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ORIGINAL ARTICLE

Effects of aquatic resistance training on health and fitness in postmenopausal women

Juan C. Colado · N. Travis Triplett · Victor Tella · Pedro Saucedo · José Abellán

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Abstract To investigate effects of 24 weeks of resistance training with aquatic resistance devices or elastic bands (EB) on markers of cardiovascular health and physical capacity. Forty-six healthy, sedentary postmenopausal women participated. The groups were aquatic exercise (AE; $n = 15$), EB ($n = 21$), and control ($n = 10$). Venous blood chemistry included cholesterol, triglycerides, glucose, and apolipoprotein B. Physical capacity was assessed by the sit-and-reach, knee push-up, 60-s squat, and abdominal crunch tests. Both AE and EB, respectively, showed a significant ($P \leq 0.05$) decrease in body fat (14.56, 11.97%) and diastolic blood pressure (8.03, 5.88%), and a significant increase in fat-free mass (2.88, 1.22%), sit-and-reach (27.94, 44.2%), knee push-ups (84.74, 51.59%), and 60-s squats (65.76, 46.04%). AE also showed a significant increase in abdominal crunches (28.11%). Aquatic resistance training can offer significant physiological benefits in health and performance that are comparable to those obtained from EB in this population.

Keywords Blood chemistry · Physical capacity · Elastic bands · Strength training

J. C. Colado (✉) · V. Tella
Department of Physical Education and Sports,
Faculty of Physical Activity and Sport Sciences,
University of Valencia, C/Gascó Oliag 3,
46010 Valencia, Spain
e-mail: juan.colado@uv.es

N. T. Triplett
Neuromuscular Laboratory,
Department of Health, Leisure and Exercise Science,
Appalachian State University, Boone, NC, USA
e-mail: tripltnt@appstate.edu

N. T. Triplett
Invited Researcher, University of Valencia,
Valencia, Spain

P. Saucedo · J. Abellán
Chair of Cardiovascular Risk,
Catholic University of Murcia, Murcia, Spain

Introduction

The physical changes associated with the aging process that affect overall health include the loss of muscle mass and increase of body fat (Doherty 2003), and a change in the blood lipid profile toward one that favors the development of atherosclerosis (Morss et al. 2004). These changes can lead to hypertension and cardiovascular disease (Bemben and Bemben 2000; Braith and Stewart 2006). While the reasons for this are many and varied, these changes are typically more marked in the sedentary individual (Nieman et al. 1993; Reaven et al. 1990). The benefits of chronic aerobic exercise for overall health have been established (Durstine and Haskell 1994; Krummel et al. 1993). What is less clear is how resistance training fits into an exercise prescription for improving body composition and lipoprotein–lipid patterns in the older individual, although several researchers have found positive results (Bemben and Bemben 2000; Elliott et al. 2002; Fahlman et al. 2002).

One indicator of health status is the analysis of blood chemistry, which is also used as an important diagnostic tool for many diseases or pre-disease states. There are accepted measures in a blood chemistry test that relate to both cardiovascular disease and to obesity, common health problems in middle-aged and older individuals. These measures include a fasting concentration profile of glucose, lipids, and lipoproteins (triglycerides and total, HDL- and LDL cholesterol) that have consistent ranges in the blood

(Morss et al. 2004). It has been shown that women have higher rates of cardiovascular disease after menopause, which is related to the blood lipid profile (Bonithon-Kopp et al. 1990; Matthews et al. 1989; Stevenson et al. 1993).

Sarcopenia, or the loss of muscle mass, is apparent beginning after the age of 30 and accelerates after the age of 50, especially in the sedentary population (Katula et al. 2006). This loss of muscle mass, and often corresponding increase in body fat, affects strength, metabolism, and functional capacity, all of which have a role in health and quality of life (Bemben et al. 2000; Katula et al. 2006). While it is accepted that resistance training programs can improve muscle mass, strength, power, and local muscular endurance, less is known about the effects of different modes of resistance training, such as aquatic resistance (Tsourlou et al. 2006), on these parameters or other indicators of health.

