre os grupos (p = 0,835).
Conclusões: as mulheres na pós-menopausa apresentaram menores valores de força de reação do solo de pico (0,65-0,75 PC) e impulso semelhante (94-133 N·s) em comparação às jovens, logo, pode-se considerar o exercício avaliado como sendo de baixa chance de lesões musculoesqueléticas, independentemente da cadência de execução.
Palavras chaves: meio aquático; hidroterapia; envelhecimento; cinética.

Introduction

The aquatic environment is conducive to physical exercise since water resistance is multidirectional, promoting an overload against movements performed in all directions (Torres-Ronda & del Alcázar, 2014). This high muscle overload is elicited with a low osteoarticular load due to buoyancy, which promotes a reduction in the apparent weight of the immersed individuals corresponding to ~70% at xiphoid process depth (Harrison, Hillman, & Bulstrode, 1992; Alberton, et al., 2013). This fact influences the exercise performance, as lower vertical ground reaction force (Fz) values have been observed in different exercises performed in the aquatic environment in comparison to dry land, such as water-walking and running (Barela, Stolf, & Duarte, 2006; Harrison, et al., 1992; Miyoshi, Shirota, Yamamoto, Nakazawa, & Akai, 2004; Orselli & Duarte, 2011), water-based vertical jumps (Colado, et al., 2010; Dell'Antonio, et al., 2016; Louder, Bressel, Nardoni, & Dolny, 2017) and water-based exercises (Alberton, et al., 2015; Alberton, et al., 2013; de Brito Fontana, et al., 2012; Fontana, Ruschel, Haupenthal, Hubert, & Roesler, 2015; Alberton, et al., 2015; de Brito Fontana, et al., 2018).

Middle-aged and older women are the main practitioners of water fitness programs. Nevertheless, the literature regarding Fz responses during aquatic exercises in this population is scarce. The advancing age greatly impacts muscle size and strength (Mitchell, et al., 2012). These declines are associated with an impairment in functional capacity, affecting the performance of daily living activities (Aagaard, Suetta, Caserotti, Magnusson, & Kjaer, 2010; Christensen, Doblhammer, Rau, & Vaupel, 2009). In addition, aging is associated with increased adipose tissue (Snijders, Verdijk, & van Loon, 2009). Such effects are more pronounced in women during and after menopause due to a reduction in the estrogen hormone, associated with increased abdominal and visceral fat, resulting in a total body weight change (Franklin, Ploutz-Snyder, & Kanaley, 2009). These changes affect the practitioners' body fat percentage and, consequently, the apparent weight during immersion and the Fz during aquatic exercise performance.

However, to the best of the authors' knowledge, few studies were found in the literature with Fz analysis during aquatic exercises in middle-aged and older individuals (Barela & Duarte, 2008; Louder, Dolny, & Bressel, 2018; Alberton, et al., 2019). Barela and Duarte (2008) investigated the Fz during the water walking performed by older and young adults (mean age: 70 and 29 years, respectively) and revealed significantly lower Fz responses for the first peak along the Fz curve in older individuals, with values corresponding to ~0.35 body weight. Louder et al. (2018) evaluated the Fz during the water-based countermovement jump in middle-aged and young adult individuals (mean age: 57 and 22 years, respectively) and reported significantly lower Fz peak values during the propulsion phase in the oldest, with values corresponding to 3.8 body weight.

Regarding water-based exercises usually employed in water fitness programs, studies have observed Fz peak magnitudes ranging from ~0.5 to 2.0 body weight in young men and women at submaximal and maximal intensities (Alberton, et al., 2015; Alberton, et al., 2013; de Brito Fontana, et al., 2018; de Brito Fontana, et al., 2012; Fontana, et al., 2015). The only study found in the literature investigating these types of aquatic exercise which investigated older women (~69 years) observed a Fz peak between 0.45 to 0.60 body weight in the stationary running exercise performed at submaximal and maximal intensity (Alberton, et al., 2019). Fz magnitude verified in these studies indicates that water-based exercises may be considered low odds for musculoskeletal injuries (Hayes & Myers, 1997).

Different aquatic exercises, such as water walking, jumping, or water-based exercises used in water fitness programs (e.g., stationary running, kicks, jumping jacks, cross country skiing), result in different Fz peak values due to their specific characteristics. The studies above-mentioned observed variation in the Fz outcome from 0.35 to 3.8 body weight for different types of aquatic exercise performed by middle-aged and older individuals (Barela and Duarte, 2008; Louder, et al., 2018). Thus, water-based exercise programs may provide a low-impact alternative to dry land for individuals who need practice exercises with low Fz loads, as it maintains a high neuromuscular stimulus for lower limb muscles (Alberton, et al., 2014).

The efficacy of water fitness programs in several health-related outcomes has been shown in postmenopausal and older population (Costa, et al., 2018; Pinto, et al., 2015; Silva, et al., 2018; Reichert, et al., 2018; Reichert, et al., 2019; Andrade, et al., 2020a; Andrade, et al. 2020b; Reichert, et al. 2020a; Reichert, et al. 2020b). Thus, improving the knowledge regarding Fz magnitude during different water-based exercises in middle-aged women is important due to their performance specificity. Therefore, the purpose of the present study was to compare the Fz during the water-based frontal kick exercise performed at different cadences between young and postmenopausal women.

Methods

The present study is a cross-sectional design, with data comparison of Fz peak and impulse in the water-based frontal kick exercise performed at different cadences (80, 100, and 120 $b.min^{-1}$) between women from different age groups, young and postmenopausal. The data presented are part of a larger research project que was conducted according to the ethical standards of the Declaration of Helsinki and was approved by the Local Research Ethics Committee (18817).

Participants

The sample comprised twenty-four participants, 12 young (20-30 years) and 12 postmenopausal women (52-62 years), who voluntarily took part in the study. As inclusion criteria, participants should be engaged in water-based programs during the preceding three months and be familiarized with the exercise employed in the study. In addition, the young group should have a regular menstrual cycle, and the postmenopausal group should not have had any menstrual cycle in the previous year. Exclusion criteria included any history of osteoarticular, musculoskeletal, and cardiovascular disorders, diagnosed by an anamnesis. All volunteers read and signed a written informed consent, containing all the information concerning the procedures and potential risks involved in the participation.

Procedures

An initial session was held for the anamnesis application and data collection of the sample characterization. Body mass and height measurements were obtained using an analogical medical scale and a stadiometer (FILIZOLA; Sao Paulo, Brazil). Afterward, participants performed a familiarization session with the exercise and cadences, in which all instructions about the care and range of movement that would need to be considered were given.

Frontal kick is a water-based exercise (Figure 1) widely used in water fitness programs, and its Fz responses have been previously investigated in the literature (Alberton, et al., 2015; Alberton, et al., 2014). This exercise is performed with a single support and flight phase. Participants should perform the lower limbs movement in two phases, in which each segmental action (hip flexion or extension) is performed in 1 beat corresponding to a support phase of one limb. The first phase corresponds to the right hip flexion to 45°, knee extension, and ankle plantar flexion starting the flight phase, followed by the right hip extension until the support phase. Lower limb movements are performed alternatingly while the upper limbs perform a light shoulder flexion followed by extension, with the elbow flexed to 90° to maintain corporal balance. The Fz data corresponding to the support phase of the right lower limb in each situation was measured.

The experimental protocol started with the measurement of the apparent weight in the aquatic environment with the participants immersed up to the xiphoid process. Then, individuals perform the water-based frontal kick exercise at three cadences, 80, 100, and 120 b.min^{-1}, each performed during 4 min in a random order, with 5 min intervals between them. Previous studies that evaluated physiological and biomechanical parameters during water-based exercises used these cadence ranges (Alberton, et al., 2011; de Brito Fontana, et al., 2012). Cadences were set using a digital metronome (MA-30, KORG; Tokyo, Japan). Participants performed the protocol barefoot in a swimming pool with the participants immersed up to the xiphoid process depth. Water temperature was maintained between 31 and 32°C.

Figure 1. Frontal kick water-based exercise

Fz was collected with a waterproof force plate (OR6-WP, AMTI; Watertown, USA) previously calibrated according to the manufacturer's specifications. The plate's capacity was 8900 N, the sensitivity was 0.08 µV/[V·N], and the useful working temperature ranged from -17 to +52°C. The sampling rate of the collected values was 500 Hz, and data were acquired using AMTIForce software. Then, files were exported for analysis with SAD32 software (Mechanical Measurements Laboratory, UFRGS; Porto Alegre, Brazil).

The digital signal was filtered using a third-order low-pass Butterworth filter with a cut-off frequency of 30 Hz. Slices corresponding to the first 10 repetitions were performed after the third minute of effort. Fz peak value (Fzpeak) was obtained from the selected repetitions, defined as the maximum value presented by the Fz occurring at any period from the beginning until the end of the cycle. Also, these data were normalized by body weight (BW) measured outside the water and presented as units of BW. Moreover, the impulse was obtained from the integral force-time for the same selected repetitions, and it will be presented as N·s. The five central valid repetitions were averaged to obtain the mean cycle for each participant in each situation. In addition, based on BW and apparent weight, the apparent weight reduction percentage was calculated.

