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ORIGINAL ARTICLE

Water-based training enhances both physical capacities and body composition in healthy young adult women

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Abstract

Purpose The purpose of this study was to determine the effectiveness of a 9 weeks aquatic training program on aerobic capacity, muscle strength, flexibility, balance and body composition in 34 healthy young adult women.

Methods Five typical water based exercises (WE) of known intensity were utilized during the classes; intensity ranged from "moderate" to "hard" according to ACSM criteria (RPE range 12–14).

Results The group physical activity level and food intake were not significantly different before and after training. A significant decrease for the skin folds sum (−4.6 %) and for %fat mass (−3.8 %) calculated according to skin folds technique was found after training. DXA regional data showed a significant increase in the fat-free mass of arms (2.4 %) and trunk (0.9 %). According to the Astrand step test, the training program led to an increase of estimated maximal oxygen uptake (14.9 %) and a decrease in sub-maximal Heart Rate (−6.9 %). A significant change in the majority of the physical capacities tested was found: abdominal and upper body muscular endurance (21 and 36 %, respectively), leg flexors and extensors maximal strength (12 and 8 %, respectively) as well as balance (34 %) all improved after training ($p < 0.05$)

Conclusions A training program based on WE of known intensity and tailored to the ACSM recommendations can significantly improve cardio respiratory fitness, muscular endurance, strength, balance and some aspects of body composition in active young adult women.

Keywords Water fitness · Aquatic exercise · Cardio respiratory fitness · Training effects

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Introduction

The selection of an appropriate physical activity (in terms of exercise mode, intensity, frequency and duration) is essential to obtain actual training effects, to avoid injuries and to ensure exercise adherence. The American College of Sport Medicine guidelines [1, 2] place a strong emphasis on the different components of physical fitness and underline how, given the specific nature of exercise adaptation, a well rounded training program should consist of aerobic, resistance and flexibility exercises.

Water-based activities (WA), in recent years, have gained popularity and are considered as one of the possible alternatives among the traditional physical activities for well-being and health [3–14]. The specific properties of water have probably encouraged this success. In particular: buoyancy reduces the effect of weight bearing on skeletal joints while the larger density of water (compared to air) provides loading during all movements. In addition, the hydrostatic pressure and the water temperature improve blood flow and favourably alter the hemodynamic responses at rest and during exercise [15–19]. Thanks to these features many people chose to perform physical activity in water rather than on land, especially people with low levels of physical fitness. These activities are often prescribed for elderly people [7, 9–11, 20–40], post-menopausal women [41, 42], subjects with orthopaedic or neurological disabilities [43–53], subjects with pulmonary disease [54–57], patients with coronary artery disease [58–60], athletes with surgically, or otherwise, treated injuries [61, 62] and obese persons [63–68]. WA are widely used also to improve the physical condition of young adult healthy individuals who regularly take part in recreational training [3, 69–71] and by athletes, as complement of training [72, 73].

The physiological and training effects of WA have indeed been investigated by several authors in different populations (especially in older adults, elderly, obese person and in subject with orthopaedic and neurological disease): some studies have examined mainly cardio respiratory factors, body composition and lipoproteins-lipids patterns [3–5, 9–11, 14, 20, 22, 28, 32, 36, 37, 42, 63, 64, 66, 68], whereas others studied mainly the resistance component of static and dynamic strength [3, 7, 25, 27, 28, 30, 32, 33, 36, 41, 43, 69, 72, 74–76] and only few studies considered other physical capacities such as flexibility [7, 10, 27, 31, 46], agility and balance [7, 28, 31, 38]. In some cases cognitive function, activity of daily living, quality of life and adherence to exercise in the aquatic environment were also considered [22, 24, 31, 32, 34, 35, 43, 49, 54, 56, 64].

However, the quantification and the control of work intensity in water remain still difficult, particularly so for aquagym, aquaerobics or callisthenics exercises (generally utilized in water fitness programs) as compared to walk, run or aqua bike, which are more easy to standardize.

Two methods to monitor exercise intensity in water are available. Colado et al. [77] showed that the exercise intensity during aquatic resistance movements can be controlled by setting the rhythm of execution and by checking the perceived effort. Raffaelli et al. [78] showed that it is possible to standardize the most common water based exercises (WE) in terms of amplitude and frequency of movement and that the intensity of exercise could be controlled by changing the type of exercise and/or the frequency of the music track. Thus, the intensity level of an aquatic fitness lesson can be predicted and the intensity of a training program could be determined and set to correspond to ACSM criteria [1, 2, 79] to maintain and improve cardiovascular fitness in a given population (e.g. young adult healthy women).

The purpose of the present study was to determine the effectiveness of a 9-week aquatic training program on aerobic capacity and body composition, in healthy young adult women. Training duration was determined based on ACSM indications (9 weeks is the minimum duration to obtain these adaptations in these subjects) [1, 2].The intensity of the WE utilized during training ranged from moderate to hard, according to ACSM criteria [1, 2, 79]. A complementary analysis of other health related physical capacities (muscle strength, flexibility and balance) was also carried out to better understand whether these WA can be considered a well rounded training program as well.

