Training in a shallow pool: Effect of upper body strength *International SportMed Journal*, Vol.12 No.1, 2011, pp.17-29
Available at URL: http://www.ismj.com

ISMJ

International SportMed Journal

Original research article

Training in a shallow pool: Its effect on upper extremity strength and total body weight in postmenopausal women

[1*]Associate Professor María Carrasco Poyatos, PhD, [2]Professor Manuel Vaquero Abellán, PhD

[1] University of Murcia, Department of Physical Activity and Sports, Spain

***Corresponding author. Address at the end of text.**

Abstract

Background: The decrease in muscle mass and muscular strength and the increase in total body weight have significant implications for the health and functioning of postmenopausal women. Exercising in water has become increasingly popular as a means of delaying the physiological decline associated with age in middle-aged and older women. **Research question:** Is a 12-month aerobic and resistance water training program in a shallow pool effective in increasing muscle strength and decreasing total body weight in postmenopausal women? **Type of study:** Randomised controlled study. **Methods:** Thirty-eight subjects were randomly assigned to an exercise group (EG; n = 21) and a control group (CG; n = 17). The exercise group enrolled in a systematic aerobic and resistance training programme for 12 months performed at a frequency of 2 sessions per week, 45 minutes per session. Upper-extremity biokinetic strength and body mass index (BMI) were measured before and after the intervention. CG participants were physically active. **Results:** EG participants improved significantly ($p \leq 0.05$) in mean force (MF: 7.92%), mean power (MP: 9.08%) and mean work (MW: 9.3%). Mean stroke length decreased significantly ($p \leq 0.05$) in EG (-5.68%) and in CG (-11.5%). BMI was also significantly decreased ($p \leq 0.05$) in EG participants (-2.75%). **Conclusions:** These results indicate that training in a shallow pool has significant implications for improving upper extremity muscular strength and total body weight in postmenopausal women. **Keywords:** water training, shallow pool, post menopause, muscular strength

***Associate Professor María Carrasco Poyatos, PhD**

Dr Carrasco is an Associate Professor of Physical Activity in Older People and Prescription of Physical Activity for Health at the Faculty of Sports Sciences, University of Murcia (Spain). Her research is focused on physiological, morphological and health-related aspects of exercise, especially for older people. She is part of the research group Physical Exercise and Human Performance (University of Murcia. Spain).

Professor Manuel Vaquero Abellán, PhD

Dr Vaquero is a Professor at the Faculty of Nursing, University of Córdoba (Spain). His main research interests are focused on labour epidemiology and the effects of physical activity on improving worker health.
Email: mvaquero@uco.es

Introduction

After the menopausal process, women experience a significant decrease in muscle mass and muscular strength [1, 2, 3]. A lower resting metabolic rate and increased total body fat are also associated with natural menopause [4, 5]. Neuromuscular changes lead to mobility impairment, functional decline, and a propensity to falls and bone fractures [6, 7].In addition, the performance of daily tasks can become a challenge, for example, housework, shopping, using public transportation, carrying groceries, and climbing stairs. The combination of less muscle mass and hormonal changes after menopause slows metabolism and an increase in total body fat may be accelerated. Therefore the decrease in muscle mass and muscular strength and the increase in total body fat have significant implications for the health and functioning of postmenopausal women which can in turn lead to chronic disease and geriatric syndromes, such as mobility impairment, falls, frailty and functional decline.

Exercising in water has become increasingly popular, and it has been reported that water exercise can be therapeutically beneficial because of the dual effects of buoyancy and resistance provided by water. It creates an environment that requires high levels of energy expenditure with relatively low movement or strain on the upper and lower body extremities. Many water exercise programmes based on calisthenics or aerobic and resistance training have been implemented to assist middle-aged and older women with age-related decline in muscle strength. In some of these only lower body muscle strength was analyzed [8, 9] while in others, either upper or lower body muscle strength was included, with reference to total body weight or body fat [10, 11, 12, 13, 14].