Statistical Analysis
Descriptive statistics were used to report data using mean ± standard deviation (SD). Shapiro-Wilk and Levene tests were used to verify data normality and homogeneity. Paired sample T-tests were applied to compare characterization data between age groups. Two-way ANOVA wit repeated measures was employed to analyze Fzpeak and impulse values with Bonferroni post hoc tests. Effect sizes were calculated using η_p^2 for the main effects in each variable. An alpha level of 0.05 was adopted, and the SPSS program version 20.0 was employed in the análisis.

Results

Significant differences in age, height, body mass, body weight, and apparent weight reduction were observed between the young and postmenopausal women groups. However, similar apparent weight values were verified between groups (Table 1).

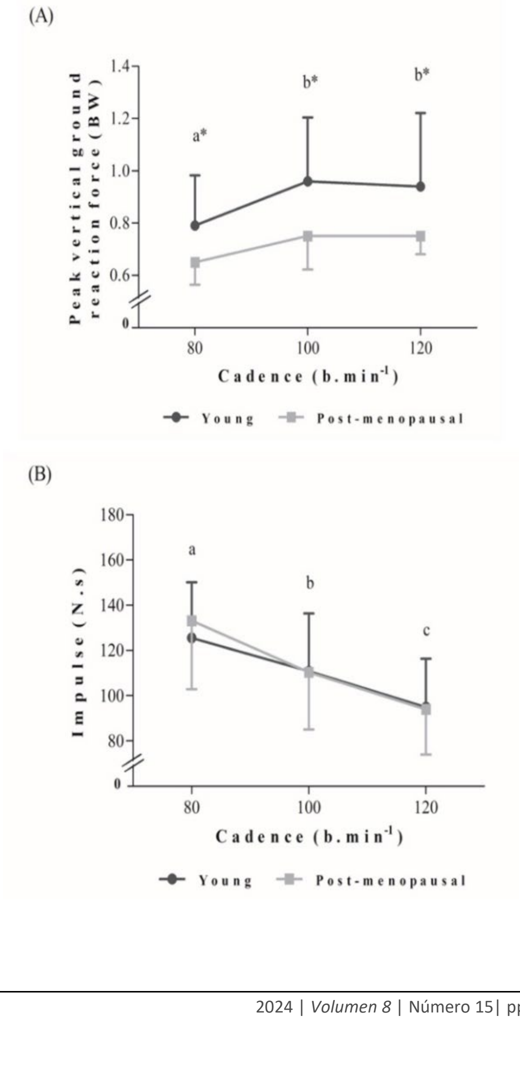
Table 1. Characterization data for young and postmenopausal women.

	Young women (n=12) Mean ± SD	Postmenopausal women (n=12) Mean ± SD
Age (years)	23.7 ± 3.6	57.3 ± 2.6*
Height (cm)	164.1 ± 7.1	158.1 ± 6.9*
Body mass (kg)	60.2 ± 5.1	69.1 ± 10.9*
Total body weight (N)	590.2 ± 50.5	669.2 ± 104.0*
Apparent weight (N)	176.7 ± 41.6	169.9 ± 55.4
AW reduction (%)	70.3 ± 5.5	74.9 ± 5.6*

Note: AW: Apparent Weight; * $p < 0.05$.

Regarding Fzpeak (Figure 2A), a significant increase was found from the cadence of 80 b.min-1 in comparison to the higher ones ($F_{(2;42)} = 9.964$; $p < 0.001$; $\eta_p^2 = 0.322$) for both age groups. In addition, the young presented Fzpeak values significantly greater than the postmenopausal women ($F_{(1;21)} = 7.656$; $p = 0.012$; $\eta_p^2 = 0.267$). Regarding impulse (Figure 2B), it was observed a significant reduction with the increasing cadence ($F_{(2;44)} = 110.500$; $p < 0.001$; $\eta_p^2 = 0.834$) for both age groups, with similar values between the young and the postmenopausal women ($F_{(1;22)} = .045$; $p = 0.835$; $\eta_p^2 = 0.002$). No significant interaction for age group*cadence was observed for Fzpeak and impulse variables.

Figure 2. Peak (A) and impulse (B) of vertical ground reaction force at different cadences between young and postmenopausal women.



Note: Graph A – Vertical axis express the peak vertical ground reaction force (Fzpeak) in units of body weight (BW). Graph B – Vertical axis express the impulse of vertical ground reaction force (Imp) in N·s. Different letters indicate significant differences between cadences (a ≠ b ≠ c). (*) indicates significant differences between groups.

Discussion

The purpose of the present study was to compare Fz values during the water-based frontal kick exercise performed at different cadences between young and postmenopausal women. The main findings were the lower Fzpeak values during the water-based exercise performance for the postmenopausal women group and the lowest evaluated cadence. In addition, impulse values were similar between age groups and reduced with the increasing cadence.

The present findings agree with those reported by Barela and Duarte (2008) and Louder et al. (2018), who investigated Fz values during water-walking and water-based jump, respectively, in older or middle-aged compared to young individuals. Louder et al. (2018) reported significantly lower Fzpeak values during the propulsion phase of the water-based countermovement jump in middle-aged individuals (~57 years) in comparison to young adults (~22 years). Barela and Duarte (2008) also showed lower Fz values in the first peak and impulse during the support phase of the water-walking for older individuals (~70 years) compared to young adults (~29 years), with similar values between groups in the second peak of Fz. Nevertheless, the latter study normalized the Fz values by the apparent weight measured in water. In contrast, in the present study the Fzpeak values were normalized by total body weight (as usually presented in the literature regarding aquatic exercises), a fact that could interfere with the interpretation of the results. In the present study, lower Fzpeak and similar impulse values were observed for the postmenopausal (~57 years) in comparison to the young women group (~24 years) during the support phase of the water-based frontal kick exercise. The differences between age groups reveal that postmenopausal women presented 78-82% of Fzpeak values observed for young women during the water-based frontal kick exercise performed at cadences from 80 to 120 $b.min^{-1}$. This percentual reduction also agrees with the values observed by Louder et al. (2018), who found values equal to 82% during the water-based countermovement jump performed at maximal effort.

Such difference in the Fz pattern between age groups may be partially explained by the differences in body composition, given that with advancing age, an increase in the practitioners' body fat percentage occurs due to the lean mass reduction and increased adipose tissue (Snijders, et al., 2009). This fact results in a greater apparent weight reduction because adipose tissue floats more than muscle mass (Torres-Ronda & del Alcázar, 2014). In addition, women are more affected by these changes in body composition since there is a reduction in the estrogen hormone during and after menopause (Franklin, et al., 2009). This explanation remains a speculation since the studies mentioned earlier and the present one has not estimated body fat percentages. However, the apparent weight data collected in the present study may help to confirm this explanation. The postmenopausal women group presented a significantly greater apparent weight reduction percentage (75%) in comparison to the young women group (~70%). This apparent weight reduction observed for young women agrees with the literature, which has reported reductions of around 69-71% for this population immersed at the xiphoid process depth (Alberton, et al., 2015; Alberton, et al., 2013; Harrison, et al., 1992). Regarding older individuals, Alberton, et al. (2019) observed a higher percentual reduction, corresponding to 79.5% at the same immersion depth. Thus, our findings are in line with those in the literature and reinforce the role of age on the apparent weight reduction percentage.

Another characteristic which could partially explain the Fzpeak differences between the age groups is the decline in muscle size and strength with aging (Mitchell, et al., 2012). Since these declines are associated with impaired functional capacity (Aagaard, et al., 2010; Christensen, et al., 2009), they may imply a reduction in the projected force during water-based exercises propulsion in postmenopausal compared to the young women. This statement is supported by data from Louder et al. (2018), who also verified a higher unweighting time and a lower peak power during the water-based countermovement jump for the middle-aged compared to young individuals, in addition to the lower Fzpeak values.

In addition, a third aspect to be highlighted is the possible difference in the kinematic parameters during the water-based frontal kick exercise performed by young and postmenopausal women. Barela and Duarte (2008) and Louder et al. (2018) analyzed spatial-temporal parameters during water-walking and water-based jump exercises, respectively, performed by individuals from different age groups. Barela and Duarte (2008) verified differences in length, duration, speed, and angular position for different joints during water-walking strides performed at self-selected intensities between older and adult individuals. Moreover, Louder et al. (2018) also reported differences in lower limb joints' angular position and velocity between middle-aged and young individuals performing water-based countermovement jump at maximal effort. In the present study, kinematical parameters were not measured; however, in contrast to the studies above, in which the intensity was self-selected or maximal and elicited different kinematical parameters between groups, we set the intensity by cadences and the range of motion was visually controlled during the experimental protocol performance, minimizing such differences in the performance technique between age groups.