While some studies have examined traditional resistance training and health indicators such as blood lipids (Blumenthal et al. 1991; Hurley et al. 1988; Kokkinos et al. 1988), only a few studies have examined training with aquatic resistance for a complete profile of glucose, lipids, and lipoproteins, even though its use, especially in the older population, is on the rise (Nowak et al. 2008; Takeshima et al. 2002; Volaklis et al. 2007). A main problem has been the inability to adequately control intensity of effort in aquatic exercise (AE) programs, which limits the ability to make strong conclusions about its efficacy. Another issue is that aquatic resistance exercises typically involve primarily concentric muscle actions, making it difficult to compare to other exercise modes which have both eccentric and concentric muscle actions. Another therapeutic mode that emphasizes the concentric phase of movement, the elastic band (EB), is being increasingly used for muscular conditioning for different aims and population types, as it is more affordable and more accessible (i.e., can be performed anywhere) than weight machines (Colado and Triplett 2008; Hostler et al. 2001; Thomas et al. 2005). The effects of EB training have been assessed on body composition and physical capacity (Capodaglio et al. 2002; Colado and Triplett 2008; Mikesky et al. 1994; Rogers et al. 2002), but not in comparison to training with aquatic resistance. Therefore, the present study was designed to compare the effects of aquatic resistance training with a controlled intensity to dry-land training with EB, regarding measures of cardiovascular health and physical performance.

Methods

Subjects

An announcement was made at the medical center of the local community. Seventy-five female volunteers responded and were medically screened before participation to ensure that they were not taking medication or hormone therapy, that they were all functionally independent and had no neurological, cardiovascular, metabolic, inflammatory, or musculoskeletal conditions that advised against their participation in a physical exercise program. None had ever participated in resistance training exercises nor were involved in aerobic exercise in the previous 4 years. Twenty women who did not comply with the criteria for inclusion in the study were excluded. Each remaining participant was randomly placed into one of three groups: AE, EB, and control (C). In anticipation of potential drop-outs that often occur during the administration of unpaid research studies, twice as many women were placed into each exercise group. Therefore, 22 women were in each exercise group and 11 were in the control group. Forty-six women completed the entire study (AE: 15, EB: 21, CG: 10). Drop-outs were in the first months primarily for family reasons. All the women had a natural menopause, with amenorrhea at least 1 year prior to the start of the study (average time of amenorrhea 4.2 ± 2.8 year). All subjects were informed of the training and testing, gave their written consent to participate, and were instructed not to modify their behavior or diet, nor to do any other type of physical exercise for the duration of the study. To ensure strict compliance to participation instructions, these aspects were monitored weekly by the researchers using a diary of activities and diet that was completed daily by the women. The study was approved by a research commission from the Department of Health Sciences, Physical Activity and Sport at the Catholic University of Murcia (Spain). Subject characteristics are presented in Table 1.

Testing procedures

A blood sample and blood pressure were taken at the same physician's office within 1 week prior to and after the physical pre- and post-testing, respectively. Anthropometric measures were always determined 24 h before the physical capacity tests, which were performed 72 h after ceasing heavy exertion. The physical tests were repeated within the testing week to obtain reliability data and to minimize learning effects. For both the pre- and post-tests for physical

Table 1 Subject characteristics (mean ± SD)

Group	Aquatic (n = 15)	Elastic band (n = 21)	Control (n = 10)
Age (year)	54.7 ± 2.0	54.0 ± 2.8	52.9 ± 1.9
Height (cm)	156.7 ± 6.7	155.6 ± 6.2	155.5 ± 4.6
Weight (kg)	67.7 ± 9.4	71.6 ± 10.6	66.8 ± 10.8
Body fat (%)	37.9 ± 5.3	40.3 ± 5.3	37.7 ± 5.8

capacity, the subjects attended a familiarization session 48 h before carrying out the first muscle function tests, to learn or review the techniques for performing the tests. Thus, the evaluation week consisted of a test familiarization or review session on Monday, first anthropometric measurements on Tuesday, first physical capacity measurements on Wednesday, a rest day on Thursday, second anthropometric measurements on Friday, and second physical capacity measurements on Saturday. The best value for each test was used in the statistical analysis. All tests showed very high intraclass correlation coefficients of $r \geq 0.90$ for test–retest reliabilities. All measurements for testing (pre-training and post-training) were made using identical equipment, positioning, test technicians, and technique for each subject. The examiners were appropriately trained and qualified.

Blood pressure, and blood sampling and analysis

Subjects reported to the physician's office in a fasted state of 12 h. A resting blood pressure measurement was taken after 10 min of quiet sitting. The blood pressure measurement was repeated in the same manner after 48 h to ensure reliability. Afterward, a 10-ml blood sample was removed from the antecubital vein, placed into a clot tube, allowed to clot, and spun at 3,000*g* for 10 min to allow for separation of the blood. The resulting serum was immediately analyzed by a certified clinical laboratory for cholesterol (total and subfractions), triglycerides, glucose, and apolipoprotein B.