The studies where upper body muscle strength was analyzed were designed to be used only for a relatively short period of time (between 8- to 24 weeks) with weekly sessions of 1-hour each ranging between 3 to 5 days. All of them used a moderate-to-high-intensity scale that ranged from 60% to 80% of maximal heart rate. In Colado et al [10], intensity was measured using a perceived exertion scale (OMNI resistance exercise scale), setting the training intensity between 5-7 points in an overall range of 0 to 10 points. These programmes fulfilled the recommendations of the American College of Sports Medicine (ACSM), and the American Heart Association (AHA) to improve muscular strength and endurance in men and women of all ages, including moderate-to high-intensity resistance training performed 2 to 3 days per week for between 3 to 6 months [15, 16]. In relation to the exercise programmes, a resistance training with aquatic resistance devices [10,12] and resistance training combined with endurance-type exercise [11, 13, 14] were undertaken. Although the design and the testing procedures were slightly different between the studies, these exercise programmes have demonstrated that when following the recommendations to improve muscular strength and endurance, water training can improve upper body muscle strength in middle-aged and older women. However considerable variation in their results was found with respect to body weight or body fat. No changes in total body weight were found in all of them, whereas total body fat decreased significantly only in Colado et al [10]. This may mean that a long-term exercise programme is necessary to provide positive results in total body weight when training in water.

To complement this information, the design of the present study was based on a long-term (12 months) aerobic and resistance water training programme in a shallow pool with postmenopausal women undertaken only 2 days per week, at 45 minutes per session. These authors hypothesise that there will be a significant increment in upper-extremity muscle strength because the programme has been designed to take the abovementioned recommendations to improve muscular strength and endurance into consideration, and because specific aquatic resistance devices will be used to assist in upper-extremity training. A significant decrease in total body weight was also expected owing to the aerobic component of training carried out over a long period of time.

Methods

Participants

Sixty-four postmenopausal women (n=64) were recruited for this study. They were volunteers recruited from the medical centres in the local community. The sample were medically screened before participation to ensure that they fulfilled the selection criteria: postmenopausal with amenorrhea for at least 5 years, aged between 50 and 70 years, and having no neurological, cardiovascular, metabolic, inflammatory or other musculoskeletal conditions that would have made their participation in the water exercise programmes inadvisable. None of the subjects had participated in a supervised systematic water exercise programme in the previous 2 years.

The participants were randomly divided into 2 groups: the exercise group (EG n=34) and the control group (CG n=30). Each participant signed a written consent after being informed of all risks and benefits associated with the study. Subjects were instructed not to alter their dietary habits. They were free to continue their other recreational physical activities, with the exception of swimming, calisthenics and resistance exercises in the water. Of the initial 64 participants, 38 completed the study and were included in the final analysis (EG n=21; CG n=17). Thirteen dropped out in both EG and CG groups. Eleven EG participants left the study for family reasons (e.g. caring for a sick family member), while only two of them left through lack of interest. On the other hand, the majority of the CG group dropped out primarily through lack of interest (n=9). Three of them left for family reasons (e.g. caring for a sick family member), and one for a medical-related reason (e.g. right shoulder surgery). Subjects' characteristics are presented in Table 1.

Table 1: Baseline characteristics of the subjects (mean ± SD)

	Exercise Group (n = 21)	Control Group (n = 17)
Age (years)	55.4 ± 6.5	56.6 ± 6.4
Height (cm)	155.6 ± 6.6	151.7 ± 10.4
Weight (kg)	66.4 ± 16.6	63.7 ± 9.6
BMI (kg/m^2)	27.3 ± 5.8	28.4 ± 8.4

BMI = Body mass index

Materials and procedures

All measurements for testing were carried out in the Faculty of Sports Sciences, University of Castilla-La Mancha (Spain), using identical equipment, positioning, test technicians and techniques for each subject. The examiners were appropriately trained and qualified. Anthropometric measures were always determined before the biokinetic strength test. All measurements were repeated within the pre- and post testing session to obtain reliable data and to minimise learning effects. For both the pre- and post tests for biokinetic strength, the subjects attended a familiarisation session 48 hours the muscle strength tests undertaken, to learn or review the techniques for performing the tests.

