Effect of strength training using resistive equipment in hydro gymnastics classes on functional fitness of middle-aged and older women

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Published online: July 31, 2021

(Accepted for publication July 15, 2021)

DOI:10.7752/jpes.2021.s3274

Abstract

Problem statement: Hydrogymnastics can improve older adults' functional fitness, but few studies have explored if using resistive elements during sessions would have any effect on functional fitness of middle-aged and older women. **Aim:** To verify strength training effects on functional fitness of middle-aged and older women while using resistive implements in hydrogymnastics. **Material and methods:** Experimental study, conducted with 15 women (mean=58.8, SD=8.2 years old), randomly divided into intervention and control groups. Hydrogymnastics training was held in 60-minute sessions, three times a week, for eight weeks. Besides traditional exercises, two specific exercises were incorporated in four series, 12-15 repetitions, with maximum speed and high intensity only for individuals in the intervention group. Functional fitness was assessed through gait speed, agility to sit and stand, and upper-limb strength and resistance at pre and post eight-week training. Data were analyzed with two-way ANOVA for repeated measures (group and time), proportional differences ($\Delta\%$), and effect size (Cohen's d). **Results:** Both groups showed an improvement in gait speed, decreasing time by five seconds ($\Delta\%$: -16%; F: 34.3; $p<0.001$). Both groups showed a significant increment in the number of repetitions for the agility to sit and stand test ($\Delta\%$: $\approx$ 14%; F: 11.63; $p<0.001$), but no interaction was observed between time and group (F: 0.17; $p=0.681$). On the strength and upper-limb resistance, individuals from the intervention group had a mean increase of 8.6 repetitions ($\Delta\%$: 45%), while those in the control group remained the same ($\Delta\%$: 1%). Though not significant (F: 3.39; $p=0.07$) a difference was found between groups (F: 9.04; $p<0.01$). The effect size was null or small for all outcome variables (0.229-3.256). **Conclusion:** The training allowed for improved functional fitness in middle-aged and older women, especially in the strength and upper-limb muscular resistance component.

Keywords: Exercise; Aquatic training; Fitness Centers; Physical Fitness; Aging; Experimental Studies.

Introduction

The high prevalence of physical inactivity observed in the population over 45 years old is a concern. Aging, associated with lack of exercise, attenuates the reduction of physiological function such as muscular strength and resistance, aerobic capacity, resulting in functional disability (ACSM, 2021; Chodzko-Zajko et al., 2009; Guthold et al., 2018; WHO, 2020). One of the main benefits of regular physical exercise for adults is the maintenance or increase of strength and muscular agility, associated with increase in functional autonomy and an independent lifestyle with the advance of age (Ludyga et al., 2016; WHO, 2020).

High proportions of women aged 55 years and older cannot perform basic household activities (Chodzko-Zajko et al., 2009). Therefore, exercise is an important prevention strategy to be adopted before reaching older age, where functional loss is more pronounced (Chodzko-Zajko et al., 2009; Ludyga et al., 2016). Resistive exercises increase muscular strength and power and, as a consequence, improve physical fitness, health, and functional autonomy (ACSM, 2021; Ludyga et al., 2016; WHO, 2020). Among them, hydrogymnastics is constantly recommended for people with advanced age, reducing articular impact due to weight sustainability and diminishing social isolation resulting in symptoms of anxiety and depression. (Kruel et al., 2018; Pucci et al., 2012; WHO, 2020).

Hydrogymnastics produces positive effects on health-related quality of life, cardiorespiratory fitness, body composition, muscular strength and power, flexibility, and functional fitness of those engaging in the activity (Costa et al., 2018; Katsura et al., 2009; Kanitz et al., 2015; Reichert et al., 2015; Sodré et al., 2019; Souza Júnior et al., 2017; Tsourlou et al., 2006). Generally, gyms or health centers offer hydrogymnastics with mixed classes for men, women, young adults, middle-aged, and older adults. One of the difficulties encountered

by professionals in hydrogymnastics consists in the heterogeneity in age and physical fitness of the participants in a single session, which may lead to difficulty in selecting type and intensity of exercise, harming biological individuality (ACSM, 2021).