Materials and methods

Subjects

Thirty-four physically active women (26.4 ± 3.8 years; 1.63 ± 0.05 m of stature; 56.9 ± 8.3 kg of body mass; 19.7 ± 1.5 kg m^{-2} of BMI) were recruited from the Faculty of Human Movement Sciences of the University of Verona and voluntarily participated to the study (WA are mainly performed by females). The inclusion criteria were an age range between 20 and 30 years, a stature range between 1.6 and 1.7 m and a body mass index (BMI) lower than 25 kg m^{-2}. The stature was selected as an inclusion criteria to standardize, as much as possible, the water level for all subjects.

The participants were instructed not to modify their physical activity level and diet for the duration of the study; all completed the study.

All participants received written and oral instructions before the study and gave their informed consent to the experimental procedure. The experimental protocol was approved by the Institutional Review Board.

Procedures

The International Physical Activity Questionnaire (IPAQ) was compiled before and after training to monitor the physical activity level of the participants; an alimentary diary was also compiled to monitor the changes in food intake before and after training.

Body composition and regional fat distribution was investigated based on measures of body stature, body mass, skin folds and selected anatomical circumferences as well as by means of total body of dual-energy X-ray absorptiometry (DXA). These measurements will be described in detail below.

Physical capacities were assessed by means of the following tests: astrand step test for aerobic capacity; sit-up and push-up tests for muscular endurance; leg-curl, leg-extension and pectoral machine tests for maximal strength; flamingo balance test for balance; sit and reach test and back stretch test for flexibility.

The participants were familiarized with each test and their performance was continuously checked, and eventually corrected, by two experienced trainers. The tests were performed at the same time of day, in the same environment and in the same order during the pre-training and post-training session with 20 min recovery in between. During each test, the subjects were verbally encouraged to perform maximally. These tests will be described in detail below.

Each subject performed the tests 1 week before training and 1 week after training. Training was carried out twice a week in a swimming pool (water depth: 1.2 m; water temperature: 28 °C) for 9 weeks. At the end of each training session the subjects were asked to report their rate of perceived exertion by means of the Borg Scale [80].

Anthropometric measurements

Body height to the nearest 1 mm was measured using a wall-mounted stadiometer (Holtain Limited, UK), body mass was measured to the nearest 0.1 kg using an electronic scale (Tanita electronic scale BWB-800 MA, Wunder SA.BI. Srl) and the body mass index was calculated from these data (BMI = body mass (kg)/height (m^2)).

The selected anatomical circumferences (arm, wrist, waist, hip, calf and thigh) were measured to the nearest 0.1 cm using anthropometry tapes. In total, eight skin folds (triceps, sub-scapular, chest, abdominal, front thigh, medial calf, supra iliac and mid-axillary) were measured using a skinfold caliper (type Harpender—GIMA), on the right side of the body, while the participant was standing with arms by her sides. All measurements were carried out by the same trained examiner under identical environmental conditions. The average of two trials was used for further analysis and, when the measurement differed by more than 1.0 mm, a third measurement was obtained and the mean value was utilized.

Total body and regional composition (lean mass, fat mass, and mineral mass) was evaluated by means of dual-energy X-ray absorptiometry (DXA) using a total body scanner (QDR Explorer W, Hologic, MA, USA; fan bean technology, software for Windows XP version 12.6.1) according to the manufacture's procedures. The percentage of fat-free mass from DXA was calculated as the sum of lean tissue mass and bone mineral content; the percentage of body fat was calculated as the ratio of fat tissue to body weight.

In addition, percent fat mass was assessed based on measurements of skin folds: the sum of seven skin folds (triceps, sub-scapular, chest, abdominal, front thigh, supra iliac and mid-axillary) was used to assess body density according to Jackson and Pollock [81], while percent fat mass was calculated on the basis of body density according to Siri [82].

Physical capacities tests

The Step Test was used to estimate aerobic capacity. The subjects were asked to step up and down a bench (bench height: 33 cm) with a cadence of 22.5 beats per minute for 3 min: during this period the heart rate (HR) was recorded. Oxygen consumption was estimated based on the ACSM stepping equations [79]. Finally, maximal oxygen consumption ($V'O_{2max}$) was calculated on the basis of the Astrand-Rhyming Nomogram equation [83].

The sit and reach test was used to test trunk flexion (the flexibility of the lower body) and was performed according to ACSM instructions [79]. The distance between the fingers and the vertical surface of the box at full stretch was measured (if the subject cannot reach the toes, a negative score was recorded) and the best of three trials (distance, cm) was recorded.

The Back Stretch test was used to assess upper-body (shoulder) flexibility and was performed according to Morrow et al. [84]. The test's score was the distance (cm) of overlap or the distance between the tips of the middle fingers. The best of three trials was recorded.

The Sit-Up test was used to assess abdominal endurance and the Push-Up test was used to assess upper-body endurance. Both tests were performed according to Morrow et al. [84]: the test's score was the total number of correct repetitions.