Anthropometric profile

Measurements of body weight and height were taken from all patients and were used for the calculation of the body mass index (BMI). An electronic and medical weighing machine (SECA 780) was used. All the subjects were measured barefoot and with light clothing.

Biokinetic strength test

A biokinetic swim bench (Biometer Swim Bench, Sport Fahnemann) measured upper-extremity force, work, power and stroke length in the prone and supine positions at a constant velocity. The swim bench was designed with a padded incline for a prone or supine position and with pull paddles for the hands of the subjects. Each paddle was connected to an isokinetic resistance device by means of one rope that runs over a pulley and around the geared spool inside (Figure 1).

Figure 1: Biokinetic Swim Bench

It provides acceleration settings from 1 (1.44 º/s^2) to 9 (3.07 º/s^2), where 1 means maximal effort and 9 minimum effort. Subjects carried out a specific warm-up protocol prior to the test. This consisted of 5 minutes of cycling on a cycle ergometer (Monark Ergomedic 828E) at 25 watts and 1x8 pulls in the prone and supine positions on a Vasa Trainer Ergometer. The peak-prone and supine position upper extremity biokinetic strength test and mean-prone position upper extremity biokinetic strength test were developed. The peak-prone biokinetic strength test consisted of a shoulder vertical extension in the prone position using consecutive double arm pulls at a mean acceleration of 1.85 º/s^2 (setting #3). Peak-prone force (PPF), power (PPP), work (PPW) and stroke length (PPSL) measurements were obtained from the better of two trials. The peak-supine biokinetic strength test consisted of a shoulder horizontal adduction in a supine position using consecutive double arm pulls at a mean acceleration of 1.85 º/s^2 (setting #3). Peak-supine force (PSF), power (PSP), work (PSW) and stroke length (PSSL) measurements were obtained from the better of two trials. Mean prone force (MF), power (MP), work (MW) and stroke length (MSL) measurements were obtained by the same peak-prone biokinetic strength test developed in one 30-second trial at a mean acceleration of 2.66 º/s^2 (setting #7). Subjects were instructed to make a maximal effort in the trial. Verbal encouragement was given during the test. This instrument was chosen to measure upper-body muscular strength because biokinetic devices allow muscles to achieve a maximal controlled effort with less risk of injury [17]. It has been used in some swimming [18], water-polo [19] and aquatic fitness programme [12] studies to assess either endurance or upper-extremity muscular strength. Testing procedures were adapted from these studies, making some changes in the mean prone and peak-supine tests in order to adapt them to the relevant fitness programme and the characteristics of the sample.

Procedures

The exercise group enrolled in a systematic aerobic and resistance training programme for 12 months performed at a frequency of 2 sessions per week, with each session lasting 45 minutes. It consisted of aerobic and rhythmic lower-body impact and upper-body resistance exercises in a shallow pool. These included aerobics, aquatic step, adapted water games or water strength circuits. Specific aquatic resistance devices (Hydro Tone Fitness Systems, Inc. California – USA) were used in this group to increase upper- and lower-body resistance training. For the upper body, the Aqua Exercisers™ paddle, Minifins™ or

Hydrotone-bells™ were used; and for the lower-body, Aquafins™ or Hydrotone-boots™ were used . The depth of the pool was 1.37 meters (4.5 feet) and water temperature was 28°-30ºC (83°-86ºF). Calisthenics and resistance training is detailed in Table 2. Every session included a warm up period (5 minutes), the main programme (35 minutes), and a cool down period of water light stretching in a shallow pool (5 minutes).