The present data revealed Fzpeak and impulse values during the water-based frontal kick exercise corresponding to 0.79-0.96 BW and 95-126 N·s for the young women group and 0.65-0.75 BW and 94-133 N·s for the postmenopausal one, respectively. These values agree with those observed in the literature. Regarding young women, values of 0.92 and 1.13 BW for Fzpeak, and 113 and 93 N·s for impulse during the water-based frontal kick exercise performed at individual physiological intensities equivalent to cadences of ~100 and ~120 $b.min^{-1}$, respectively (Alberton, et al., 2013). Concerning older individuals, values of 0.45–0.60 BW for Fzpeak and 0.07–0.17 N.s/BW for impulse were reported during the performance of the water-based frontal stationary running exercise performed at cadences of 80 $b.min^{-1}$, 100 $b.min^{-1}$, and maximal, respectively (Alberton, et al., 2019). In addition, Barela and Duarte (2008) observed Fzpeak values around 0.35 BW for older individuals during water walking, while Louder et al. (2018) reported Fzpeak values corresponding to 3.8 BW for middle-aged individuals (similar age to the present postmenopausal group) during the propulsion phase of the water-based countermovement jump. This great range of Fzpeak values observed for the different types of aquatic exercises reinforces the importance of the present study in verifying age effects on Fz during a water-based exercise widely used in water fitness programs, which have not been investigated in the literature yet.

Regarding cadence, a significant increase in the Fzpeak from 80 to 100 and 120 $b.min^{-1}$ was observed in the present study, whereas a significant reduction in the impulse with the increasing cadence was verified for both age groups. These results corroborate with the literature, since previous studies analyzing water-based exercises (Alberton, et al., 2015; Alberton, et al., 2013; de Brito Fontana, et al., 2018; de Brito Fontana, et al., 2012), water-walking or running (Haupenthal, Fontana, Ruschel, dos Santos, & Roesler, 2013; Haupenthal, Ruschel, Hubert, de Brito Fontana, & Roesler, 2010) and walking or running on land (Cappellini, Ivanenko, Poppele, & Lacquantini, 2006; Nilsson & Thorstensson, 1989) also observed these responses. As the cadence increases, the individuals must perform a greater propulsive force to overcome water resistance, promoting an increase in acceleration during the support phase and consequently in the Fz (Haupenthal, et al., 2013; Haupenthal, et al., 2010). Due to this, there is an increased angular velocity for the exercise performance while maintaining the range of motion. On the other hand, as intensity increases, the contact time is reduced (Nilsson & Thorstensson, 1989). Consequently, the literature reports that the impulse is decreased regardless of the increase in Fzpeak during water-based exercises (Alberton, et al., 2015; Alberton, et al., 2013).

Conclusion

Based on the present results, the water-based frontal kick exercise presents lower Fzpeak values for postmenopausal compared to young women at the three investigated submaximal cadences, with similar impulse values between age groups. In addition, an increased cadence results in greater Fzpeak and lower impulse responses.

Practical Application

Thus, water fitness sessions may safely employ the frontal kick exercise for young and postmenopausal women since the observed Fzpeak values correspond to a low risk of developing musculoskeletal injuries. However, care should be taken regarding practitioners who should avoid this type of load. For this purpose, water fitness instructors might choose lower intensities to perform the frontal kick at low cadences and to reduce Fz responses in water-based programs for women of different ages. In this scenario, older women may also benefit from lower Fz loads than the youngest.

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UNA REVISIÓN DE ALCANCE DE LA PROGRAMACIÓN DE EJERCICIOS DE LA ARTHRITIS FOUNDATION

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Resumo
Antecedentes: A artrite afeta 1 em cada 4 adultos nos EUA, com prevalência aumentando com a idade. O exercício é um dos tratamentos não invasivos mais eficazes para os sintomas relacionados à artrite. Para facilitar a participação em exercícios apropriados para esta população, a Arthritis Foundation criou uma série de programas de exercícios para indivíduos com artrite, incluindo o Programa de Exercícios da Arthritis Foundation (AFEP), o Programa de Exercícios Aquáticos da Arthritis Foundation (AFAP) e Pessoas com artrite podem se exercitar e caminhar. Com facilidade AFEP.
Objetivos: O objetivo deste projeto foi revisar sistematicamente a literatura revisada por pares para relatar qualitativamente os efeitos e o impacto da participação no AFEP e no AFAP entre indivíduos com artrite. Nosso objetivo foi fornecer um resumo descritivo dos resultados avaliados durante a participação nesses programas para estabelecer áreas de evidências existentes e identificar lacunas relacionadas à eficácia da AFEP e da AFAP no manejo da artrite que devem ser abordadas em estudos futuros.
Método: Duas revisões de escopo independentes foram realizadas para descrever a literatura existente sobre os efeitos da participação em 1) AFEP e 2) AFAP. Os artigos revisados incluíram avaliação dos sintomas da artrite, aptidão física, função, atividades da vida diária e adesão ao exercício.
Resultados: Oito dos 1.578 artigos da AFEP e oito dos 511 artigos da AFAP atenderam aos critérios de inclusão. A programação AFEP e AFAP encontrou melhorias gerais, mas houve resultados equívocos para muitos dos sintomas característicos da artrite, incluindo dor, flexibilidade/ADM, mobilidade funcional, força e resistência muscular, equilíbrio, capacidade aeróbica, qualidade de vida e autoeficácia.
Conclusões: Foram identificadas muitas lacunas na investigação que devem ser abordadas em estudos futuros para determinar a eficácia da AFEP e da AFAP no tratamento da artrite.
Palavras-chave: fitness, exercício aquático, função, tratamento da artrite, tratamento da dor

A Scoping Review of Arthritis Foundation Programming.
Background: Arthritis impacts 1 in 4 adults in the US with prevalence increasing with age. Exercise is one of the most effective, non-invasive treatments for arthritis-related symptoms. To facilitate participation in appropriate exercise for this population, the Arthritis Foundation created a series of exercise programs for individuals with arthritis including the A*rthritis Foundation Exercise Program (AFEP), Arthritis Foundation Aquatic Exercise Program (AFAP),* and *People with Arthritis Can Exercise and Walk With Ease AFEP*.
Goals: The goal of this project was to systematically review peer-reviewed literature to qualitatively report the effects and impact of participation in AFEP and AFAP among individuals with arthritis. Our objective was to provide a descriptive summary of the outcomes assessed when participating in these programs to establish areas of existing evidence and identify gaps related to the efficacy of AFEP and AFAP in arthritis management that should be addressed in future studies.
Method: Two independent scoping reviews were conducted to describe the existing literature on the effects of participating in 1) AFEP and 2) AFAP. Articles reviewed included assessment of arthritis symptoms, physical fitness, function, activities of daily living and exercise compliance.
Results: Seven of the 1,578 AFEP and eight of the 511 AFAP articles met the inclusion criteria. AFEP and AFAP programming found improvements overall, but there were equivocal results for many of the hallmark symptoms of arthritis, including pain, flexibility/ROM, functional mobility, muscular strength and endurance, balance, aerobic capacity, quality of life and self efficacy.
Conclusions: Many gaps in the research have been identified that should be addressed in future studies to determine the efficacy of AFEP and AFAP in arthritis management.
Keywords: fitness, aquatic exercise, function, arthritis management, pain management.

Resumen: Una revisión exploratoria de la programación de la Arthritis Foundation.
Antecedentes: La artritis afecta a 1 de cada 4 adultos en los EE. UU. y la prevalencia aumenta con la edad. El ejercicio es uno de los tratamientos no invasivos más eficaces para los síntomas relacionados con la artritis. Para facilitar la participación en el ejercicio adecuado para esta población, la Arthritis Foundation creó una serie de programas de ejercicios para personas con artritis, incluidos el Programa de ejercicios de la Arthritis Foundation (AFEP), el Programa de ejercicios acuáticos de la Arthritis Foundation (AFAP) y la AFEP Las personas con artritis pueden hacer ejercicio y caminar con facilidad.
Objetivos: El objetivo de este proyecto fue revisar sistemáticamente la literatura revisada por pares para informar cualitativamente los efectos y el impacto de la participación en AFEP y AFAP entre las personas con artritis. Nuestro objetivo fue proporcionar un resumen descriptivo de los resultados evaluados al participar en estos programas para establecer áreas de evidencia existente e identificar brechas relacionadas con la eficacia de AFEP y AFAP en el manejo de la artritis que deben abordarse en estudios futuros.
Método: Se realizaron dos revisiones exploratorias independientes para describir la literatura existente sobre los efectos de participar en 1) AFEP y 2) AFAP. Los artículos revisados incluyeron la evaluación de los síntomas de la artritis, la aptitud física, la función, las actividades de la vida diaria y el cumplimiento del ejercicio.
Resultados: Ocho de los 1.578 artículos de la AFEP y ocho de los 511 de la AFAP cumplieron los criterios de inclusión. La programación de AFEP y AFAP encontró mejoras en general, pero hubo resultados equívocos para muchos de los síntomas característicos de la artritis, incluido el dolor, la flexibilidad/ROM, la movilidad funcional, la fuerza y resistencia muscular, el equilibrio, la capacidad aeróbica, la calidad de vida y la autoeficacia.
Conclusiones: Se han identificado muchas lagunas en la investigación que deben abordarse en futuros estudios para determinar la eficacia de la AFEP y la AFAP en el manejo de la artritis.
Palabras clave: fitness, ejercicio acuático, función, manejo de la artritis, manejo del dolor.