The exercises chosen to assess maximum dynamic strength were: leg-extension, leg-flexion and adduction of arms (leg-curl, leg-extension and pectoral machine—Personal Selection TUV, Technogym, Italy); the method utilized was the One Repetition Maximum (1-RM): the subjects started from a workload that they could move up to 5/6 times; the workload was gradually increased to the load that could be moved one-time only: the test's score was this final load.

The Flamingo Balance test was used to assess balance capacity. In our case the test was modified as proposed by Zurc et al. [85]. The test's score was the time passed from the start to the moment the bent leg touched the floor; maximal duration of the test was set to 1 min.

Training Program (in the swimming pool)

Each subject underwent a training program two times a week for 9 weeks. Each lesson lasted for 45 min: the program consisted of a 10 min of warm-up, 30 min of workout and 5 min of cool-down; each session was led by trained fitness instructors. The frequency of training (twice a week) was the most convenient for our participants and was also choose to avoid dropouts.

Five typical water based exercises (WE), commonly utilized during water fitness activities (without specific equipment, such as aquagym and aquaerobics), were utilized during the classes [78]:

1. "Running on the spot raising the knees high" (S)
2. "Jumping on the spot moving the legs sideways (in the frontal plane)" (SJ)

3. "Jumping on the spot moving the legs backward and forward (in the sagittal plane)" (FJ)
4. "Alternate forward kicks (in the sagittal plane)" (FK)
5. "Alternate sideways kicks (in the frontal plane)" (SK).

These exercises were performed at different frequencies (corresponding to different music tracks): $F_1 =$ 110–120 bpm; $F_2 =$ 120–130 bpm; $F_3 =$ 130–140 bpm (corresponding to 1.8–2.0, 2.0–2.17 and 2.17–2.33 Hz, respectively). Every leg movement (e.g. raising the leg or lowering the leg, in the skip) corresponded to a sound beat. These frequencies were selected because the most frequently utilized in the music tracks that accompany WA. Participants were verbally encouraged to maintain the correct movement amplitude and frequency.

During training, the warm up and cool down phases were carried out asking the subjects to perform a specific combination of S, SJ and FJ at F1 and SJ and FJ at F2. As indicated by Raffaelli et al. [78] this combination of exercises and frequencies correspond, for subjects of this age and fitness level, to a "light" intensity level (20–39 % of $V'O_{2max}$) according to ACSM classification [2]. The 30 min of workout were carried out using mainly FK and SK. These exercises can indeed be considered as "moderate" (40–59 of $V'O_{2max}$) when performed at F_1 and F_2 and as "hard" (60–84 of $V'O_{2max}$) at F_3. In the workout phase we also used S, SJ and FJ exercises but at higher frequencies (F_2 and F_3) than during the warm up and cool down phases since, at these frequencies their intensity becomes "moderate" (40–59 of $V'O_{2max}$) as indicated by Raffaelli et al. [78].

As indicated by Table 1, were the training schedule is schematically represented, the warm up and cool down phases were always the same. On the contrary the workout was progressively increased: during the first 2 weeks the intensity was always "moderate", form the third to the fifth week the intensity ranged from "moderate" to "hard" while during the last 4 weeks the intensity was always "hard". As indicated by Table 1, during training the participants worked at about 20–39 % of their $V'O_{2max}$ during warm up and cool down and at 40–84 % of $V'O_{2max}$ during the workout. This level of intensity should, according to ACSM guidelines [2], maintain and improve cardiovascular fitness in subjects of this age and physical capacity level.

Statistical analysis

Data are presented as mean ±1 standard deviation (SD). Percent changes (before to after) were calculated as well. Normality of distribution was assessed for each variable with the Shapiro–Wilk test. Normally distributed variables were compared (pre-post training) by means of a parametric test (two-tailed paired Student's test), otherwise a non-parametric test (Wilcoxon Signed Rank Test) was applied; the level of significance was set at $p < 0.05$. Statistical analysis was performed by using SigmaStat 3.5.

Results

The group attendance to training was about 93 %. The study was completed without any case of injury. The group's physical activity level (see Fig. 1) and food intake were not significantly different ($p < 0.05$) before and after training.

The IPAQ questionnaire results showed that 83 % of participants in the study was moderately active (from 700 to 2500 METs min week$^{-1)}$ or active (over 2500 METs min week^{-1}) whereas 17 % was not sufficiently active (less than 700 METs min week^{-1}). Also these subjects, however, performed moderate physical activity at least twice a week for at least 30 min.

Anthropometric measurements

A significant decrease was found for the majority of the selected skin folds and circumferences (see Table 2) after training: even when the changes were not significant, the trend was towards a decrease (except for hip circumference). Indeed, a significant decrease in skin fold sum and % fat mass (calculated according to these measurements) was found after training (see Table 3).

The total body DXA data indicated no significant changes after training even if the trend was for a decrease, in agreement with what found for the anthropometric measures (see Table 3). On the other hand, the DXA regional data showed a significant improvement in the fat-free mass of arms and trunk (see Table 3).