The use of resistive implements in hydrogymnastics allows for different acute physiological responses (Barbosa et al. 2009; Kanitz et al., 2015; Kruehl et al., 2018), and the use of elastic bands increases muscular strength and resistance in women 50-60 years old (Pinto et al., 2008). No studies have been found that tested the effect of strength training using resistive implements in hydrogymnastics on functional fitness of women of different ages. In this context, this study aimed to verify effects of strength training using resistive implements in hydrogymnastics on physical fitness of middle-aged and older women.

Materials & methods

Study design, location, and ethics

An experimental study was conducted with 15 women (45-73 years old) enrolled in a gym in a low-income neighborhood in Curitiba, Brazil. Participants were informed of the study's aim, procedures and signed a consent form. The study was approved by the Ethics Committee in Research from the Pontifical Catholic University of Parana (#2.867).

Selection of participants

The participants should be apparently healthy (ACSM, 2021), aged ≥ 45 years, with an experience of ≥ 12 months in systematic hydrogymnastics sessions (of 50-60 minutes, in a single period of the day, alternate days, three times a week) and not engage in other exercises.

Thirty women filled the criteria and were invited to participate in the study. Twenty accepted (67%) and were randomly divided into an intervention and a control group. Previously, it was established that the absence in $\geq 15\%$ of sessions or one of the assessments (pre or post) would be a reason for exclusion from the analysis. Five participants were excluded (25% of sample loss) (Figure 1).

Figure 1. Allocation flowchart showing the participants included in the intervention and control group.

Independent variable: training program

In hydrogymnastics sessions, the training program was conducted for eight weeks, in three weekly sessions, for 55-60 minutes on alternate days (48 hours interval). The sessions were conducted in a warm water pool (29°C), 1.50 meters in depth, 18 meters in length, and 12 meters in width (Kruehl et al., 2018).

Both groups had the same training program. Each session was constituted of four phases: 1) warm-up: displacement exercises (10 minutes); 2) muscular strengthening: local exercises of low and moderate intensity for larger muscle groups (20 minutes); 3) strength training: resistive exercises of high intensity (15 minutes); 4) cool-down: stretching and relaxing exercises (10 minutes).

Phase 3 included two exercises for strength training in participants' routine: crucifix and frontal kick. To certify the quality of moves, standard instructions were offered, so the participants were aware of the aim for each motor action. For the crucifix, the initial position was standing, lower limbs laterally apart, semi-flexed knees, shoulders under the water, abducted and extended upper limbs, palms facing front, and point of toes raised. At the end of the movement, the concentric phase, the participants would adduct upper limbs in transversal plane keeping articulations of the elbows extended in such way that hands are brought close together. In frontal kick, the initial position was standing, lower limbs laterally apart aligned with iliac crest and upper limbs extended alongside the body. For the concentric phase, the frontal elevation of one of the lower limbs, keeping the limb stretched.

The execution was alternated, and the exercises were conducted in four series of 12-15 repetitions, with maximum execution velocity and high intensity (ACSM, 2021; Krueger et al., 2018; Tsourlou et al., 2006). The intensity was measured with the perceived exertion scale (PES) (ACSM, 2021; Moreira et al., 2019) and participants were monitored and should perform exercises in intensities between *vigorous* and *almost maximum* (7-10 points in PES) (Chodzko-Zajko et al., 2009). An active pause of walking in low intensity was conducted between the series, lasting three minutes.

Both groups performed the exercises with the parameters previously discussed. However, to characterize strength training, the intervention group used two accessories frequently available in gyms and fitness centers for hydrogymnastics sessions. The exercise crucifix used the smile accessory in both hands (10.5 cm diameter), while the frontal kick used ankle weights (1 kg). The control group did not use accessories.

Dependent variable: functional fitness

Participants were evaluated in three visits. On the first day, measurement of weight (digital scale Urano Ps180A, 100g precision) and height (stadiometer Cardiomed®, 1 mm precision); and familiarization and adaptation to the functional fitness tests (gait speed, sit and stand on the chair, and upper-limb strength (Rikli & Jones, 1999; 2013). Tests were explained and possible questions were answered. The participants were allowed two tries in each test. On the second day (48h later), pre-training functional fitness was assessed. The third visit was 48 hours after eight weeks of hydrogymnastics training (post-training).