Body composition and stature

An eight-polar bioelectrical impedance system (BC-418, Tanita Corp., Tokyo, Japan) was used to determine body composition. All subjects were assessed in compliance with the guidelines proposed by Dixon et al. (2005) and the manufacturer. Values for body mass, fat-free mass (FFM), fat mass were obtained. This device was chosen as this type of bioelectrical impedance analyzer is significantly more accurate than traditional bioelectrical impedance analyzers (Pietrobelli et al. 2004), showing a satisfactory correlation with DXA (Malavolti et al. 2003), specifically $r = 0.87$ ($P < 0.01$) for total body fat percentage and $r = 0.96$ ($P < 0.01$) for skeletal muscle mass (Pietrobelli et al. 2004). Weight and height values were then used for the calculation of BMI. In addition, the waist circumference at the end of a normal inspiration was measured (Ross and Marfell-Jones 1995).

Physical capacity tests

Four physical capacity tests were chosen for this investigation. The subjects carried out a specific warm-up protocol prior to the tests and had a minimum recovery period of 10 min between the tests. The subjects were tested at the same time of day and tests were performed in the same order for pre- and post-testing. The sit-and-reach test was chosen for lower body flexibility (ACSM 1999) and was performed first, with a slight modification in the starting position such that the subject began the test with the back flat against the wall and reached forward from that position (Colado 2004). The knee push-up test for total repetitions was chosen as the measure of upper body muscle endurance (ACSM 1999) and was performed second. This test was performed from the bent-knee position and was not timed. In contrast, the 60-s squat test was chosen as a measure of lower body muscle endurance (ACSM 1999). It was performed third, and for the greatest possible number of repetitions in 1 min with a thigh position parallel to the floor at the bottom of the range of movement and without carrying out assistance movements using other body segments. The abdominal crunch (partial curl-up) test, or Canadian crunch test, was employed for assessing abdominal muscle endurance. It consists of the number of repetitions completed in 3 min at a pace of 25 repetitions per minute with a cadence marked by a metronome of 50 beats per minute (Colado 2004). This test must be stopped when the subject cannot continue, when there is poor technique of more than two consecutive repetitions, or when the maximum number of repetitions (75) is reached (Colado 2004). The physical tests took place in the morning, approximately 1.5 h after the subjects had consumed their normal breakfast and after approximately 8 h of sleep. All subjects were verbally encouraged throughout all physical tests. Each test was supervised by the same examiner, with two reference examiners who attended to monitor strict compliance with protocol.

Training protocol

The subjects were instructed in the different exercise techniques and in controlling exercise intensity through the combined use of a targeted number of repetitions and perception of effort during two sessions before beginning the training program, following the criteria of body position, ranges of motion and movement speed described by Colado (1996, 2004). The number of sets, repetitions, rest period length between sets and exercises, and the desired perception of effort for the sets were the same for both groups during the 24 weeks of training (Fig. 1). Qualified personnel led each training session, and at least one trained monitor was always present to verify the correct application of the methodology. All the subjects adhered strictly to the program, with a minimum 95% attendance at training sessions. Due to the design and monitoring of training protocol no women were injured during the training program and they experienced no significant muscle soreness.