Table 2: Calisthenics and resistance training

Training stages	Weeks	Intensity (RPE in Borg Scale)	Description
Initial stage	1-6	10-11	Water games based on walking, jumping, pushing or carrying. All exercises were carried out under water. Aerobics.
	7-8	11-12	
Stage of improvement	9-20	12-13	Water games based on walking, jumping, pushing or carrying. Aerobics, aquatic step. Water strength circuits (3x12/30" active rest between exercises. 2' active rest between series). 10 exercises (dorsal, pectoral, biceps, triceps, gluteus, quadriceps, biceps femoris, gastrocnemius and abdominal) were trained under water in each circuit. Specific aquatic resistance devices were used.
	21-32	13-15	
Maintenance stage	33-48	12-15	Water games based on walking, jumping, pushing or carrying. Specific aquatic resistance devices were used. Aerobics, aquatic step. Water strength circuits

Following the ACSM and AHA recommendations [15], exercise programmes were carried out at a moderate intensity. In order to determine this, the Borg Perceived Exertion Scale was applied. For the first 6 weeks, subjects worked at a level of *light exertion* (Rating Perceived Exertion of 10-11 on the Borg Scale). For the following 10 months subjects worked at a *somewhat hard-hard exertion* level (RPE of 11-15 on the Borg Scale). Exercise intensity was progressively increased. Training was designed following the guidelines of Mahler et al. [20].

All exercise sessions were supervised by qualified staff. All the subjects adhered strictly to the programmes, with a minimum 95% attendance at training sessions. No women were injured during the training programme and no significant soreness was experienced.

Statistical analyses

Since all outcome variables were normally distributed, descriptive statistics were calculated. One-way ANOVA and Bonferroni post hoc tests were used to compare means at baseline and at post test. A Paired-Samples T Test was applied to assess the impact of the exercise programme. Data were analysed using the SPSS (version 17.0, SPSS Inc, Chicago, IL) computer software program.

Results

As shown in Table 3, at the end of the study the EG participants had significantly reduced their BMI (-0.75 kg/m^2; 2.75%). There were no significant changes in CG participants and there were no significant differences between EGs and CGs.

Table 3: BMI Paired Samples T-Test for exercise and control groups (mean ± SD)

Variable	Group	n	Pre	Post	Pre-Post	Pre-Post (%)	t	df	p
BMI	EG	21	27.31±5.9	26.56±5.6	0.75±0.7	2.75	4.8	20	*
	CG	17	28.42±8.4	27.19±5.5	1.22±5.0	4.29	1.0	16	

*Significant difference from pre-training value (p<0.05).

Regarding peak-prone and supine values for the upper-extremities using the Biokinetic Swim Bench, no significant changes were found either in EG participants or CG participants at the end of the study (Figures 2-5). In relation to mean values, there was a significant improvement in the EG participants' mean force (2N; 7.9%), mean power (8.33Nm/sec; 9.04%) and mean work (143.86Nm; 9.25%), but a significant decrease in mean stroke length (-0.05$m \cdot strokes^{-1}$; -5.68%) was also obtained. On the other hand, CG participants' mean values did not change, with the exception of a significant decrease in mean stroke length (-0.1 $m \cdot strokes^{-1}$; -11.5%) (Figures 2-5). No significant differences between the exercise and control groups were found in upper extremity variables at the end of the study (Figures 2-5).