Physical capacities tests

RPE was measured every training session in all subjects: the average values (±1 SD) are reported in Fig. 2 which shows that perceived exertion was in the 12–14 range for the entire duration of training (from moderate to hard) in line with ACSM recommendations.

Submaximal HR during the step test and estimated maximal oxygen consumption changed significantly after training: HR decreased from 146.7 ± 15.3 to 136.5 ± 12 bpm (Δ % = −6.9, $p < 0.001$) and $V'O_{2max}$ improved from 47.3 ± 9.1 to 54.3 ± 8.8 mL min^{-1} kg^{-1} (Δ % = 14.9, $p < 0.001$) from the first to the ninth week of training (see Fig. 3).

Table 1 A general overview of the training program

Week	Training program					
	Warm-up (10 min) and cool down (5 min)			Workout (30 min)		
	Exercise type and movement frequency	Relative intensity (%$V'O_{2max}$)	Target ACSM	Exercise type and movement frequency	Relative intensity (%$V'O_{2max}$)	Target ACSM
I	SJ,F1-FJ,F1	31	Light	SJ,F3-FJ,F3	43	Moderate
	S,F1-SJ,F2-FJ,F2	37		S,F2	45	
				FK,F1-SK,F1	47	
				S,F3	54	
				FK,F2-SK,F2	56	
II	SJ,F1-FJ,F1	31	Light	SJ,F3-FJ,F3	43	Moderate
	S,F1- SJ,F2-FJ,F2	37		S,F2	45	
				FK,F1-SK,F1	47	
				S,F3	54	
				FK,F2-SK,F2	56	
III	SJ,F1-FJ,F1	31	Light	SJ,F3-FJ,F3	43	Moderate
	S,F1-SJ,F2- FJ,F2	37		S,F2	45	
				FK,F1-SK,F1	47	
				S,F3	54	
				FK,F2-SK,F2	56	
				FK,F3-SK,F3	63	Hard
IV	SJ,F1-FJ,F1	31	Light	S,F3	54	Moderate
	S,F1-SJ,F2- FJ,F2	37		FK,F2-SK,F2	56	
				FK,F3-SK,F3	63	Hard
V	SJ,F1- FJ,F1	31	Light	S,F3	54	Moderate
	S,F1-SJ,F2- FJ,F2	37		FK,F2-SK,F2	56	
				FK,F3–SK,F3	63	Hard
VI	SJ,F1- FJ,F1	31	Light	FK,F3-SK,F3	63	Hard
	S,F1- SJ,F2 -FJ,F2	37				
VII	SJ,F1-FJ,F1	31	Light	FK,F3-SK,F3	63	Hard
	S,F1-SJ,F2-FJ,F2	37				
VIII	SJ,F1-FJ,F1	31	Light	FK,F3-SK,F3	63	Hard
	S,F1-SJ,F2- FJ,F2	37				
IX	SJ,F1-FJ,F1	31	Light	FK,F3-SK,F3	63	Hard
	S,F1-SJ,F2- FJ,F2	37				

S: "running on the spot raising the knees high"; SJ: "jumping on the spot moving the legs sideways (in the frontal plane)"; FJ: "jumping on the spot moving the legs backward and forward (in the sagittal plane)"; FK: "alternate forward kicks (in the sagittal plane)"; SK: "alternate sideways kicks (in the frontal plane)"; F_1 = 110–120 bpm; F_2 = 120–130 bpm; F_3 = 130–140 bpm

Before and after training there was also a significant change in the majority of the physical capacities tested: muscular endurance, maximal strength and balance all improved after the training program. On the contrary, flexibility wasn't improved after the training program (see Table 4).

Discussion

The purpose of the present study was to determine the effectiveness of a 9 weeks aquatic training program on aerobic capacity, muscle strength, flexibility, balance and body composition in healthy young adult women with the aim to understand if WA, standardized in terms of exercises intensity, can be considered a well rounded training program. To this purpose we choose to utilize filed tests that can be easily reproduced by water fitness teachers.

The high adherence to the study suggests that aquatic exercise training is well tolerated by these subjects; this type of physical activity seems to facilitate adherence to training and to limit dropouts. Indeed our RPE data (range 12–14) are in line with the target value associated with high adherence to training as indicated by ACSM [2]. High adherence to a water-based training program was found

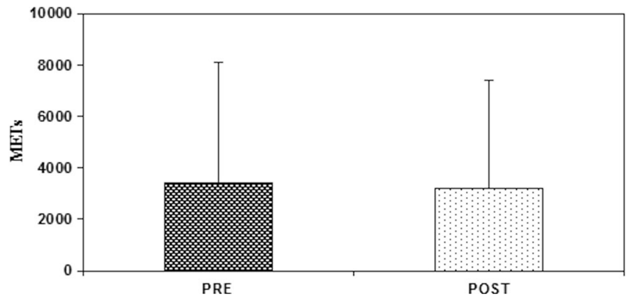

Fig. 1 Physical Activity Levels (MET min wk$^{-1)}$ before (pre) and after (post) training; bars represent 1 SD

also by Mc Namara et al. [54] in people with chronic obstructive pulmonary disease. These authors have shown that six factors were highly rated to exercise adherence: staff support, enjoyment, sense of achievement, noticeable improvements, personal motivation and participant support.