Introduction

Arthritis is an overarching term for a collection of more than 100 diseases and disorders that have different pathologies, but often similar signs and symptoms. Arthritis affects nearly a quarter of the population (Barbour et al., 2017) from children to older adults, and recent estimates indicate increased prevalence over the next few decades (Hootman et al., 2016). While arthritis impacts a wide spectrum of ages, prevalence and impact are noted to increase with age (Barbour et al., 2017). Symptoms range in severity and can typically include pain, redness, swelling, decreased mobility, diminished function, and increased risk of developing additional chronic diseases such as hypertension, heart disease, diabetes, and cancer (Barbour et al., 2017). These hallmark symptoms often lead to limitations in completing common activities of daily living (ADL) with nearly half (43.5%) of individuals diagnosed with arthritis reporting some limitation in their daily lives (Barbour et al., 2017). Pain is noted to be the primary symptom resulting in motivation to seek medical care and concluding in disability (Barbour et al. 2016; Kennedy et al., 2014).

With no cure available, management of arthritis and its related symptoms is multifactorial, commonly including medication (e.g., NSAIDs, corticosteroids, analgesics, and disease-modifying antirheumatic drugs) as well as nonpharmacological treatments comprised of therapy, surgery, weight loss, and exercise. Indeed, exercise is one of the most effective, non-invasive treatments for arthritis-related symptoms (Ambrose & Golightly, 2015). Habitual exercise elicits many favorable outcomes for those affected by arthritis including reducing pain, increasing the range of motion of affected joints, improving strength, and increasing mobility (Lee et al., 2006; Valderrabano & Steiger, 2011). Resistance training can increase muscle strength and power, which can help with joint stability (Hall et al., 2017), while aerobic exercise, such as walking, cycling, and aquatic classes can reduce pain and improve functional status and gait (Resnick, 2001).

To facilitate the adoption of appropriate exercise for this population, the Arthritis Foundation created a series of exercise programs for individuals with arthritis including the Ar*thritis Foundation Exercise Program (AFEP), Arthritis Foundation Aquatic Exercise Program (AFAP), Walk With Ease AFEP,* and previously *People with Arthritis Can Exercise (PACE).* The *Arthritis Foundation Exercise Program* (AFEP) is a land-based exercise program designed to provide individuals with arthritis a safe program to manage and reduce the symptoms of arthritis. It includes a warm-up, a main segment that can include cardiovascular, strengthening, range of motion, balance, flexibility, and coordination exercises, and finishes with a cool-down. AFEP is designed to be adjusted to various needs of those with arthritis and arthritis-related diseases while focusing on flexibility, strength, balance, coordination, muscular strength and endurance, and cardiorespiratory endurance. Further, AFEP aims to educate participants on the importance of exercise and how to perform exercises safely while instilling confidence in an environment that is inclusive, enjoyable, and safe to exercise while alleviating the symptoms of arthritis.

Similar to AFEP, AFAP is a community-based program designed to reduce arthritis-related symptoms and increase muscle strength and endurance, flexibility, functional status, and self-confidence while reducing fatigue and pain. The AFAP utilizes the unique properties of water to enhance the experience and outcomes of exercise for those with arthritis. Aquatic exercise has been noted as one of the most beneficial forms of exercise for treatment of arthritis (Dong et al., 2018). The unique properties of water can help control and reduce arthritis-related symptoms while promoting muscular strength and endurance as well as overall function (Johnson et al., 2019). For example, hydrostatic pressure redistributes excess fluid to remedy edema and water's enhanced heat conduction can aid in the control of inflammation, muscle spasm, and muscle tension (Kinnaird & Becker, 2008). The viscous property of water provides both support and resistance to improve balance while increasing muscle activity; buoyancy creates an offloading effect that provides ease with movement, reductions in pain, and increased physical activity levels (Becker, 2009). Specific programming capitalizing on the advantages of the aquatic environment, designed to focus on the needs of those with arthritis and arthritis-related diseases, including the Arthritis Foundation Aquatic Program (AFAP), are promoted by the Center for Disease Control (CDC) and the Arthritis Foundation (Center for Disease Control and Prevention, 2021).

While previous research has examined the effects of participating in AFEP and AFAP among individuals with arthritis, the scope and impact of these programs has not been thoroughly reviewed. Therefore, the aim of this paper was to systematically review peer-reviewed literature to qualitatively report the effects and impact of participation in AFEP and AFAP among individuals with arthritis. Our objective was to provide a descriptive summary of the outcomes assessed when participating in these programs to establish areas of existing evidence and identify gaps related to the efficacy of AFEP and AFAP in arthritis management that should be addressed in future studies.

Methods

Two independent scoping reviews were conducted following established scoping review methodology (Peters et al., 2015) to describe the existing literature on the effects of participating in 1) AFEP and 2) AFAP among individuals with arthritis. Independent literature searches were conducted between February 2021 and March 2021 for articles related to 1) AFEP and 2) AFAP. Databases included PubMed and Google Scholar; English language, but not date, restrictions were used. Literature identified through the search was screened for duplicates and relevance. Full text articles were reviewed for inclusion eligibility and the final body of literature was determined. A descriptive charting of the results was conducted and refined.

AFEP

On February 15th, 2021 a search on Pubmed was conducted using the search terms ("Arthritis foundation" AND exercise) from which 485 articles were identified. On February 27, 2021 a search on Google Scholar was conducted using the search terms ((AFEP OR arthritis) AND exercise) from which 46 articles were identified. On March 9, 2021 a search on Google Scholar was conducted using the search terms (YMCA arthritis foundation) and excluded (aquatic OR water OR hydro OR aqua OR aquatics) from which 928 articles were identified. On March 17, 2021 a search on Google Scholar was conducted using the search terms (Arthritis foundation exercise program) from which 119 articles were identified. In total, 1,578 articles were identified (Figure 1). Articles were extracted into an excel spreadsheet, checked for duplicates, and screened independently by duplicate reviewers for eligibility. Articles were excluded if they didn't specifically use the Arthritis Foundation Exercise Program as an experimental group in the research study. Titles, abstracts, and full text portions were reviewed to determine final articles for analysis. Data from relevant peer-reviewed literature was extracted including: study design, objective, measurements, and results. Significant and non-significant (NS) findings were reported.

AFAP

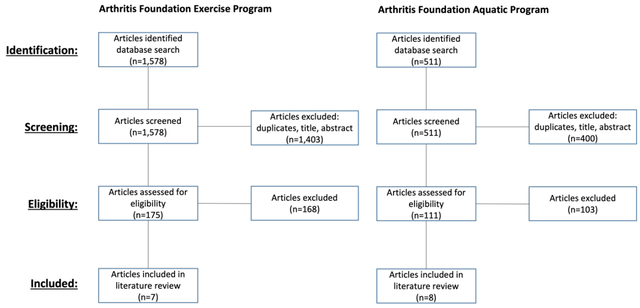
On February 18th, 2021 a search on PubMed for "("arthritis foundation" AND "aquatics")" found no results while a search on Google Scholar identified 511 titles. On March 14th, a search on PubMed and Google Scholar for ("arthritis foundation YMCA aquatic exercise program") did not provide any new articles. Articles were extracted into an excel spreadsheet, checked for duplicates, and screened for eligibility by two independent reviewers. Titles, abstracts, and fill text portions were reviewed by duplicate reviewers to determine final articles for analysis.

Specific inclusion criteria were any articles that mentioned the AFAP program. Articles were excluded if they were theses, literature reviews, or if they did not use the AFAP program as their intervention method in their study. Data from relevant peer-reviewed articles was extracted including objective, measurements, study design, and results. Significant and non-significant (NS) findings were reported.

Results

Figure 1

Flow diagram of research studies of the Arthritis Foundation Exercise Program (AFEP) and Arthritis Foundation Aquatics Program (AFAP)



AFEP

Of the 1,578 articles identified, 1,570 were removed for incomplete inclusion criteria. The remaining 8 articles were found to meet all inclusion criteria, specifically, use of AFEP; however, one was excluded (Mays et al., 2021) because data was pooled from 4 different community-based exercise programs and the outcomes specific to participation in AFEP could not be determined (Figure 1). The included studies had participants ranging from age 18 to 91 years old and included osteoarthritis, rheumatoid arthritis, and self-reported arthritis (Table 1). The articles included in this review were comprised of various intervention strategies which range from 8 – 10 weeks with 45 – 75 minute classes (Table 1).