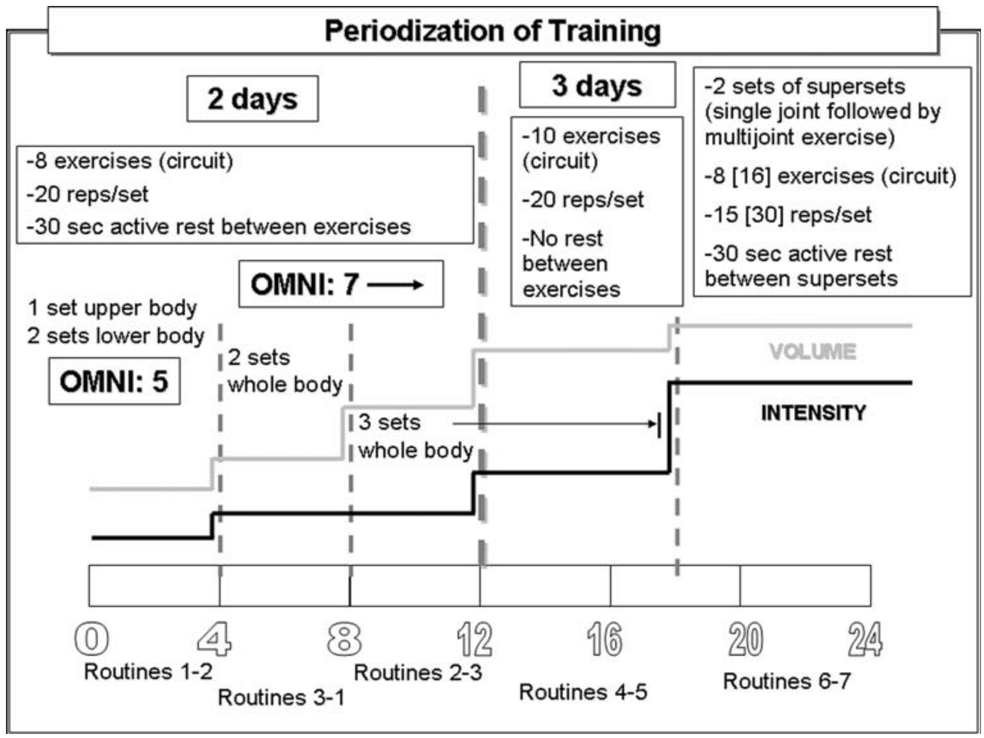

Fig. 1 Diagram of the training program. Training was performed twice per week in first 12 weeks and three times per week for weeks 13–24. Weeks 1–12 consisted of eight exercises of 20 repetitions per set and one to three sets per exercise, depending on the week. Weeks 13–18 consisted of ten exercises of 20 repetitions per set and three sets per exercise. Weeks 19–24 consisted of exercise supersets of 15 repetitions per set. OMNI ratings increased from 5 in weeks 1–4 to 7 in the remainder of the program

In order to equalize the intensity of the exercise, the targeted number of repetitions was maintained (Campos et al. 2002; Kraemer et al. 2001) while applying the rating of perceived exertion in active muscles by using the OMNI resistance exercise scale for active muscles (Gearhart Jr et al. 2002; Lagally and Robertson 2006; Robertson et al. 2003). This scale has a continuum of values from 0 to 10. The maximum value (10-extremely hard) indicates that the subject has perceived that the set performed with a previously determined number of repetitions has been performed with a maximal volitional effort, while the 0 value (extremely easy) indicates no effort at all (Colado and Triplett 2008). The EB used were light intensity Thera-Band™ with a relaxed length of 1 m, and each woman always trained with the same band. The EB group varied the grip width of the bands to adjust the resistance to the repetitions and OMNI value prescribed at each particular moment. To assist in the adjustment, 20 symmetrical reference points 2.5 cm apart were marked from the central point of the EB. The AE group chose from four different upper body and two different lower body aquatic resistance devices (Sprint Aquatics, San Luis Obispo, CA, USA), with varying levels of resistance, in order to match the repetitions and OMNI value (Fig. 2). The devices (in order of increasing resistance) used for the upper body were the hands alone, Aquagloves™, Aqua Exercisers™ paddle, and Hydro-tone Bells™. For the lower body, the AE group used Aquafins™ or Hydro-tone Boots™.

Fig. 2 Subjects training with the various aquatic devices

In each of the familiarization and training sessions the women were instructed in the exercises followed during the program. The exercises consisted of movements which included the major joints of the body, such as shoulder horizontal add-abduction with elbow extension–flexion, shoulder ab-adduction, elbow flexion–extension, hip flexion–extension, hip ab-adduction, abdominal flexion and torsion, and jumping. Exercises rotated between different muscle groups such that, for example, a lower body exercise always followed an upper body exercise. In order to increase motivation, the type and order of the exercises was changed every 2–3 weeks in the same way for both groups. Thus, the exercise groups were trained using seven different routines (Fig. 3). A warm-up of 6–7 min of light