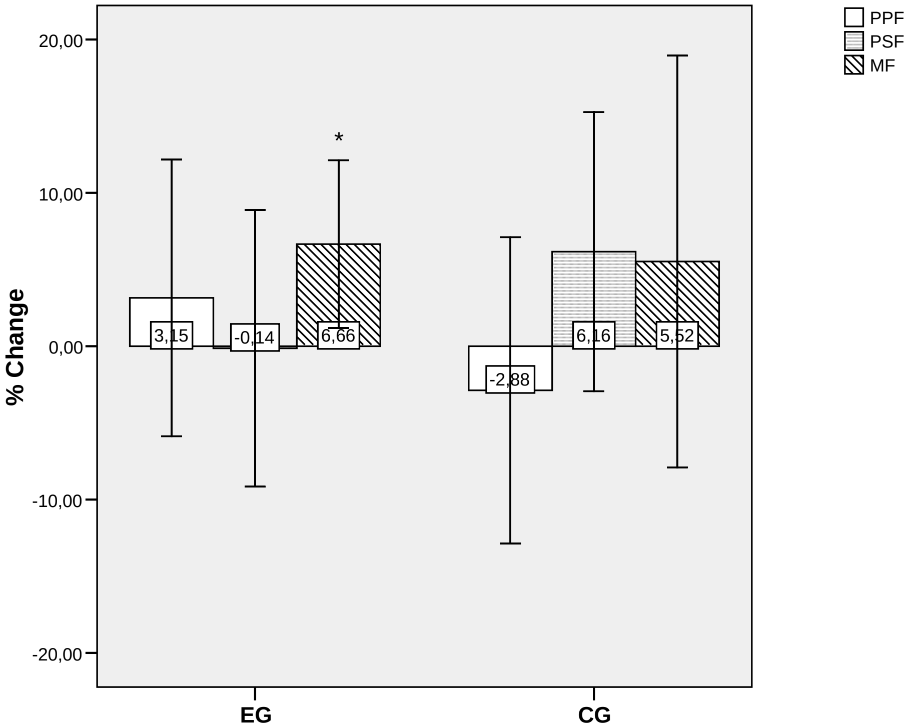

Figure 2: Percentage of change in peak- and mean-force in the exercise (EG) and control (CG) groups (= p<0.05). (PPF=peak-prone force, PSF=peak-supine force, MF=mean force)*

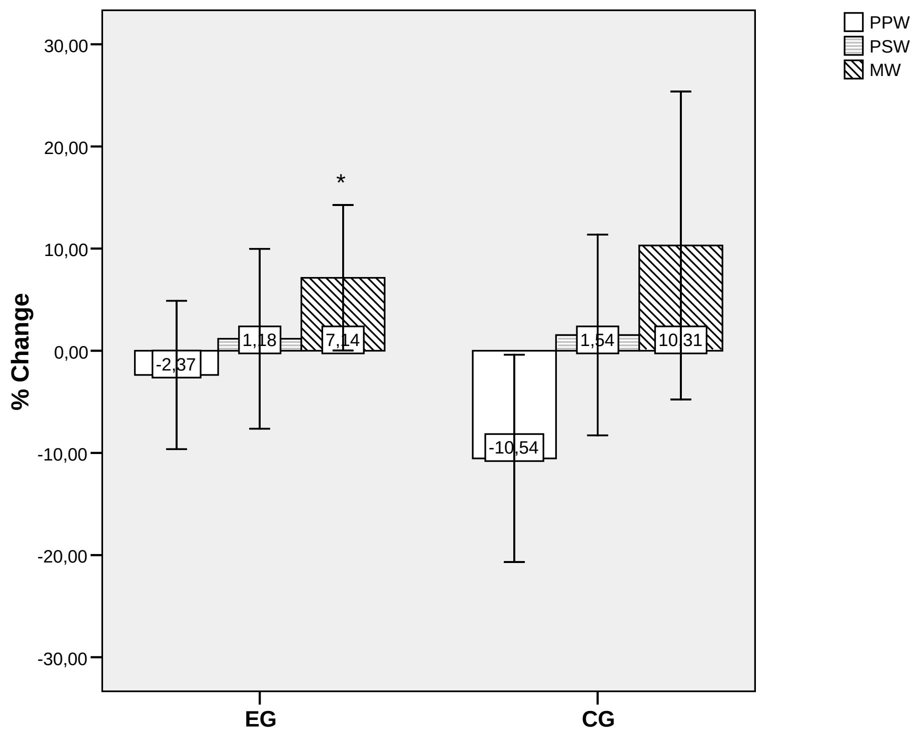

Figure 3: Percentage of change in peak- and mean- work in exercise (EG) and control group (= p<0.05). (PPW=peak-prone work, PSW=peak-supine work, MW=mean work)*