Participating in AFEP elicited increased upper and lower body strength (Callahan et al., 2008), decreased blood pressure (Zgibor et al., 2017) and risk of falls (Schlenk et al., 2016), and reduced the number of poor mental health days (Freburger et al., 2010) as well as limited activity days (Freburger et al., 2010). Participants of AFEP with hypertension at baseline had controlled hypertension at 6 months and improved control of diabetes (Zgibor et al., 2017). Sleep quality was measured in two studies (Freburger et al., 2010; McManus et al., 2015) and found fewer sleep disturbances (McManus et al., 2015), decreased likelihood of waking up in the middle of the night, and diminished likelihood of waking up tired (Freburger et al., 2010). Two studies reported positive participant feedback, noting participants were satisfied with the exercise program, rated the instructors as excellent or very good, and would recommend it to a friend (Schlenk et al., 2016; Roncone, 2013).

AFEP did not modify balance, mobility, endurance, depressive symptoms or perceived helplessness (Callahan et al., 2008). Across studies, there were equivocal results for arthritis related pain (Callahan et al., 2008; McManus et al., 2015; McManus, 2013; Schlenk et al., 2016; Zgibor et al., 2017), stiffness (Callahan et al., 2008; Schlenk et al., 2016; Zgibor et al., 2017), and function (Callahan et al., 2008; Zgibor et al., 2017) as well as self-efficacy (Callahan et al., 2008; McManus, 2013; Roncone, 2013) and physical activity (Callahan et al., 2008; Freburger et al., 2010; Schlenk et al., 2016) with some studies showing improvements or declines, and others showing no significant effects.

Two studies examined the efficacy of participating in the Arthritis Foundation Exercise Program with or without including "10 Keys to Healthy Aging" (10 KHA) program (an educational program promoting actions and choices individuals can make to achieve a healthier lifestyle) (Schlenk et al., 2016; Zgibor et al., 2017). Those that completed AFEP +10 KHA showed decreased risk of falls (Schlenk et al., 2016) and systolic blood pressure (Zgibor et al., 2017). One study found improved arthritis related pain and function (Zgibor et al., 2017) while another found no significant effect on pain or stiffness (Schlenk et al., 2016). Participants with hypertension at baseline had controlled hypertension and showed improved control of their diabetes (Zgibor et al., 2017), but no significant effects on fasting blood glucose (Schlenk et al., 2016). However, there were no differences between completing the AFEP alone and completing the AFEP +10 KHA (Zgibor et al., 2017).

Table 1. Review of Studies for AFEP

Author	Study Design	Participants	Intervention	Measures	Results
Schlenk, et al. 2016	Pre-post pilot/feasibility study	N= 51, average age = 75.5 y (SD 9.3 y) self-reported osteoarthritis with no medical contraindications 73% arthritis diagnosis	AFEP + 10 KHA 10 wk w/ 1-2 75 min classes/wk	Attendance, adherence, satisfaction Preventive measures – smoking status, cancer screening, immunizations, physical activity, musculoskeletal health, social contact, and combating depression WOMAC; Fasting blood glucose; Fasting LDL cholesterol	75% attended >50% of sessions; 53% adherence at 6 mo, 54% adherence at 12 mo; 97% highly rated satisfaction; NS preventive measures; ↓ risk of falls; ↓ physical activity; NS pain and stiffness (WOMAC); NS fasting blood glucose; NS LDL
Zgibor, et al. 2017	Cluster-randomized trial comparing AFEP vs. AFEP + 10 KHA	N=462, 73 y with self-reported osteoarthritis, no medical contraindications	AFEP vs. AFEP + 10 KHA	Height; Weight; Blood pressure; Fasting glucose; SPPB; WOMAC	NS between groups all measures Within group, pre-post: AFEP: Improved physical function (SPPB), Arthritis related pain, stiffness, and function (WOMAC), SBP, controlled HT, controlled diabetes; AFEP +10 KHA: Improved Arthritis related pain and function (WOMAC), SBP, controlled HT, controlled diabetes
McManus, Visker, and Cox 2014	Convenience sample comparison study AFEP vs. Control	AFEP n=19 ,76-91 y Control n=20, 55-88 y with rheumatoid arthritis	AFEP classes 2x/wk vs. no intervention Control 8 wk	Rheumatoid Arthritis Pain Scale (RAPS) Pittsburgh Sleep Quality Index (PSQI)	↓ Pain (RAPS) AFEP vs. Control ↑ Sleep (PSQI) AFEP vs. Control
Callahan, et al. 2008	Randomized Controlled Trial PACE vs. Control with delayed intervention	N=346, average age 70 y with self-reported arthritis	PACE classes 2x/wk vs. no intervention Control 8 wk	Pain, Stiffness, Fatigue; Health Assessment Questionnaire disability scale; 10-pound lifts; Timed chair stands; Timed 360-degree turn; Gait speed test; 6-minute walk test ; Physical Activity Scale for the Elderly (PASE); Rheumatoid Arthritis Self-efficacy (RASE); Self-efficacy for Physical Activity (SEPA); Center for Epidemiological Studies Depression Scale (CES-D); Helplessness Subscale of the Rheumatology Attitudes Index (RAI)	↓ Pain, Fatigue AFEP vs. Control; Improved Arthritis Self-Efficacy (RASE) AFEP vs. Control; ↑Lower Body Strength (Timed chair stands) AFEP vs. Control; ↑Upper Body Strength (10 pound lifts) AFEP vs. Control; NS Stiffness, Self-reported function (HAQ), Standing Balance (timed 360 turn), Functional mobility (walking speed, normal and fast), Aerobic endurance (6 min walk test), Physical Activity Level (PASE), Physical activity self-efficacy (SEPA), Depressive symptoms (CES-D), Perceived Helplessness (RAI)
McManus K. 2014	Convenience sample control trial	AFEP n=13 Control n=14 All 55-81 y with rheumatoid arthritis	AFEP classes vs. no intervention Control 8 wk	Arthritis Self-efficacy Scale (ASES-8) Rheumatoid Arthritis Pain Scale (RAPS)	NS Self-efficacy ↓ Pain (RAPS) AFEP vs. Control
Freburger, et al.2010	Randomized Controlled Trial vs. Control with delayed intervention	N=346, age 18+ with self-reported arthritis.	PACE classes 2x/wk vs. no intervention Control 8 wk	4-item Self-reported Sleep quality 5 items from Health Related Quality of Life Scale (HRQoL)	NS Trouble falling asleep (self-reported sleep quality); ↓ Waking up at night (self-reported sleep quality); NS Trouble staying asleep (self-reported sleep quality); ↓ likelihood of waking up tired (self-reported sleep quality); NS Overall health (HRQoL); NS Physical health (HRQoL); ↓Poor mental health days (HRQoL) ; ↓Limited activity days (HRQoL)

***** Abreviations: KHA, Keys of Healthy Aging; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index; SPPB, Short Physical Performance Battery; SBP, Systolic Blood Pressure; RAPS, Rheumatoid Arthritis Pain Scale; PSQI, Pittsburgh Sleep Quality Index; PACE, People with Arthritis Can Exercise; PASE, Physical Activity Scale for the Elderly; RASE, Rheumatoid Arthritis Self-efficacy; SEPA, Self-efficacy for Physical Activity; CES-D, Center for Epidemiological Studies Depression Scale; RAI, Helplessness Subscale of the Rheumatology Attitudes Index; ASES-8, Arthritis Self-efficacy Scale; HRQoL, Health-Related Quality of Life Scale.

AFAP

Of the 511 articles identified, 503 were removed for incomplete inclusion criteria. The remaining 8 articles were found to meet all inclusion criteria, specifically, use of AFAP (Figure 1). The included studies had participants ranging from age 4 to 91 years of age and included osteoarthritis (OA), rheumatoid (RA), juvenile rheumatoid arthritis (JRA), self-reported arthritis, and systemic lupus erythematosus (SLE) (Table 2). The articles included in this review were comprised of various intervention strategies, however, all classes included a warm-up, a main segment including flexibility, strengthening and some aerobic exercises, and a cool-down. The class sessions were 45- 60 minutes in duration while the intervention length ranged from 6 weeks to 4 months (Table 2).

Participating in AFAP increased hand-eye coordination and flexibility (Suomi & Koceja, 2000). Improvements in the knee injury and osteoarthritis outcome score (KOOS) was also noted to show significant reductions in knee swelling, noise, hang up, and straightening (Yázigi et al., 2019). Additionally, a high rate of exercise compliance was noted for AFAP participation (Suomi & Collier, 2003; Suomi & Koceja, 2000) with increased attendance for those with high goal specificity, task self-efficacy, and scheduling self-efficacy (Gyurcsik et al., 2003) with an increase in self-efficacy for performing water exercise without aggravating symptoms (Wong & Scudds, 2009). Participation improved ability to complete ADLs, including increased grip strength and donning clothes with greater ease (Suomi & Koceja, 2000).