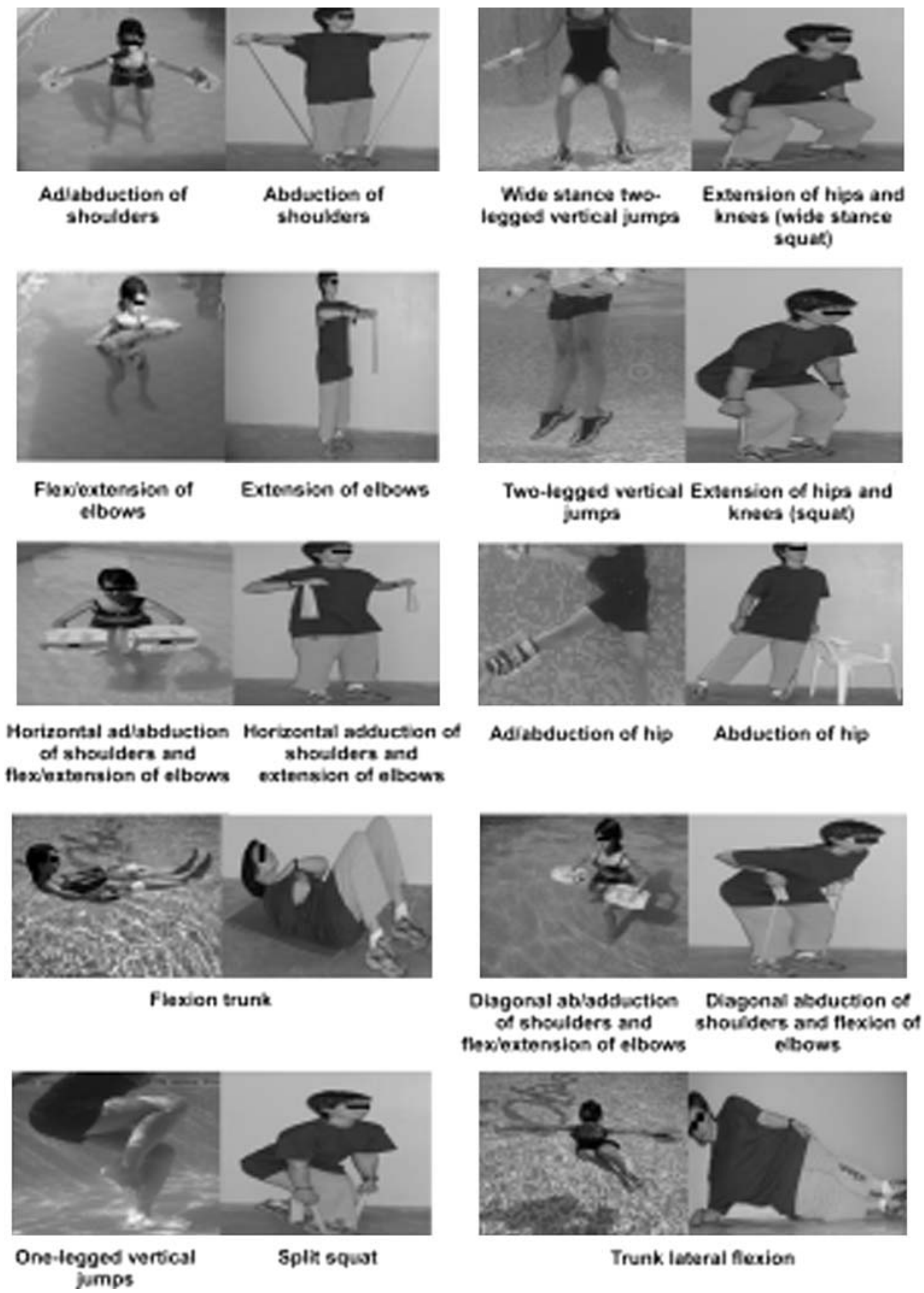

Fig. 3 Example comparing the aquatic and elastic band resistance exercises

cardiovascular exercise followed by 3–4 min of light stretching was always performed prior to the training sessions. A cool-down of 1 min of light cardiovascular exercise followed by 4 min of light stretching was always performed after the training sessions. The total duration of the training session ranged from 35 to 60 min depending on the phase of periodization of the training program (Fig. 1). The total duration of the training session for the mesocycles was: 35 min during weeks 1–4; 40 min during weeks 5–8; 50 min during weeks 9–12; 45 min during weeks 13–18; and 60 min during weeks 19–24. Using the correct grip width, the EB subjects had to perform the movement without the band fully losing tension in the eccentric phase, and complete the concentric phase until the maximum amplitude defined was reached. In the aquatic environment, during the performance of each exercise (except the jumps) both phases of movement are concentric and no significant eccentric muscle actions occur. For example, in the hip ab-adduction exercise, during the abduction phase the gluteals (minimus and medius) are activated, while in the adduction

Table 2 Changes in body composition (mean ± SD)