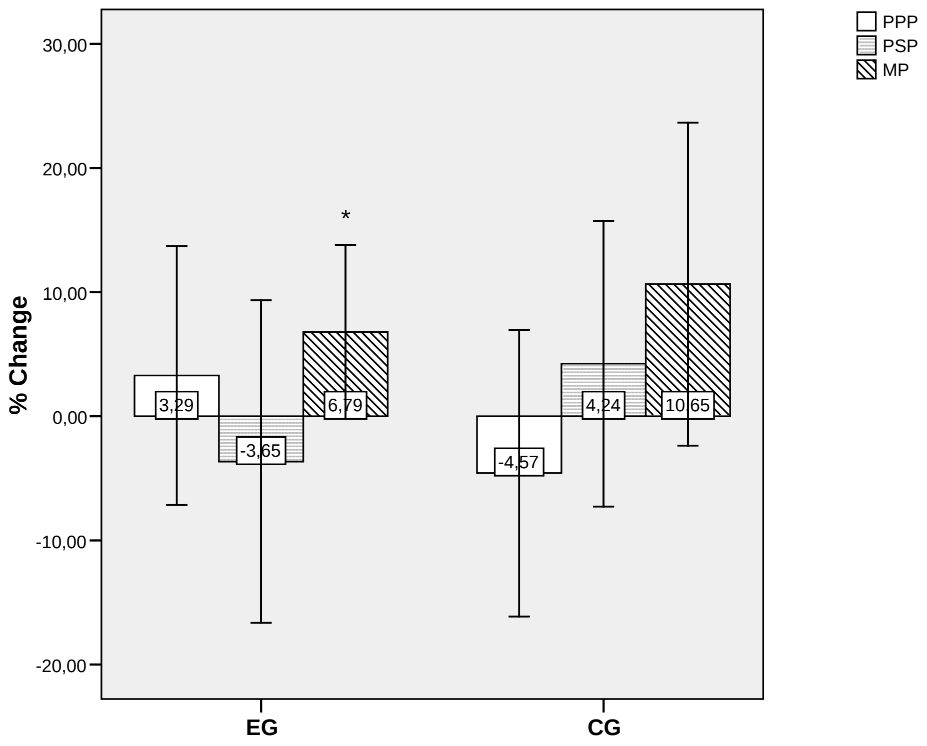

Figure 4: Percentage of change in peak- and mean-power in the exercise (EG) and control (CG) groups (=p<0.05). (PPP=peak-prone power, PSP=peak-supine power, MP=mean power)*