AFAP did not improve disability (Cadmus et al., 2010; Wong & Scudds, 2009), physical activity (Fisher et al., 2004), or depression (Cadmus et al., 2010). No significant change was found in the speed of quadriceps contraction (Fisher et al., 2004), VO_2 (Fisher et al., 2004), HR (Fisher et al., 2004), BP (Fisher et al., 2004), gait (Bacon et al., 1991) or BMI (Cadmus et al., 2010). Goal difficulty was shown to negatively correlate with aquatic exercise attendance while it, along with goal specificity, task self-efficacy and scheduling self-efficacy, were non-significant predictors for attendance (Gyurcsik et al., 2003).

Across studies, there were equivocal results for arthritis related pain (Fisher et al., 2004; Cadmus et al., 2010; Suomi & Koceja, 2000; Wong & Scudds, 2009; Yázigi et al., 2019), functional status (Bacon et al., 1991; Fisher et al., 2004; Suomi & Koceja, 2000; Wong & Scudds, 2009), quality of life (Cadmus et al., 2010; Wong & Scudds, 2009), balance (Bacon et al., 1991; Suomi & Collier, 2003), muscular strength (Fisher et al., 2004; Suomi & Koceja, 2000), walking (Bacon et al., 1991; Fisher et al., 2004; Suomi & Koceja, 2000; Yázigi et al., 2019), stair climbing/navigation of stairs (Bacon et al., 1991; Yázigi et al., 2019), range of motion (Bacon et al., 1991; Suomi & Koceja, 2000; Yázigi et al., 2019), and various self-efficacy outcomes (Cadmus et al., 2010; Gyurcsik et al., 2003; Wong & Scudds, 2009) with some studies showing improvements and others showing no significant effects.

Table 2. Review of Studies for AFAP

Author	*Study Design*	*Participants*	*Intervention*	*Measures*	*Results*
Wong and Scudds 2009	Pre-test, within study design	N=31, 18-65 y with RA or SLE mean disease duration 5.97 y (SD 5.62)	4-wk AFAP + 8-wk maintenance	CHAQ questionnaire; Pain Visual Analog Scale (VAS); QOL – Chinese SF-36 ; Arthritis Self-efficacy Scale (ASES) – related to exercising regularly and self-management	NS Disability (CHAQ); ↓Pain (VAS) ; ↑ QOL in general health, physical functioning, role-physical, role-emotional, bodily pain, vitality; NS QOL in social functioning, mental health; ↑ self-efficacy (ASES) in performing water exercise without aggravating symptoms
Yazigi et. al. 2019	Single-blinded, randomized control trial	N=48, 40-65 y with BMI ≥ 28 KG/M^2 and clinical and radiographic KOA	2x/wk, 60 min/session using the PICO protocol vs control 12 wk	Knee injury and osteoarthritis outcome score (KOOS) and it's 5 components: quality of life, knee pain, ADL, other disease-specific symptoms, and recreation function	↓Pain (KOOS); ↓Swelling (KOOS); ↓knee noise (KOOS); ↓Hang Up (KOOS); ↑Straighten (KOOS); ↑Walking (KOOS) ; ↑Up/Down Stairs (KOOS)
Fisher et al. 2004	Convenience sample pre/post intervention	N=18 KOA	3x/wk, 45 min/class using AFAP 8 wk	Jette functional status index (JFSI); Habitual physical activity questionnaire (HPA); RPE; Maximal voluntary isometric contraction strength of the quadriceps & hamstrings (MVIC); Sustained MVICq x 90 sec (muscular endurance); Speed of quadriceps contraction; Graded exercise test – cycle ergometer (VO_2, BP, HR)	NS JFSI; NS Walking time; NS pain, difficulty, dependence; NS HPA; NS maximal isometric strength of quadriceps; NS maximal isometric strength of hamstrings; NS sustained maximal isometric strength of quadriceps; NS sustained maximal isometric strength of hamstrings; NS Speed of quadriceps contraction NS VO_2, HR, BP
Cadmus et.al. 2009	Randomized control trial AFAP vs Control	N=249 55-75 y with OA	2-5x/wk, 45-60 min AFAP classes vs control 20 wk	Perceived Quality of Life scale (PQOL); self- efficacy scale; VAS scale; Health Assessment Questionnaire (HAQ); Disability Index (DISINDEX) of HAQ (activity limitation); Center for Epidemiological Studies Depression Scale (CES-D) ; BMI	↑Perceived QOL BMI moderates relationship between AFAP and PQOL NS self-efficacy scale, VAS, HAQ, DISINDEX, CES-D, BMI
Suomi & Collier 2000	Pre-post intervention study	N=32 60-79 y with diagnosed OA or RA	2x/wk x 45 min sessions using AFAP or PACE vs control 8 wk	Exercise Compliance; Modified Functional Capacity Evaluation – difficulty in ADL and pain Functional Fitness Assessment for Adults over 60 – Flexibility, Coordination, Agility/Dynamic Balance, Strength & Endurance, Cardiorespiratory Endurance Nicholas Manual Muscle Tester (MMT) – hip & shoulder	Exercise Compliance rate high for both AFAP (79%) & PACE (90%) AFAP ↑ MMT in R/L shoulder & L hip; ↑ Flexibility; ↑ Hand-eye Coordination; ↑ R/L Arm Curl; ↓ Pain; ↓ ADL difficulty
Suomi & Koceja 2003	Pre-post intervention Study	N=24 45-70 y with diagnosed OA or RA	3x/wk x 45 min classes using AFAP vs control 6 wk	Static two-legged stance with vision (S2V); Static two-legged stance without vision (S2WOV); Exercise Compliance	High Exercise Compliance (82%); ↑ balance with vision; ↑ balance without vision
Gyurcsik, Estabrooks, Frahm-Templar 2003	Comparative analysis	N=216 32-91 y with arthritis	AFAP classes 2-5x/wk 8 wk	Impact of Goal Difficulty, Goal Specificity, Task Self-Efficacy & Scheduling Self-Efficacy on Aquatic Exercise Attendance (AexA)	High Goal specificity, task self-efficacy, & scheduling self-efficacy yields ↑ AExA; Goal difficulty negatively correlated with AExA; Goal Difficulty, Goal Specificity,Task Self-Efficacy & Scheduling Self-Efficacy NS predictors for AExA
Bacon, Nicholson, Binder, White 1991	Pre-post intervention Pilot Study	N=11 4-13 y with Juvenile RA (JRA)	AFAP classes 2x/wk x 45 min classes + 15 min free play 6 wk	ROM; Gait; Balance; Lower Extremity Functional mobility (LEFM); Timed single-leg stance; Heel-to-toe walking; Timed 25-foot run; 100-foot walk; 13-step stair-climb; Timed change from supine to standing position; Gait velocity; Cadence; Stride length; HR	↑ bilateral internal and external hip rotation, R hip flexion with knee extension (ROM); NS plantar flexion; NS balance, Timed single-leg stance, Timed change from supine to standing position, Timed 25-foot run, 100-foot walk, 13-step stair-climb; NS gait velocity, cadence, stride length; Improvements in HR, full recovery after 5 minutes of vigorous activity

***** Abreviations: SLE, Systemic lupus erythematosus; RA, rheumatoid arthritis; CBWEP, Community-based water exercise program; CHAQ, Chinese Health Assessment Questionnaire; VAS, visual analog scale; QOL, quality of life; JFSI, Jette functional status index; HPA, Habitual physical activity questionnaire; MVIC, Maximal voluntary isometric contraction; PQOL, Perceived Quality of Life scale; HAQ, Health Assessment Questionnaire; DISINDEX, Disability Index; CES-D, Center for Epidemiological Studies Depression Scale; MMT, Manual Muscle Tester; S2V, Static two-legged stance with vision ; S2WOV , Static two-legged stance without vision; AexA, Aquatic Exercise Attendance; JRA, Juvenile Rheumatoid Arthritis.