Group	Aquatic	Elastic band	Control
Fat mass (kg)			
Pre	26.1 ± 7.0	28.4 ± 7.4	25.4 ± 7.9
Post	22.3 ± 8.5**	25.0 ± 6.8**	24.8 ± 8.1
Fat-free mass (kg)			
Pre	41.6 ± 2.5	40.8 ± 3.2	40.6 ± 3.1
Post	42.8 ± 2.9**	41.3 ± 2.6**	40.6 ± 3.2
BMI (kg m^{-2})			
Pre	27.6 ± 3.7	29.5 ± 3.3	27.5 ± 3.3
Post	26.4 ± 3.5**	28.3 ± 3.1**	27.5 ± 3.2
Waist circumference (cm)			
Pre	90.4 ± 11.2	90.8 ± 8.6	85.4 ± 7.0
Post	86.7 ± 10.1**	87.2 ± 6.7**	87.7 ± 8.5*

* Significant difference ($P \leq 0.05$) from pre-training value

** Very significant difference ($P \leq 0.01$) from pre-training value

Table 3 Changes in physical capacity (mean ± SD)

Group	Aquatic	Elastic band	Control
Sit-and-reach (cm)			
Pre	20.4 ± 6.9	18.1 ± 8.2	23.3 ± 7.0
Post	26.1 ± 6.0**	26.1 ± 8.3**	23.5 ± 7.7
Knee push-up (reps)			
Pre	11.8 ± 5.4	15.7 ± 9.2	17.3 ± 10.2
Post	21.8 ± 8.9#*	23.8 ± 13.1#**	11.8 ± 11.2
Sixty-second squats (reps)			
Pre	25.7 ± 6.4	27.8 ± 3.8	26.2 ± 8.2
Post	42.6 ± 7.5##**	40.6 ± 6.7##**	29.2 ± 10.0
Abdominal crunch (reps)			
Pre	46.6 ± 17.8#	40.2 ± 16.9	29.3 ± 12.7
Post	59.7 ± 17.6##†*	45.2 ± 16.8##	23.8 ± 14.5

* Significant difference ($P \leq 0.05$) from pre-training value

** Very significant difference ($P \leq 0.01$) from pre-training value

† Significant difference ($P \leq 0.05$) from elastic band group

Significant difference ($P \leq 0.05$) from control group

Very significant difference ($P \leq 0.01$) from control group

phase of the exercise the adductors, pectineus, and gracilis are activated. The technique of the both exercise groups was controlled by visual observation and correction by trained personnel present at each training session.

Statistical analyses

The homogeneity of the dependent variables was confirmed using Levene's test ($P > 0.05$) and their normality was also confirmed via Kolmogorov–Smirnov statistics ($P > 0.05$). Descriptive statistics were then calculated. One-way (group) ANOVA for repeated measures was performed. Bonferroni post hoc tests were used to determined specific differences between means. All differences with $P \leq 0.05$ were accepted as statistically significant and those with $P \leq 0.01$ as very significant.

Results

As shown in Table 2, both exercise groups significantly increased their FFM and significantly decreased their fat mass, BMI, and waist circumference. Both exercise groups also improved on the sit-and-reach, knee push-up, and 60-s squat tests, but only the AE group improved on the abdominal crunch test (Table 3). Both exercise groups were significantly better than the control group for the knee push-up, 60-s squat, and abdominal crunch post-tests. The EB group significantly improved the HDL cholesterol value and the ratio of total cholesterol to HDL cholesterol (Table 4). The control group was significantly worse in total cholesterol, LDL cholesterol, glucose, and waist circumference, with the exercise groups being significantly better than the control group after the training program with glucose concentrations. Finally, both exercise groups improved diastolic blood pressure (Table 5).

Table 4 Changes in blood chemistry (mean ± SD)

Group	Aquatic	Elastic band	Control
Total cholesterol (mg dl^{-1})			
Pre	226.6 ± 31.4	223.9 ± 31.1	223.0 ± 36.9
Post	220.4 ± 19.9	227.4 ± 36.5	242.2 ± 52.3*
HDL cholesterol (mg dl^{-1})			
Pre	69.8 ± 10.4	64.1 ± 11.9	67.7 ± 14.9
Post	68.1 ± 12.0	72.0 ± 9.7**	73.6 ± 9.9
LDL cholesterol (mg dl^{-1})			
Pre	133.4 ± 30.6	139.6 ± 25.4	138.8 ± 32.1
Post	133.6 ± 24.6	136.9 ± 31.7	159.2 ± 47.3*
TC:HDL			
Pre	3.3 ± 0.7	3.6 ± 0.7	3.4 ± 0.8
Post	3.4 ± 0.7	3.2 ± 0.7**	3.4 ± 0.6
Triglycerides (mg dl^{-1})			
Pre	105.4 ± 36.2	100.4 ± 41.0	83.1 ± 26.4
Post	97.7 ± 36.3	96.8 ± 42.9	84.1 ± 36.9
Glucose (mg dl^{-1})			
Pre	92.7 ± 9.0	95.2 ± 9.1	94.1 ± 7.3
Post	92.8 ± 8.4#	97.0 ± 7.8#	100.9 ± 8.0*
Apolipoprotein B (mg dl^{-1})			
Pre	120.1 ± 21.8	114.5 ± 22.1	115.4 ± 22.4
Post	111.9 ± 21.6	111.1 ± 23.2	119.3 ± 25.9