The physical activity level of the subjects was over the range of 450–750 METs min week^{-1} which is indicated as the minimal value for this population [1]; according to the replies received in the questionnaires, the participants' lifestyle patterns (which include physical activity levels and dietary intakes) did not seem to have changed throughout the training period. It is therefore fair to assume that the pre to post differences can indeed be attributed to training itself. This is in line with previous studies showing that, in healthy young active women, physical capacity and body composition do not change in such a short period of time (9 weeks) unless there are important changes in food intake and/or physical activity level [65, 86].

Anthropometric characteristics

In this study no significant changes in body mass were recorded (with both measurement techniques). This result is in agreement with Rica et al. [64], Takeshima et al. [10], Bocalini et al. [36] and Broman et al. [37] who did not find changes in body mass after a water-based training program. On the contrary, Volaklis et al. [87] and Gappmaier et al. [68] did found significant decreases in body mass (1.7–2.0 and about 6 %, respectively) as well as Greene et al. [66]. The regional DXA data, however, showed a significant increase of fat-free mass for trunk and arms in line with other studies that found a significant increase in fat free mass after water resistance training [20, 66, 69, 74].

Our training program revealed adaptations on body composition as assessed with anthropometric measures (skin folds and circumferences) and DXA regional data. Anthropometric techniques do not estimate body composition per se but are an excellent indicator of subcutaneous adiposity. For these parameters (skin folds and circumferences, see Table 2) our data are in line with the results of Takeshima et al. [10], Volaklis et al. [87] and Gappmaier et al. [68] that found a significant decrease in skin fold sum after aquatic training.

While % fat mass assessed by skin folds was decreased after training in agreement with Gappmaier et al. [68],

Table 2 Effects of training on the anthropometric characteristics of the subjects

	Pre	Post	% Change	p	95 % IC
Skin folds (mm)					
Triceps	17.6 ± 5	15.9 ± 4.8	−9.2 ± 11.9	0.000	0.863 to 2.381
Sub-scapular	10.4 ± 4.3	10.1 ± 4.2	−2.5 ± 7.7	0.108	–
Chest	8.8 ± 3.6	8.4 ± 3.2	−4.6 ± 18.8	0.175	–
Abdominal	18.1 ± 7.9	17.1 ± 6.7	−5.9 ± 12.5	0.048	n.p.
Front thigh	26.4 ± 6.6	25.2 ± 6.5	−4.5 ± 9.5	0.011	0.292 to 2.096
Medial calf	15.3 ± 3.8	14.7 ± 3.7	−3.4 ± 8	0.040	n.p.
Supra-iliac	14.5 ± 6.6	14.3 ± 6.4	−1.2 ± 10.5	0.517	–
Mid-axillary	8.5 ± 4.2	8.4 ± 4.2	−1.3 ± 10.6	0.475	–
Circumferences (cm)					
Arm	25.6 ± 2.7	25.1 ± 2.4	−1.7 ± 3.3	0.014	n.p.
Wrist	14.9 ± 0.6	14.8 ± 0.6	−0.4 ± 1.7	0.241	–
Waist	68.3 ± 6.1	67.8 ± 6	−0.8 ± 1.6	0.009	0.150 to 0.956
Hip	93.7 ± 17.9	96.3 ± 5.5	2.7 ± 20.2	0.696	–
Calf	34.4 ± 2.2	34.3 ± 1.9	−0.4 ± 2.5	0.344	–
Thigh	50.6 ± 3.5	49.6 ± 3.1	−1.9 ± 2.6	0.000	0.521 to 1.467

Data are mean ± 1 SD. In the last column are reported the 95 % IC of the paired Student's t test (for $p < 0.05$) and it is indicated whether a Wilcoxon Signed Rank Test was utilized instead (non-parametric test: n.p.)

Table 3 Effects of training on body composition

	Pre	Post	% Change	p	95 % IC
Skin fold technique					
Sum of skin folds (mm)	104.3 ± 34.7	99.5 ± 32.1	−4.6 ± 7.7	0.002	0.945 to 7.736
Fat mass (%)	19.5 ± 5.2	18.7 ± 4.8	−3.8 ± 6.5	0.002	0.283 to 1.198
Body mass (kg)	56.9 ± 8.3	56.6 ± 8.1	−0.5 ± 2	0.176	–
DXA					
Total mass (kg)	56.4 ± 8.2	56.2 ± 8	−0.2 ± 0.5	0.903	–
Total fat mass (kg)	16.3 ± 5.6	16 ± 5.5	−1.6 ± 6.9	0.495	–
Total fat-free mass (kg)	38 ± 3.9	38.1 ± 3.8	0.3 ± 2.2	0.384	–
Fat mass (%)	28.4 ± 5.5	28.0 ± 5.5	−1.4 ± 5.7	0.166	–
Trunk fat-free mass (kg)	19.2 ± 2	19.4 ± 2	0.9 ± 2	0.037	−33.04 to −10.92
Arms fat-free mass (kg)	1.74 ± 0.2	1.79 ± 2	2.4 ± 0.5	0.005	−70.39 to −13.64
Legs fat-free mass (kg)	6.3 ± 0.7	6.2 ± 0.7	−1 ± 2.2	0.138	–