Table 3. AFAP and AFEP Outcome Measures

Outcome Measures	AFAP	AFEP	Both AFAP and AFEP
Pain (WOMAC, SPPB, RAPS, Modified Functional Capacity Evaluation)	↓Pain (VAS) ↓Pain (KOOS) NS pain ↓ Pain (Modified Functional Capacity Evaluation)	NS pain and stiffness (WOMAC) Within group, pre-post: AFEP: Arthritis related pain, stiffness, and function (WOMAC) ↓ Pain (RAPS) AFEP vs. Control ↓ Pain, Fatigue AFEP vs. Control ↓ Pain (RAPS) AFEP vs. Control	Decrease pain in both programs.
Flexibility/ROM (ROM, LEFM)	↑ Flexibility ↑ bilateral internal and external hip rotation, R hip flexion with knee extension (ROM) NS plantar flexion	NS Stiffness	Equivocal findings in flexibility/ROM between programs.
Functional Mobility (SPPB, Timed 360-degree turn, Gait speed test, KOOS, DISINDEX, HAQ, Heel-to-toe walking, Timed 25-foot run, 100-foot walk, 13-step stair-climb, Timed change from supine to standing position, Gait velocity, Cadence, Stride length)	↑Walking (KOOS) ↑Up/Down Stairs (KOOS) NS Walking time NS Timed 25-foot run, 100-foot walk, 13-step stair-climb NS gait velocity, cadence, stride length ↓ ADL difficulty NS JFSI NS DISINDEX NS HAQ ↑ Hand-eye Coordination	Within group, pre-post: AFEP: Improved physical function (SPPB) NS Self-reported function (HAQ), Functional mobility (walking speed, normal and fast)	Improvements in function illustrated in both programs
Muscular Strength & Endurance (10-pound lifts, Maximal voluntary isometric contraction strength of the quadriceps & hamstrings (MVIC), Sustained MVICq x 90 sec (muscular endurance), Speed of quadriceps contraction)	↑ R/L Arm Curl NS maximal isometric strength of quadriceps ↑ MMT in R/L shoulder & L hip NS maximal isometric strength of hamstrings NS sustained maximal isometric strength of quadriceps NS sustained maximal isometric strength of hamstrings NS Speed of quadriceps contraction	↑Lower Body Strength (Timed chair stands) AFEP vs. Control ↑Upper Body Strength (10 pound lifts) AFEP vs. Control	Some improvements in muscular strength and endurance in both programs.
Balance (S2V, S2WOV, Timed single-leg stance)	↑ balance with vision ↑ balance without vision NS balance, Timed single-leg stance, Timed change from supine to standing position	↓ risk of falls NS Standing Balance (timed 360 turn)	Equivocal findings in balance between programs.
Aerobic Capacity (6-minute walk test, VO_2, HR response)	NS VO_2 Improvements in HR, full recovery after 5 minutes of vigorous activity	NS Aerobic endurance (6min walk test) ↓ Fatigue AFEP vs. Control	Equivocal findings in aerobic capacity between programs.
Quality of Life (HRQoL, QOL – Chinese SF-36, PQOL)	↑ QOL in general health, physical functioning, role-physical, role-emotional, bodily pain, vitality NS QOL in social functioning, mental health BMI moderates relationship between AFAP and PQOL	NS Overall health (HRQoL) NS Physical health (HRQoL) ↓Poor mental health days (HRQoL) ↓Limited activity days (HRQoL)	Some improvement in QOL for both programs.
Self-Efficacy (SEPA, Perceived self-efficacy, ASES, self- efficacy scale, Task Self-Efficacy & Scheduling Self-Efficacy)	↑ self-efficacy (ASES) in performing water exercise without aggravating symptoms NS self-efficacy scale Task Self-Efficacy & Scheduling Self-Efficacy NS predictors for AExA	NS Physical activity self-efficacy (SEPA) ↑Perceived self-efficacy (90% reported)	Some associated improvements were found in both programs.

AFEP and AFAP

Discussion

The purpose of this work was to systematically review peer-reviewed literature to qualitatively report the effects and impact of participation in AFEP and AFAP among individuals with arthritis. Our objective was to provide a descriptive summary of the outcomes assessed when participating in these programs to establish areas of existing evidence and identify gaps in determining the efficacy of AFEP and AFAP in arthritis management that should be addressed in future studies.

Overall findings suggest that Arthritis Foundtion programming can improve pain, function, quatlity of life, and muscular strength and endurance, but their impact on balance, flexiblility/ROM, and aerobic capacity are inconsistent. Both the land and aquatic Arthritis Foundation programs found equivocal results for key arthritis-related symptoms, including pain, stiffness, and impaired function. In part, the equivocal findings of the present scoping review are attributed to differences between subjects (e.g., type of arthritis, degree of onset) as well as interventions (e.g., length of intervention). For example, it is common in human exercise intervention research for the greatest improvements to be found in those with the poorest measures at baseline (e.g., those with the highest blood pressure at the start of an exercise program will exhibit the greatest reduction in blood pressure by the end of the program). Osteoarthritis is graded on a 0 (none)-4 (severe) scale; inclusion criteria for subjects with a 3-4 arthritis grade could be an important factor for determining the impact of an intervention when studying individuals with OA. Additionally, most outcomes were assessed in only 1-2 studies making it difficult to draw firm conclusions regarding the impact of these programs on specific outcomes. Therefore, to best determine the impact on arthritis-specific outcomes future research should control for subject characteristics (e.g., body weight, arthritis severity), include a variety of outcomes measures, and implement more controlled interventions (e.g., controlling for physical activity outside of the AFEP/AFAP program).

AF exercise improves muscular strength and flexibility, but the majority of studies investigated these outcomes on the lower extremity. Future studies should also include upper extremity outcomes, particularly the hands. Many individuals who suffer from arthritis systemically will have arthritis in the joints of their hands and digits, which can dramatically impair important ADLs. The AFAP and AFEP dedicate an entire section within their manuals to exercises focused on the hands and wrists. This is due to the prevalence of arthritis impacting the hand, as it is the most common site for OA and RA (Bobos et al., 2019). Additionally, joint protection is taught and reinforced throughout the AF programming. Both exercise and practicing joint protection are common treatments for individuals with arthritis impacting their hands (Bobos et al., 2019) thus it would be prudent to focus studies on this population. Since some types of arthritis are more likely to occur with aging (e.g., osteoarthritis) and production of muscle power rapidly deteriorates with age, muscular assessments should also include outcomes specific to power production. Age related muscle mass and function loss can typically be slowed with interventions that include exercise (Larsson et al., 2019). This holds significant importance in relation to power production as it has been directly associated with reducing falls and fall-related injuries (Larsson et al., 2019). The inability to produce muscular power results in a slowing of movement resulting in the failure to adequately react to a fall stimulus (Larsson et al., 2019).

Many forms of arthritis are associated with increased fall risk, attributed to typical symptoms of arthritis such as pain, stiffness, and impaired function, including compromised gait and balance (Doré et al., 2015; Guillamón et al., 2019; Stanmore et al., 2013). Reviews of both AFEP and AFAP found equivocal results for these key symptoms. Lower extremity weakness in addition to balance and gait deficits are reported to be the most important individual risk factors in relation to falls

(Guillamón et al., 2019; Moreland et al., 2004; Rubenstein, 2006). Moreover, limitations in strength, flexibility, balance and reaction time are considered to be the greatest modifiable fall risk factors (Guillamón et al., 2019; Myers et al., 1996). Both the AFEP and AFAP programs propose an emphasis on the aforementioned fall risk factors within the program design. Further, water exercise has been shown to diminish fear of falling while training for improved balance due to the reduced risk associated with movement errors (Guillamón et al., 2019; Sá & Palmeira, 2019; Simmons & Hansen, 1996). Future research using AFAP as an intervention for reducing fall risk and its associated risk factors should be considered.

Improvements in strength, power, reaction time, and flexibility should be assessed alongside injury, fall rate, and use of assistive devices as there is a direct, negative correlation between neuromuscular improvements and risk of injury, falls, and balance, especially among older individuals. Each of these physiological characteristics relating to basic and skill-related physical fitness, can be improved through application of appropriate training stimuli during AFAP and AFEP.

Another area that deserves further investigation is the impact of these programs on weight loss and maintenance. It has been well established that individuals with arthritis are at an increased risk of obesity which can aggravate symptoms and limit function (Magliano, 2008). Losing weight is one of the first lifestyle-recommendations physicians may make to individuals with arthritis related obesity (Egerton et al., 2018). Moreover, body composition changes reflecting an increase in body fat and reduced muscle mass, that have similarly been reported with advancing age and functional impairments, can also be positively impacted by exercise interventions (Larsson et al., 2019). Furthermore, arthritis commonly exacerbates muscle wasting, strength loss, and impairment in skeletal muscle function due to disuse or joint function (Liao et al., 2020). The increased caloric expenditure associated with exercise in addition to the positive functional outcomes associated with AFAP and AFEP, can contribute to weight loss as well as overall function. Losing weight through a combination of diet and exercise could help preserve muscle mass and bone health, while reducing the strain and impact to arthritis-affected joints and should be studied.

While both the AFEP and AFAP exercise programs are designed to maximize joint health during exercise, individuals that have self-limited physical activity due to arthritis related pain, including those that are overweight or obese, may find land-based exercise less comfortable than water-based trainingWhile both programs improved pain, there is some support in favor of aquatic exercise as a preferred environment for exercise for those with arthritis-related pain (Bartels et al., 2016; Kunduracilar et al., 2018). Findings suggest reductions in pain and improved physical performance of exercises when executing exercises while immersed (Bartels et al., 2016; Kunduracilar et al., 2018). Future research utilizing the AFAP program as an entry-level form of exercise to promote increased physical activity in individuals that have self-limited physical activity due to pain should be considered.