* Significant difference ($P \leq 0.05$) from pre-training value

** Very significant difference ($P \leq 0.01$) from pre-training value

Significant difference ($P \leq 0.05$) from control group

Table 5 Changes in blood pressure (mean ± SD)

Group	Aquatic	Elastic band	Control
Systolic (mm/Hg)			
Pre	132.7 ± 17.7	132.0 ± 16.2	138.0 ± 14.6
Post	123.5 ± 11.4	129.7 ± 13.9	132.9 ± 11.2
Diastolic (mm/Hg)			
Pre	84.7 ± 9.2	81.7 ± 6.9	80.2 ± 6.6
Post	77.9 ± 7.4**	76.9 ± 6.3**	81.0 ± 8.0

** Very significant difference ($P \leq 0.01$) from pre-training value

Discussion

The most noteworthy findings of this investigation are that aquatic resistance exercise is as effective as the use of EB regarding improvements in physical capacity with resistance training, and also has some benefits regarding body composition and blood pressure. These results are supported by previous works (Takeshima et al. 2002; Tsourlou et al. 2006; Volaklis et al. 2007) who found improvements in body composition and physical capacity with water-based exercise. Regarding blood chemistry measurements, in the current investigation only the exercise groups demonstrated a significant difference compared to the control group with the glucose measurement. However, after training both exercise groups were significantly better than the control group with some measures of physical performance, and that finding is supported well in the literature (Bemben and Bemben 2000; Bemben et al. 2000; Campos et al. 2002; Elliott et al. 2002; Hostler et al. 2001; Kraemer et al. 2001; Rogers et al. 2002; Takeshima et al. 2002; Volaklis et al. 2007). It appears, from the results of this investigation, that the volume of the exercise protocol used was sufficient to invoke a significant physiological response in measures of physical performance, but may need to be increased to have the same effect in measures of blood chemistry (Braith and Stewart 2006), and fat and weight loss (ACSM 2001).

Overall, the EB and AE groups were similar regarding improvements in body composition, blood pressure, and physical capacity over the course of the training. In fact, there was a significant improvement over time in nearly every variable measured, except for some blood chemistry measures. With regard to body composition, the subjects in the current investigation in both exercise groups improved FFM and decreased fat mass. Although both Takeshima et al. (2002) and Volaklis et al. (2007) found improvements in body composition in the exercise groups of their respective investigations, the methods used to determine body composition (sum of skinfolds) were different from the methods used in the current investigation (bioelectrical impedance). Thus, it is difficult to make definitive statements about changes in body composition between the various studies that employed some form of aquatic resistance exercise, except that this form of exercise can lead to a positive change in body composition, which can ultimately help to improve health. Another measure which is used as an indicator of health status, blood pressure, did not change in the Nowak et al. (2008) and Takeshima et al. (2002) studies, unlike in the current investigation, where there were improvements over time in the diastolic blood pressure in both exercise groups. This finding is very interesting considering aerobic exercise, traditionally thought to be a better type of exercise to improve blood pressure, made up a greater proportion of the training program of the Takeshima et al. (2002) study, yet elicited no improvements. The current investigation focused primarily on local muscular endurance, and found better improvements. Thus, our findings are in agreement with the current criteria that suggest that moderate intensity resistance training could become part of non-pharmacological intervention strategy to prevent and combat high blood pressure, with a possible major influence on diastolic blood pressure (Cornelissen and Fagard 2005).

The results of the current investigation regarding physical performance were highly encouraging. Both exercise groups significantly improved flexibility, and upper and lower body muscle endurance over time. The AE group additionally improved the endurance of the flexor muscles of the trunk, even compared to the EB group. This may be due to the trunk muscles being more active during the AE, to maintain correct body position (Colado et al. 2008), resulting in more of a training effect. However, EMG was not used in the current investigation to confirm this reasoning. There was also an interaction effect, as upper and lower body and truck muscle endurance in the two exercise groups were significantly better than the control group. Thus, it appears that AE has similar or greater benefits than EB regarding physical performance. These benefits may have the potential to transfer well to activities of daily living, which are often low-intensity and repetitive in nature.