Participants were assessed individually in a comfortable and familiar environment in the gym; tests were conducted in a standard order, and after explaining procedures, the researcher did not exert motivational influence. The quality of functional assessment followed standards (Rikli & Jones, 1999; 2013).

Gait speed

Participants were assessed walking through a predetermined course. The participant remained seated on a chair and feet should not touch the ground. In the chair's posterior face, two cones were diagonally put within a distance of four meters from the chair and three meters from each other, forming a triangle. At the signal, the participant should touch the feet to the ground, walk as fast as possible to the cone on the left of the chair, go around it and return to the initial position. Quickly stand up again, go around the cone on the right side and go back to the chair. The course consisted of going around both cones twice. Time was measured with precision in seconds.

Agility and strength of lower limbs

They were assessed in the action of sitting and standing on a chair. The participant should remain seated on a chair (leaning on a wall), with a straight back, feet on the ground, and upper limbs crossed over the chest. At the signal, the participant should stand up, remain in a fully upright position and then go back to the initial position. Participants were encouraged to a complete sitting position as many times as possible within 30 seconds. The complete moves were then counted, as many repetitions as possible.

Strength and upper-limb resistance

The assessment included actions of extension and flexion of elbows. Participants started in a prone position, knees on the ground, back straight, lower limbs joined, and feet overlapped. Hands remained on the ground in the distance, similar to shoulders and toes forward. The movement consisted of a complete extension of elbows. The abdomen should be kept contracted during the execution to avoid curving of thighs and hips. The eccentric phase consists of elbows' flexion to the point where the chest is closed to the ground. Complete movements were performed to exhaustion and counted as many repetitions as possible.

Statistical analysis, effect size, and sample power

The data normality was analyzed using the Shapiro-Wilk test, and parametric tests were considered. Results were described with mean, standard deviation, and percent alterations ($\Delta\%$). Comparison between groups was calculated by independent sample t-test. The training effect was analyzed with two-way ANOVA for repeated measures (group and time), and Cohen's d computed effect size based on F-value (Brydges, 2019). Data were analyzed using SPSS 26.0, and the level of significance was maintained at 5%. The sample power was

calculated *a posteriori* based on effect size value using the software G*Power 3.1.1 and showed a mean power of 42% for an alpha value of 5%.

Results

Fifteen women complete all phases of the study (Figure 1 and Table 1 – age: 58.8 ± 8.2 years; weight: 68.7 ± 6.9 kg; height: 1.58 ± 0.05 meters; body mass index: 27.7 ± 3.8 kg/m²; length of experience in hydrogymnastics: 18.5 ± 1.6 months; gait speed: 0.31 ± 0.04 sec.; agility to sit and stand: 15.9 ± 1.7 rep.; strength and upper-limb resistance: 15.2 ± 6.4 rep.). There was no significant difference between groups on pre-training (Table 1).

Table 1. Descriptive characteristics of middle-aged and older women in pre-training measurements (n=15).

Variables	Intervention group (n=8)	Control group (n=7)	sig.	All
Age (years)	61.8 ± 8.3	55.4 ± 7.3	0.14	58.8 ± 8.2
Weight (kg)	68.6 ± 8.0	68.9 ± 6.1	0.95	68.7 ± 6.9
Height (m)	1.57 ± 0.05	1.59 ± 0.05	0.33	1.58 ± 0.05
Body mass index (kg/m ²)	28.1 ± 3.8	27.4 ± 4.1	0.73	27.7 ± 3.8
Experience in hydrogymnastics*	18.3 ± 1.3	18.7 ± 2.0	0.98	18.5 ± 1.6
Gait speed [#]	0.31 ± 0.04	0.31 ± 0.03	0.85	0.31 ± 0.04
Agility to sit and stand [†]	16.1 ± 1.0	15.6 ± 2.4	0.56	15.9 ± 1.7
Strength and upper-limb resistance [‡]	19.2 ± 6.9	10.6 ± 6.2	0.09	15.2 ± 6.4