Data are mean ± 1 SD. In the last column are reported the 95 % IC of the paired Student's t test (for $p < 0.05$)

DXA: total body densitometry (DXA Hologic QDR Explorer W, Fan Beam technology)

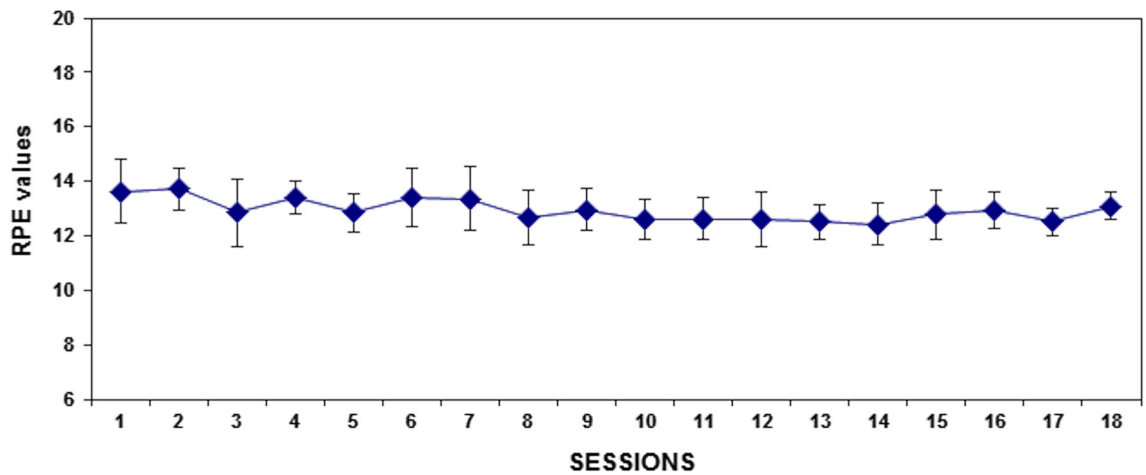

Fig. 2 RPE average values (bars represent 1 SD) during the eighteen training sessions (9 weeks, two sessions per week)

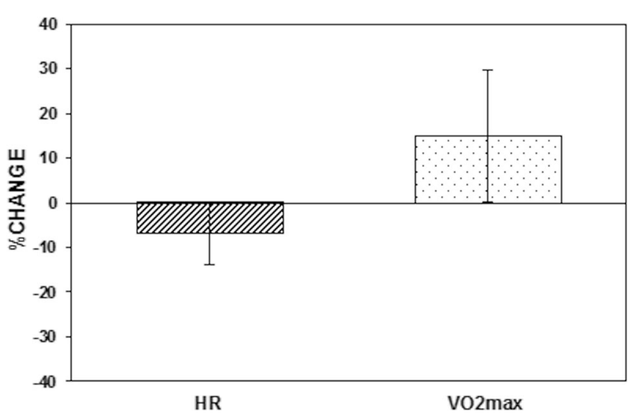

Fig. 3 Percentage changes (pre-post training) of sub-maximal Heart Rate (*black column*) and estimated Maximal Oxygen Consumption (*white column*) as assessed by means of the Astrand step test; *bars* represent 1 SD

Colado et al. [69], Greene et al. [66], Bergamini et al. [28], Kasprzak et al. [63] and Irandoust et al. [20], % fat mass assessed by DXA showed only a decreasing trend. Moreover, the values of % fat mass assessed by means of skin folds measurements were found to be substantially lower than those assessed by means of DXA.

This difference was previously reported by Peterson et al. [88], Silva et al. [89] and España-Romero et al. [90] who examined the accuracy of the existing equations to estimate percent body fat (such as the Jackson and Pollock's equation utilized in this study); these authors have indeed shown that % fat mass assessed by means of anthropometric measurements is underestimated when compared to the three or four-compartment model, as found in our study. In general terms, the studies that compared body composition measurements using DXA,

Table 4 Effects of training on physical capacities

Test	Pre	Post	% Change	p	95 % IC
Muscular endurance					
Sit-up (N of repetitions)	37.6 ± 26.6	45.4 ± 29.9	20.8 ± 44.6	0.004	n.p.
Push-up (N of repetitions)	23.5 ± 13.1	31.9 ± 15.4	35.9 ± 36	0.000	−11.39 to −5.49
Maximal strength					
Leg-curl (1 RM)	32.6 ± 7.5	36.5 ± 7.6	11.9 ± 15.9	0.000	n.p.
Leg-extension (1 RM)	43.8 ± 14.9	47.5 ± 16.9	8.5 ± 25.2	0.036	n.p.
Pectoral machine (1RM)	15.4 ± 4.3	17.4 ± 6.2	12.9 ± 33.8	0.051	n.p.
Balance					
Flamingo balance (s)	28.4 ± 22.7	42.8 ± 22.7	33.9 ± 91	0.049	n.p.
Flexibility					
Sit and reach (cm)	6.5 ± 7.6	5.9 ± 9.4	−8.6 ± 104.9	0.613	–
Back stretch (cm)	8 ± 5.9	7.7 ± 4.2	−4.36 ± 67.2	0.318	–