Though this review identified many outcome variables that have been investigated, albeit with few studies, many health-related outcomes have yet to be investigated. Perhaps most important is bone health. The negative consequences of arthritis to bone health and function are well established; however, exercise is among the primary modifiable risk factors capable of influencing bone health by preserving bone mass and strength and preventing the death of bone cells (Loprinzi et al., 2015; Santos et al., 2017; Weaver et al., 2016). Moreover, water exercise has been shown to have further effects on bone health due to the unique environmental stimuli, reduction in joint impact and risk of fracture due to trauma (Lv et al., 2021; Simas et al., 2017). Significant effects on bone metabolism, reductions of bone resorption and increases in bone formation have been noted (Lv et al., 2021). Future research investigating the impact of AFEP or AFAP could incorporate bone health assessments to determine the beneficial outcomes of exercise on bone. In line with bone health, examining the effects of an AF exercise program to the impact on inflammation, rate of joint change, or quality of synovial fluid could provide important mechanistic insights to any associated improvements in arthritis-related symptoms with Arthritis Foundation program participation.

Aside from health-related outcomes, the benefits of participating in an education-based, group exercise program have been understudied. Some research has investigated the impact to mental health, exercise adherence, enjoyment, and quality of life, but the results were equivocal and additional work should be implemented to further elucidate the impact of Arthritis Foundation programming on these favorable outcomes. Moving forward, outcomes specific to exercising with peers with similar symptoms could be investigated. For instance, mixed-methods research could evaluate the impact of AFEP and AFAP programs on exercise motivation, the impact of social engagement on exercise adherence, and improvements to social isolation. Further, both programs incorporate educational components, but few studies investigated the impact of this education on knowledge gains and behavior change. Incorporating these outcomes to future studies could evaluate the impact of this education programming and provide recommendations for improvement and increased use.

Conclusion

The Arthritis Foundation created a series of exercise programs for individuals with arthritis to facilitate the adoption of appropriate exercise for this population. This scoping review of peer-reviewed literature qualitatively reported the effects and impact of participation in AFEP and AFAP among individuals with arthritis. AFEP and AFAP programming found improvements overall, but there were equivocal results for many of the hallmark symptoms of arthritis, including pain, stiffness, and impaired function. Recommendations for future research are to control for subject characteristics, include a variety of outcomes measures, and implement more controlled interventions to best determine the impact on arthritis-specific outcomes. Additionally, we identified many gaps that should be addressed in future studies to determine the efficacy of AFEP and AFAP in arthritis management, including bone health, fall risk, weight loss, muscular power, and benefits of exercising in a group of peers with similar symptoms.

Contribution and practical implications

This scoping review of Arthritis Foundation programming (AFAP and AFEP) highlights several practical implications of participating in the Arthritis Foundation Exercise Program (AFEP) and the Arthritis Foundation Aquatic Exercise Program (AFAP). Findings from table 3 suggest that both AFAP and AFEP positively influence pain, functional mobility with some improvement ins in muscular strength and endurance, QOL and self-efficacy. There were equivocal findings for flexibility/ROM, balance and aerobic capacity. Practical implications of this information suggest that participating in AFEP can have several positive effects on physical and mental well-being, including improved strength, reduced blood pressure, decreased risk of falls, and better sleep quality. However, the program may not consistently impact certain areas such as arthritis-related symptoms, self-efficacy, or physical activity levels. The addition of the 10 KHA program does not appear to yield significant additional benefits. It is important to consider individual variations and further research to fully understand the effectiveness and potential limitations of AFEP in addressing the needs of individuals with arthritis. Further, these findings suggest that participating in AFAP can have positive effects on hand-eye coordination, flexibility, knee-related symptoms, and certain aspects of ADLs. However, the program may not consistently improve disability, physical activity levels, depressive symptoms, or several other outcomes associated with arthritis. The results vary across different studies, with some showing improvements and others finding no significant effects. Further research is necessary to better understand the specific benefits and limitations of AFAP in addressing the needs of individuals with arthritis.

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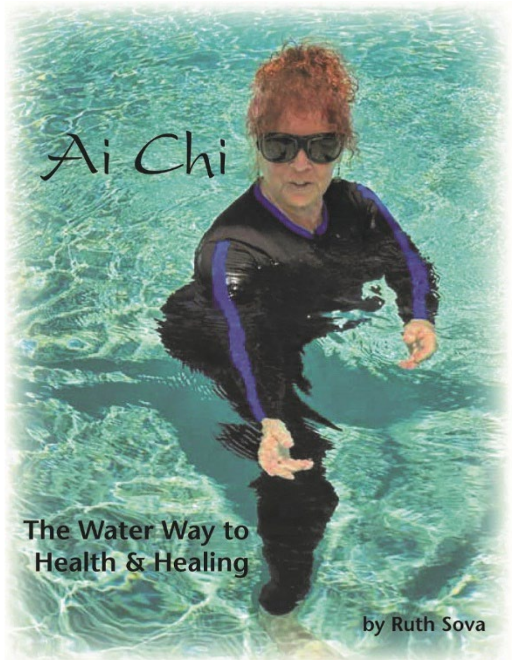

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Ai Chi is an aquatic program emphasizing breath paired with broad movements that is utilized for a myriad of health and wellness concerns. This technique was created in the early 90's by Jun Konno who later collaborated with Ruth Sova to create reference tools and books illustrating the importance, utilization and execution of Ai Chi. To date, hundreds of studies, focused on a variety of populations, have been conducted employing Ai Chi as the intervention. Findings support the importance of Ai Chi as both a rehabilitation and wellness tool. Ruth Sova's latest book titled Ai Chi: The Water Way to Health & Healing continues to explore and explain the benefits of Ai Chi.

In 1996, the first text on Ai Chi titled *Ai Chi: Flowing Aquatic Energy* (1996) was published, providing a reference tool for aquatic practitioners. This text introduced the technique, reasoning, progression and movements. *Ai Chi: Balance, Harmony & Healing* (1999) expanded on concepts, benefits, and uses of Ai Chi. Sova's latest text strengthens the argument for integration of Ai Chi into plans of care and exercise prescriptions across the rehabilitation and wellness spectrum. This text presents eight major thematic blocks: 1) Introducing Ai Chi (concepts and postures), 2) History, 3) Benefits to the body's systems, 4) Clinical relevance and effectiveness, 5) Breathing, 6) Finding a focus for the Ai Chi session, 7) Clinical populations, and 8) Versions of Ai Chi. Additionally, the book is accompanied by two videos on Ai Chi to further deepen the foundational knowledge of the practicing individual and practitioner.

Chapter 1 introduces Ai Chi, explaining the origins, the fundamental principles behind the technique and its benefits for physical and mental health. The images in combination with the step-by-step instructions for each posture in addition to the single-page reference for the nineteen postures aids the ability to reproduce the movements with success.

The foundational aspects of Ai Chi, including the basic stances, breathing techniques and the importance of relaxation and mindfulness are explored in chapter 2. While the first two chapters guide the reader towards specific stances, movements and breaths, it is continually noted by the author that Ai Chi "will turn out exactly the way it was meant to be."

Chapter 3 provides practical advice on how to begin practicing Ai Chi, including choosing the right aquatic environment, safety considerations, and the potential benefits. The extensive benefits of this technique are reviewed in-depth utilizing language that is easy to understand yet clinically applicable.

The essential aspects beyond the postures of Ai Chi are reviewed in chapter 4. Importance of positioning, movement intensity and level of immersion, the influence that water has on the body and recommended temperatures, breath, bodymind connection, and the clinical relevance of the various body mechanics are reviewed.

Chapter 5 reflects on the power of breathing and the various techniques that may be employed during Ai Chi. Additional focus on how breathing can affect relaxation and increase vagal activation. These presented integrations of breath with Ai Chi provide an interesting application of the technique for various physical and mental health conditions.

Chapter 8 is a resource guide for evolutions of Ai Chi including Ai Chi Ne (a partnered version of Ai Chi), Ai Chi Core (Ai Chi with a greater focus on alignment and posture), Ai Chi with Nidra Principals, and many others. Illustrations, instructions and even example scripts are included for enhanced understanding and facilitation ability.

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With the growing mental and physical health concerns across the globe, Ai Chi offers a low-cost, accessible, inclusive, therapeutic exercise option. As the book explains, it benefits nearly every body system while offering a plethora of positive mental health benefits as well. Further, Ai Chi can be performed by a wide range of individuals regardless of age, fitness level, or physical limitation. This level of inclusivity paired with its comprehensive impact on mental and physical health have the potential for profound effects on the practicing individual.

Ai Chi can be practiced individually, within a small or large group, or be led by a practitioner. It is a versatile technique that can be done as a portion of an exercise or therapeutic program or as a standalone practice. For the individual using this as a reference for self-guided Ai Chi, explanations, images, and the accompanying videos help to understand and perform the technique. For practitioners and instructors, the book delves into suggestions for teaching effective and resonating Ai Chi. The detailed descriptions and illustrations, holistic approach, practical applications, and research-supported findings presented in the text are particularly helpful for maximizing the benefits of Ai Chi. Personal anecdotes and case studies enrich the narrative while offering real-life examples of the transformative impact that Ai Chi can elicit.

Ai Chi: The Water Way to Health and Healing by Ruth Sova is a valuable resource for anyone interested in exploring the therapeutic potential of Ai Chi. This text is appropriate for those wishing to learn about Ai Chi as well as those seeking additional resources to deepen their practice of this mindful aquatic exercise.

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