sig: p-value for independent t-test, * months, [#]seconds, [†]repetitions

Both groups showed a significant improvement in gait speed, reducing time in course for a mean five seconds ($\Delta\%$: – 16%) (Table 2 and 3). For agility to sit and stand, both groups showed a significant increase in repetitions (F: 11.6; $p < 0.001$). However, no interaction was observed between time and group (F: 0.17; $p = 0.681$) (Table 2). The larger $\Delta\%$ effects were observed in strength and upper-limb resistance, in which the participants in the intervention group had a mean increase of 8.7 repetitions ($\Delta\%$: + 45%), while those in the control group practically remained unaltered ($\Delta\%$: + 1%) (Table 3). However, such a difference was not significant (F: 3.39; $p = 0.07$) but was found a difference between groups (F: 9.04; $p < 0.01$) (Table 2). The effect size was null or small for all outcome variables (Table 3).

Table 2. Effects of strength training in hydrogymnastics on middle-aged and older women (n=15).

	Intervention group		Control group		Interaction**	
	Pre	Post	Pre	Post	F	p
Gait speed [#]	0.31 ± 0.04	$0.26 \pm 0.02^*$	0.31 ± 0.03	$0.26 \pm 0.04^*$	34.3	<0.001
Agility to sit and stand [†]	16.1 ± 1.0	$18.5 \pm 2.4^*$	15.6 ± 2.4	$17.4 \pm 3.5^*$	0.17	0.681
Strength and upper-limb resistance [‡]	19.2 ± 6.9	$27.9 \pm 6.2^\dagger$	10.6 ± 6.2	10.7 ± 4.6	9.04	<0.01

* $p < 0.001$ and $^\dagger p = 0.07$ between pre-and post-test within group; **interaction term between time and group;

[#]seconds; [†]repetitions

Table 3. Absolute and relative* change (Δ), and effect size of strength training in hydrogymnastics on middle-aged and older women (n=15).

	Δ absolute			Δ relative (%)			<i>d</i>	Effect size
	IG	CG	Dif.	IG	CG	Dif.		
Gait speed [#]	– 0,05	– 0,05	0,00	– 16%	– 16%	0,0	3.256	Small
Agility to sit and stand [†]	+ 2,4	+ 1,8	+ 0,6	+ 15%	+ 12%	+ 3%	0.229	Null
Strength and upper-limb resistance [‡]	+ 8,7	+ 0,1	+ 8,6	+ 45%	+ 1%	+ 44%	1.672	Small

[#]seconds; [†]repetitions; *difference between pre-and post-test within group; Dif: difference between pre-and post-test between group

Discussion

This study sought to verify the effect of strength training using resistive implements in hydrogymnastics on functional fitness of middle-aged and older women. In this sense, the study presents original contributions once similar studies are scarce in the literature. The results showed that training provided improved functional fitness for both groups in gait speed (16%) and sit and stand ($\approx 14\%$) tests. However, the intervention group showed a sharp increase in the upper limb strength test (45%).

Functional fitness is an essential component of health in individuals with more advanced age (Chodzko-Zajko et al., 2009; Guillamón et al., 2019; Tomás et al., 2018). There is a structural and functional decrease in the physiological systems throughout the years, even in healthy individuals. Therefore, regular physical activity benefits include maintenance and functional autonomy improvement (Chodzko-Zajko et al., 2009; Tomás et al., 2018). Around 30 years of age, there is a reduction in the muscular cross-sectional area with decay in strength levels after the fourth decade of life, more prominent between 60-75 years of age, and the strength deficit is considered an essential predictor of incapacity and mortality risk (Chodzko-Zajko et al., 2009). The type II fibers

are more affected by age, and the reduction of the cross-sectional area of the muscle stands out in women (Chodzko-Zajko et al., 2009; Tomás et al., 2018).

Strength training is an important strategy to increase hypertrophy, strength, and muscular power at all ages, and the American College of Sports Medicine recommends different resistive exercises and not only those commonly referred to with weights and machines (ACSM, 2021; Chodzko-Zajko et al., 2009). An alternative would be hydrogymnastics practice (Costa et al., 2018; Kruehl et al., 2018). The activity is efficient to increase muscular strength and power (Barbosa et al., 2009; Katsura et al., 2009; Moreira et al., 2019; Reichert et al., 2015; Tsourlou et al., 2016) even though it is not a common practice (Lima et al., 2020).