One aspect of health that is more difficult to obtain consistent results with an exercise program is blood chemistry. Variable training responses in blood chemistry parameters have been shown previously in the literature. For example, only total cholesterol and LDL cholesterol improved with combined resistance and aerobic aquatic training in the Takeshima et al. (2002) study, only HDL cholesterol improved with EB resistance training in the Bemben and Bemben study (2000), and only total cholesterol and triglycerides improved in the Volaklis et al. (2007) study. That study (Volaklis et al. 2007) employed a combination of resistance and aerobic training in the water, but also compared it to a dry-land version of the training. In the current investigation, which there were also two types of training groups, the AE group showed no changes over time in blood chemistry variables and the EB group only improved over time in HDL cholesterol and the TC/HDL ratio. This is in contrast to the Volaklis et al. study (2007), who found similar changes in both exercise groups. In the current investigation, the control group worsened over the same time in some of the measures of blood chemistry, but was otherwise stable in all other measurements. There were no changes in blood chemistry in the control groups of the other similar investigations (Takeshima et al. 2002; Volaklis et al. 2007), but those training programs were shorter in duration. It is possible that, while an attempt was made to equate the groups prior to training, the individual variability of the subjects was large enough to mask any group differences as a result of the training, as older individuals tend to respond at different rates and magnitudes to a training routine. Hence, although most studies have shown some positive changes in blood chemistry, there is no definitive exercise program that will consistently result in definitive changes in specific blood chemistry parameters. This pattern may be an argument for regular program variations, as changing the focus of an exercise program for a few weeks may alter how the body responds with improvements in the lipid profile or glucose concentrations, thus improving many parameters of blood chemistry.

It is possible that the many improvements seen over time in the exercise groups of the current investigation, compared to other studies, can be explained by the differences in the exercise program design. Program duration varied, from 6 months in the current investigation to 4 months in the Volaklis et al. (2007) and Bemben and Bemben (2000) investigations to 3 months in the Takeshima et al. (2002) investigation. Also, the AE program utilized in this investigation was focused on improving local muscular endurance rather than cardiovascular endurance, and consisted of a maximum duration of 45 min of resistance exercises. In contrast, Takeshima et al. (2002) employed an AE program that was primarily cardiovascular in nature, with 30 min of walking or dancing, and only 10 min of resistance exercises with similar devices to those used in the current investigation. Also, there was no real control of the intensity of the sets, only the speed of movement, which was instructed to be as rapid as possible. In the current investigation, changing the grip width on the EB adjusted the resistance, and a variety of aquatic devices were available in order to increase the chances of having a resistance that was optimal of the number of reps and the OMNI value needed at a particular time (Colado and Triplett 2008). These program specifics may have contributed to the improvements in all the muscular performance tests seen over time in the current investigation in both exercise groups, in contrast to the Takeshima et al. investigation (2002), which only demonstrated improvements in trunk extension strength and vertical jump, but not truck flexion or agility.

Another positive finding of this investigation was that using the OMNI rating of perceived exertion along with a targeted number of repetitions was successful in producing significant training adaptations. This method may therefore be employed when conducting exercises that do not have a measurable resistance, such as AE or EB (Colado and Triplett 2008), or even manual resistance. AE are gaining in popularity, especially with the senior population, and this technique is easy to teach and should result in more gains from the exercise program since the level of intensity can be better controlled. However, the specific use of the OMNI perceived exertion scale for resistance exercise was not a question of our study; indeed, the study was not designed to address this specific issue. Future studies could be performed which compare the effects of programs with or without the use of this scale.

Conclusions

One of the primary goals of any exercise program is to improve not only overall health, but functional ability and the performance of activities of daily living. Although most of the improvements that were seen in the health-related measured variables (blood chemistry, blood pressure, body composition) in the exercise groups of the current investigation were not significantly different to the control group values (i.e., no interaction effect), there was an obvious time effect of the training program, and there were significant improvements due to the training when compared to a group that did not exercise. Thus, training with aquatic resistance exercises is a viable alternative to traditional resistance with EB, and may provide more benefits to individuals who would be more sensitive to heavier loading or to impact, which may occur when training on dry land with certain devices and exercises.

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