Data are mean ± 1 SD. In the last column are reported the 95 % IC of the paired Student's t test (for $p < 0.05$) and it is indicated whether a Wilcoxon Signed Rank Test was utilized instead (non-parametric test: n.p.)

BIA (Bioelectrical Impedance) and skinfold measurement techniques in children and in adults [91–93], have consistently shown that body composition estimates are highly dependent on the method utilized: these results therefore underline the importance of using the same method when comparing data before and after training.

Our data suggest that 9 weeks of aquatic training are not sufficient to modify total body mass in our population. Despite this, small changes in body composition (especially for subcutaneous adiposity and for the lean tissue of trunk and arms) and a decreasing trend for all investigated body composition parameters (as assess by both methods) were observed after training.

Physical capacities test

The duration of our training program was of 9 weeks. The ACSM guidelines [2] indicate that a 15–20 weeks training may be an adequate minimum standard to evaluate the efficacy of exercises of various intensities, frequencies, and durations on fitness variables. However, these guidelines also indicate that to evaluate the time course of adaptations to training, shorter training programs such as the one of our study, may suffice.

The physical capacity tests we utilized are filed tests that can be easily reproduced by any water fitness teacher to evaluate the training effects of their program.

Aerobic capacity

The majority of the data published in the literature about water fitness training (from 8 to 12 weeks) show increases in $V'O_{2max}$ similar to the ones reported in this study (about 15 %). Our results are in line with data reported by Pinto et al. [3], Greene et al. [66], Bocalini et al. [32], Ruoti et al. [40], Tauton et al. [94], Takeshima et al. [10] and Broman et al. [37] who found an improvement in $V'O_{2max}$ of 10–15 %. In comparison with our study, Chu et al. [60] and Bocalini et al. [36] found larger (22 and 42 % respectively) and Cider et al. [95] lower (6 %) gains in $V'O_{2max}$ after water fitness training. Other studies [55, 57, 64] investigated the changes in "aerobic capacity" after water-fitness training finding improvements in this parameter; a direct comparison with our results is, however, difficult because, in those papers, the change in aerobic capacity (e.g. $V'O_{2max}$) was not directly measured, but estimated based on the outcome of a 6-min walking test.

As far as data of HR are concerned, the majority of the studies reported in the literature analyse changes in resting heart rate, rather than in sub maximal heart rate but for Broman et al. [37] who found a decrease in sub maximal heart rate (3 %) after training comparable to the one reported in our study (6.7 %).

It is worth noting that all the above cited papers refer to elderly subjects [10, 32, 36, 37, 40, 60, 64, 94], to people with chronic obstructive pulmonary disease [55–57], to obese older women [64] or to physically inactive overweight and obese adults [66], and/or to subjects with chronic heart failure [95] or chronic stroke 60]. Only Pinto et al. [3] investigated the change in aerobic capacity in young women. Our data therefore extend this body of knowledge to young adult female subjects and indicate that this kind of activity is suitable to improve cardiovascular fitness in physically active subjects too.

Muscular endurance and strength

The muscular endurance and strength test utilized in this study to assess the effects of training were similar to the movements that were practiced during the training itself and the effectiveness of these tests to assess functional mobility has been well established [79, 96]. Moreover, these tests were selected because suitable for different populations, because they can be performed outside the laboratory without expensive and sophisticated equipment and because they allow to assess (although indirectly) health related physical capacity.

Generally, when the training's aim is to improve strength, aquatic resistance devices or elastic bands are used to modulate drag force [7, 10, 69, 74, 76]. In our study we utilized the frequency of movement as a "resistance device" (hydrodynamic resistance indeed increases with the square of the speed of movement) and hence our training was standardized both in terms of exercise intensity (%$V'O_{2max}$) and in terms of hydrodynamic resistance.

On this line of reasoning it seems possible to compare data reported in the literature about water resistance training with the results obtained in this study. Our results indicated that 9 weeks of aquatic training increased abdominal and upper body muscular endurance by 21 and 36 %, respectively. These improvements are in line with the results reported by Ruoti et al. [40] whereas Colado et al. [74] found higher improvements of abdominal and upper body muscle endurance (28 and 50 %, respectively); the training period of that study, however, was about three times longer than ours (24 vs. 9 weeks). On the contrary, Tauton et al. [94] did not found any significant change before and after training for muscular endurance data.