In the gait speed test, both groups significantly reduced time in course by five seconds (16%). Similar results were found in studies where the effects of traditional resistance training and hydrogymnastics were evaluated. Silva et al. (2008) examined significant improvement ($\approx 7\%$) on the Timed up and go test performance in older adults submitted to a 24-week strength training. In a study by Katsura et al. (2009), participants showed significant improvement in plantar flexion, gait speed, and the same test. Similar to what was found in this study, Tsourlou et al. (2006) showed significant improvement ($\approx 20\%$) in the Timed up and go test of 12 older women submitted to a hydrogymnastics program of 24 weeks. It is important to highlight that the number of repetitions in Tsourlou et al. (2006) was similar to those found in the present study. However, the intervention period was longer. Other studies have found results that may favor and explain better performance in gait speed after some weeks of hydrogymnastics such as higher O₂ consumption (12%), increase in flexibility (11-28%), speed (2%), and gait capacity (93%) (Alves et al., 2004; Moreira et al., 2019; Reichert et al., 2015).

In the agility to sit and stand (lower limb), both groups showed significant improvement in the number of repetitions (intervention group: 15%; control group: 12%). Likewise, results were reported in the literature, varying from 6-32% (Alves et al., 2004; Pinto et al., 2008). Other studies showed that hydrogymnastics might increase agility in the 60 seconds test (83%) and the step test (22%) (Moreira et al., 2019; Reichert et al., 2015), as well as increase strength in extension (8-29%), and flexion of the knee (9-13%) and muscular power (9-32%) (Pinto et al., 2008; Reichert et al., 2015; Tsourlou et al., 2006). Pinto et al. (2008) found a significant increase of 32% in the number of repetitions in the same test after four weeks of hydrogymnastics using elastic bands in women aged 50-60. However, Alves et al. (2004) found a 6% significant increase in the number of repetitions for the same test after a program of traditional hydrogymnastics of 12 weeks.

Even though strength and upper-limb resistance did not significantly differ compared to pre-training, the intervention group showed an improvement of 45% in the arm flexion and extension test. Similar results (49%) were found by Colado et al. (2009) on the same test after 24 weeks hydrogymnastics program. The authors also concluded a significant increase in strength and muscular resistance of abdominal muscles by 64% (Moreira et al., 2019). Other studies also find a significant increase in pectoral strength, varying from 7-26% (Reichert et al., 2015; Tsourlou et al., 2006). In studies from Pinto et al. (2008) and Alves et al. (2004), the increase in elbow flexors' muscular strength was significant, in 9% and 46%, respectively. Evidence supports the affirmation that using strategies to increase intensity in resistive exercises may improve muscular strength.

One possible explanation for the muscular strength increase from hydrogymnastics practice may be the low level of participants' conditioning (Barbosa et al., 2009; Elias et al., 2012). Nonetheless, in the present study, all participants presented a minimum of 18 months of experience in the activity. Therefore, we may infer that functional fitness improvement was due to the methodological training procedures and not low levels of strength and muscular resistance (Barbosa et al., 2009).

As a limitation of this study, we may include the reduced number of participants in both groups. The final sample size is low (small sample power) so statistical analysis, and the risk of type II errors is great. However, it is important to highlight that inclusion criteria were rigorous and may have limited other women's inclusion. However, if there were an increase in participants, we hypothesize that possibly the same results would be found. Furthermore, the intervention period (eight weeks) and the number of evaluations (two - pre and post) limit a better understanding of the program's effect. In case it would be possible to follow participants for a more extended period of time (16-24 weeks) and make more assessments (every four weeks), perhaps a better explaining of functional fitness behavior would be visualized.

Conclusion

Strength training using resistive implements in hydrogymnastics sessions allows for improved functional fitness of middle-aged and older women in gait speed and muscular strength and upper-limb resistance.

The findings show implications for structured programs in hydrogymnastics. Even though regular practice improves physical and functional fitness, strength levels tend to stabilize after a certain period. Therefore, there is a need to use training strategies to provide sufficient stimuli to alter homeostasis in training. The strength training applied was well accepted by the participants; there were no complaints on exercise intensity, and the use of the PES was of easy understanding. Future studies must analyze different strength training methodologies, a larger number of participants, and longer follow-up time to verify consistency of the results.

Conflicts of interest: None

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