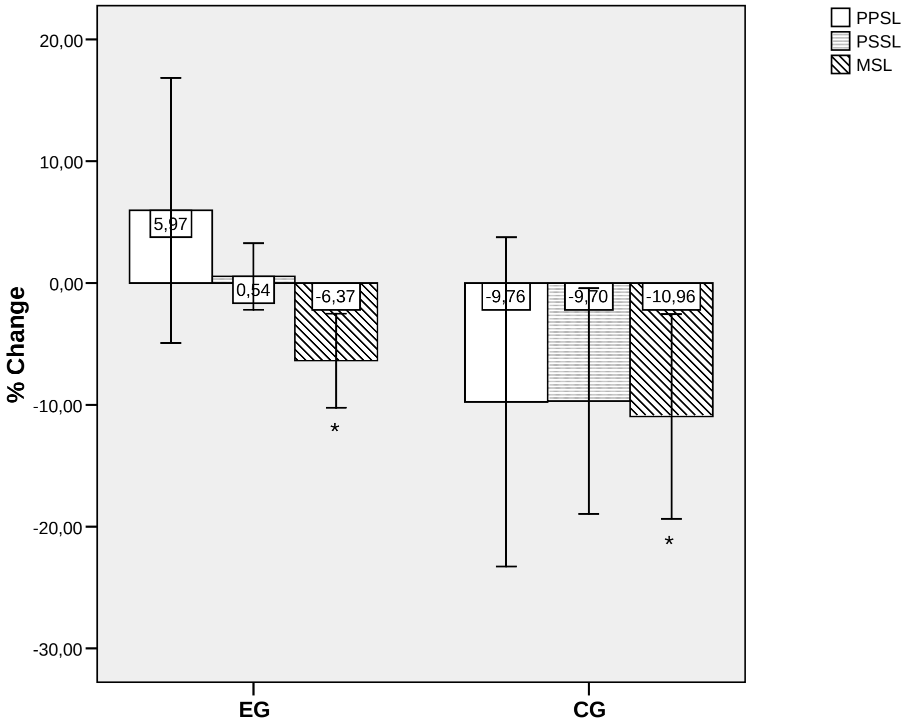

Figure 5: Percentage of change in peak- and mean- stroke length in exercise (EG) and control (CG) group (=p<0.05). (PPSL=peak-prone stroke length, PSSL=peak-supine stroke length, MSL=mean stroke length)*

Discussion

In the present study, the water exercise programme led to an increase in upper-extremity biokinetic mean force, power and work. Furthermore, a reduction in body mass index was observed following the year-long trial. These results indicate that aerobic and resistance training in a shallow pool is effective regarding improvements in strength and a decrease in body weight in postmenopausal women and has significant implications for certain health-related components of fitness.

Recently the benefits that can result from adding resistance training to the water-based exercise programmes of active older people have been recognised [21]. The present shallow-pool exercise programme consisted of moving arms against the resistance of the water, carried out with moderate intensity (RPE = 10-15 in Borg Scale), and distinguished by the use of specific aquatic resistance devices to increase upper-body resistance training. These exercises significantly improved mean upper-extremity biokinetic muscle force, power and work in the EG. The results are in accordance with the findings of Gehlsen et al [12], who found significant increments in biokinetic force, power and work after a 10-week water-based exercise programme in six women and four men with multiple sclerosis. The percentage of increase in mean force obtained in Gehlsen's study ranged from 46.7 to 85.0%, whereas in the present study it was 7.9%. In the same way, the percentage of increase in total work (82%) and power (37.2-67.2%) was higher than in the present study (9.25% and 9.04% respectively). Although in both studies similar test protocols on the biokinetic swim bench were used and despite the fact that the present study was longer, in Gehlsen's study higher increments were found in mean force, power and work respectively. It is important to remember, however, that the sample was different in Gehlsen's study. It was composed of men and women with multiple sclerosis and who were 10 years younger (mean age of 40.2 years) than the participants in the present study. Furthermore, the aquatic exercise programme was carried out in a 3 one-hour exercise sessions with a higher intensity (60-75% of maximum heart rate = 14-16 points in Borg Scale).

Despite the differences between both studies, training the upper-extremities with specific aquatic resistance devices in a shallow pool by middle-aged women leads to upper-extremity muscular force, power and work improvements. Following Kraemer et al [22], moderate-intensity muscle training can improve muscular resistance, particularly in water, and if specific aquatic resistance devices are used, this effect is greater [23, 24]. In addition, the power increase was related to the ability to produce a higher velocity when moving arms against resistance. This is in accordance with the intensity and the increased velocities of the exercises that were developed in the final stage of the programme. Following Elliot et al [25] muscular training at high velocities improves strength at fast speeds; however, if training takes place under conditions of high resistance or slow velocities or both, speed and power are sacrificed.