In our study, maximum dynamic strength was assessed by means of the method of One Repetition Maximum (1-RM) and improved by 12 % for leg flexors ($p = 0.000$), 8 % for leg extensors ($p = 0.036$) and 13 % for pectoral muscles ($p = 0.051$) after training. These results are in line with Tsourlou et al. [7], who found an improvement of dynamic strength in leg-extension (29.4 %), leg press (29.55 %) and chest press (25.7 %) and with Pinto et al. who found an improvement in lower body 1RM both in postmenopausal women [41] and in young women [71]. Our results are also comparable with data reported by Colado et al. [69] who found significant improvements in maximal strength of the upper limbs assessed by vertical row, horizontal bench press, horizontal bench row, arm lateral raise (3.7 %, on the average), with data reported by Volaklis et al. [87] who found an improvement of total strength assessed by bench press, pull down, seated row, leg extension and hamstring curl (12.8 %, on the average) and with data reported by Oh et al. [27] who found a significant improvement for strength of hip abduction and adduction. In line with these results, Bento and Rodacki [25] and Rica et al. [64] reported an improvement in maximal dynamic strength while Bergamini et al. [28] reported that water-based training was beneficial only in maintaining knee-extension strength. Finally, Graef et al. [33] showed that a significant increase in maximal 1RM can be obtained only when the exercise load can be accurately determined and administered.

In the literature, maximum strength is also evaluated by means of different methods, e.g. by measuring the peak isometric torque; peak torque of knee extension and flexion was shown to improve significantly after aquatic training [7, 10, 25, 30, 41, 60, 71, 76]. These data are therefore in agreement with our findings and indicate that aquatic training produces significant effects on muscular endurance and strength.

It is worth remarking that most data published in the literature about the effects of water exercise on endurance and muscle strength refer to older subjects [7, 10, 25, 27, 28, 30, 33, 40, 64] or postmenopausal women [41, 74], to subjects with chronic heart failure [87] or chronic stroke [60] and that only few papers [3, 69, 71, 76] refer to fit young subjects. Our data therefore extend this body of knowledge to young adult female subjects and indicate that this kind of activity is suitable to improve neuromuscular performance in physically active subjects too.

Flexibility

Data reported in this study did not show any significant improvement in lower and upper body flexibility in line with the results of Oh et al. [27] and of Taunton et al. [94]. Other studies have shown a significant improvements of this physical capacity after aquatic exercise training: Sanders et al. [26] found a significant improvement in flexibility (8 %) as Sato et al. [31] who presented similar data. Takeshima et al. [10] found a significant change in trunk extension (11 %) whereas Bergamini et al. [28], Tsourlou et al. [7], Bocalini et al. [36] and Colado et al. [74] found an improvement of lower body flexibility (from 11 to 44 %) and upper body flexibility after training. In other papers [e.g. 46, 47] statistically significant differences after water training are reported but, in these cases, the range of motion and not flexibility is considered. The lack of differences observed in our study could be attributed to the fact that, unlike the above cited studies, we did not use specific flexibility exercises during training.

Balance

Our results showed significant improvements in balance (33 %, $p = 0.049$). It is quite difficult to compare this finding with those from other studies [e.g. 7, 21, 26, 28, 36, 38, 60] where functional mobility, agility and fear of falling were assessed instead of balance (balance is, however, a strong component of these parameters) but our findings are in line with those of Sanders et al. [26], Devereux et al. [38], Fisken et al. [43], Tsourlou et al. [7] and Bocalini et al. [36]. Bento et al. [21] and Bergamini et al. [28] founded improvements after training only for dynamic balance. On the contrary, in the paper of Chu et al. [60], no improvement was reported in this parameter; in their study balance was assessed by the 14-item Berg Balance Scale (that measures balance while a person is sitting, standing or stepping). However, the balance assessment is highly dependent on the method utilized so, it seems difficult to compare data obtained from different tests.

Limitations of this study

This is a pre-test, post-test single group design; no control group was recruited. As discussed in the literature (e.g. Micallef [97]) there are some advantages in using a single group instead of a double group design since non-active participants (control group) could loose interest and drop out or develop a competitive attitude against the intervention group ("compensatory rivalry"). Moreover, a within subjects analysis has the advantage that subjects act as their own controls. At this regard, we carefully checked that no changes in physical activity of daily living (physical activity level) and in food intake occurred during training. These parameters have been measured/estimated by means of the IPAQ questionnaire and the alimentary diary and, since no pre to post differences were observed in these parameters the effects of training could indeed be attributed to training itself.

Conclusions

Our results indicate that a training program based on water exercises of known intensity and tailored to the ACSM recommendations, can significantly improve cardio respiratory fitness, muscular endurance and strength as well as balance and some aspects of body composition in active young adult women. In addition, the high adherence to our protocol seems to indicate that this type of physical activity is well tolerated by this population of subjects even if the specific properties of medium make it particularly suitable for elderly people and person with orthopaedic and neurological disease. On the basis of our findings, WA of known intensity (from moderate to hard) can indeed be considered a well rounded training program to improve health related aspects of physical fitness in healthy subjects as well.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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