In other studies based on calisthenics and resistance water training with mean age and older participants, upper-body muscular strength was also improved. Cider et al [11] obtained significant increments in isotonic heel lift and shoulder flexion, and in isometric shoulder abduction, after an 8-week water training programme with a moderate intensity (40-70% of maximal heart rate reserve) in older chronic heart failure patients. In the same way, significant improvements in upper-body muscular strength measured by a hydraulic resistance machine were found in Takeshima et al [13] and Tsorlou et al [14] studies. In the former, thirty older women (60-75 years) carried out an aerobic and resistance water training programme in a shallow pool with a moderate intensity (60-80% of maximum heart rate = 14-17 points on the Borg Scale) over 12 weeks. Increments of 7-11% on the chest press and pull respectively and 4-6% on the shoulder press and pull respectively were obtained. The latter had a similar training design and was carried out on women of over 60-years-old over a period of 24 weeks. Significant increments in the chest press (25%) were also found. These results indicate that, although the testing procedures and the intensity and duration of the exercise period were different, similar moderate-intensity calisthenics and resistance water training programmes induce upper-body muscular improvements in middle-aged and older women.

A significant decrease in stroke length was found in both the exercise and the control groups. Isokinetic (biokinetic) instruments require a very high similarity between the direction of movement in the training and in the test [26]. It means that the training programme did not include enough exercises focused on shoulder flexion and extension in the frontal plane. Therefore, it is recommended that this be taken into consideration for future studies. On the other hand, this decrease was an expected result in the CG because arm movements were not controlled in their recreational physical activities.

The exercise programme was not suitable for achieving improvements in peak biokinetic values. This may be related to the velocity and the intensity of training. To increase maximum strength and power, a high-intensity and high-velocity training programme is required [22, 27, 28], and the present exercise programme design did not fulfil these requirements. In the control group no significant improvements were obtained in peak or mean biokinetic values. The recreational physical activities developed by the CG participants did not cause a sufficient stimulus to improve upper-extremity biokinetic muscle force, power and work.

Finally, the exercise programme was effective regarding improvements in BMI over the course of the training. These changes are similar to those reported by other studies in elderly women after between 4 and 6 months of resistance and moderate-intensity aerobic training in a shallow pool [10, 29]. Thus with no intention of making definitive statements about changes in body composition, calisthenics and water-based resistance exercise can lead to a positive change in BMI in postmenopausal women, which can ultimately help in improving their general health. BMI indicates if overweight (obesity) is a risk factor for health [30]. If it is between 25-29.9kg/m^2, the first stage of obesity has been reached. It is not recommended to allow BMI to reach 30 kg/m^2 and above because this is related to cardiovascular risk factors, such as stroke, hypertension and type 2 diabetes [23]. In the present study, BMI decreased significantly in the EG participants from 27.31 kg/m^2 to 26.56 kg/m^2. This means that women who participated in the long-term calisthenics and resistance programme decreased their degree of obesity and risk of heart disease. These findings are interesting because the most significant losses in weight and body fat with exercise generally occur in studies of men, especially in younger individuals, and in the presence of dietary energy restriction [31]. However, it is more difficult to improve body composition after menopause [32, 33].

Conclusions

Upper-body resistance exercises developed with specific aquatic resistance devices in a shallow pool are effective in improving upper-extremity biokinetic force, power and work in postmenopausal women. There was also an obvious effect produced by the exercise programme on total body weight. Therefore water-based exercise has significant implications for improving some health-related components of fitness in postmenopausal women.

Acknowledgements

The present study received the financial support of the *Junta de Comunidades de Castilla-La Mancha* (Spain) over a period of three years from the University of Córdoba, Department of Public Health, Spain.

Address for correspondence:

Associate Professor María Carrasco,
Departamento de Actividad Física y Deporte, Universidad de Murcia, Facultad de Ciencias de la Actividad Física y el Deporte, C/Argentina, S/N. 30720 San Javier, Murcia, Spain.
Tel./Fax: +0034 696878330
Email: mariacarrasco@um.es

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