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ORIGINAL RESEARCH

Effects of a 10-week combined Aerobics and Aquafitness training program on anthropometric parameters, aerobic fitness, muscle endurance, and dynamic balance in middle-aged women

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Abstract

Background: Physical inactivity represents a growing global concern, particularly affecting middle-aged women by increasing risks of adverse health outcomes and functional limitations. Existing research has demonstrated significant health and fitness benefits from individual land-based (e.g., Aerobics) and water-based (e.g., Aquafitness) exercise programs. However, limited evidence exists regarding the effects of combining these training modalities. **Objective:** This study aimed to examine the effects of a 10-week combined Aerobics and Aquafitness training program on anthropometric parameters, aerobic fitness, muscle endurance, and dynamic balance in middle-aged women. **Methods:** Thirty middle-aged women (mean age ± *SD* = 55.5 ± 4.1 years) were allocated into an experimental group (EG) or a control group (CG). The EG completed a 10-week training program consisting of two Aerobics sessions and two Aquafitness sessions per week. The CG maintained their usual activity levels without structured exercise. Outcome measures included body weight, waist circumference, hip circumference, body mass index, waist-to-hip ratio, resting heart rate, 2 km walk test, push-up test, chair squat test, crunch test, and tandem walking backwards. **Results:** Baseline comparisons revealed no significant difference between EG and CG except waist-to-hip ratio ($p < .001$) and chair squat test ($p < .001$). Within-group analysis showed significant reductions in body weight ($p < .001$), waist circumference ($p < .001$), hip circumference ($p = .002$), body mass index ($p < .001$), and 2 km walk test ($p < .001$) in the EG. Additionally, significant improvements were observed in the EG for chair squat test ($p = .003$), crunch test ($p < .001$), and tandem walking backwards ($p < .001$). The CG showed no significant within-group changes for these variables. **Conclusions:** A 10-week combined Aerobics and Aquafitness program significantly improved anthropometric parameters, aerobic fitness, muscle endurance, and dynamic balance in middle-aged women. These findings support the efficacy of combined training approaches, particularly for women with sedentary occupations.

Keywords: physical inactivity, middle-aged women, combined training program, aerobics, aquafitness, physical fitness

Introduction

Physical inactivity is a growing global concern, posing significant health risks (Dumith et al., 2011). Women, in particular, face unique challenges in maintaining regular physical activity due to factors such as limited social support and lack of motivation (Litt et al., 2011; Power et al., 2011). Addressing these challenges is crucial, as physical inactivity can exacerbate existing health conditions in women and lead to functional limitations (Booth et al., 2012). Fortunately, numerous studies have established the well-documented benefits of regular physical activity. Research has shown that engaging in physical activity reduces the risk of weight gain, improves quality of life, and enhances physical fitness (Brach et al., 2004; Rýzková et al., 2018; Šmída et al., 2018; Urbanova & Labudova, 2010).

Physical fitness itself is a multifaceted concept that encompasses both physical and functional capabilities, enabling individuals to effectively respond to physical demands and environmental stressors (Caspersen et al., 1985). This adaptability and overall health status are influenced by a person's fitness level, which is developed and maintained through appropriate and consistent exercise (Godin et al., 2008). Interestingly, women's engagement in physical activity is often shaped by their experiences during childhood and adolescence. Long-term adherence to exercise can be positively influenced by choosing activities they find enjoyable (Othman et al., 2022). Swimming and water-based activities rank as the third most popular sport among female high school students. This preference is similarly observed among adult women, indicating a consistent interest in aquatic exercise across different age groups (Brunovský, 2023). This highlights the importance of understanding and accommodating women's preferences when promoting and designing physical activity programs.

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The latest guidelines for optimal physical activity in adults recommend a combination of aerobic exercise and strength training, typically structured according to the FITT principle: Frequency, Intensity, Time, and Type (Piercy & Troiano, 2018). This principle outlines key components of an effective training program, including frequency (3–5 sessions per week), intensity (moderate, corresponding to 40–60% of maximum heart rate), duration (150 min per week), and type of exercise (American College of Sports Medicine, 2021; Young et al., 2022). Among various exercise options, many women find group-based, music-driven activities such as Aquafitness particularly appealing due to their social and engaging nature (Urbanova & Labudova, 2010). This form of exercise offers significant health benefits, with its physiological impact reportedly comparable to endurance running (Garber et al., 1992; Nieman, 1990). Similarly, water-based exercise programs, collectively known as Aquafitness, provide an alternative with reduced impact on joints and potentially lower cardiovascular strain while maintaining intensity due to water resistance (Hallage et al., 2010; Porcari et al., 1995; Zuzda et al., 2019). Moreover, participation in Aquafitness training programs does not require prior swimming skills (Urbanova & Labudova, 2010).

Numerous studies have demonstrated the health and fitness benefits of both Aerobics (Abadi et al., 2019; Avelar et al., 2010; Broman et al., 2006; Kantyka et al., 2015; Kim & O'Sullivan, 2013; Moreira, 2004; Pinto et al., 2014) and Aquafitness (Avelar et al., 2010; Gaspard et al., 1995; Hallage et al., 2010; Zuzda et al., 2019). While existing research has examined the effects of these individual exercise modalities, relatively few studies have investigated the potential benefits of combining land-based and water-based training. Emerging evidence suggests that such combined programs may be particularly effective for middle-aged women (Colado et al., 2012; Torlaković et al., 2010).

This study aims to examine the effects of a 10-week combined training program incorporating both land-based Aerobics and water-based Aquafitness on anthropometric parameters, aerobic fitness, muscle endurance, and dynamic balance in middle-aged women. The findings will contribute to a better understanding of how combined exercise programs influence health and fitness in this population, potentially addressing the unique needs and preferences of women regarding physical activity.

Methods

Participants

The study sample consisted of 30 middle-aged women (mean ± *SD*: 55.5 ± 4.1 years) with sedentary jobs. Participants were recruited through personal contact and had to meet specific inclusion criteria: they were required to be between 50 and 60 years old, have a body mass index (BMI) of 25 kg/m² or higher (indicating overweight), and have no history of musculoskeletal injuries that could hinder their participation in exercise tests. Additionally, they had to be free from neurological, cardiovascular, respiratory, hormonal, or muscular disorders. Women who regularly participated in structured exercise programs or had medical conditions that might interfere with the study were excluded. The inclusion of overweight individuals was intentional, as the study aimed to assess the effects of the intervention on a population at increased risk for certain health conditions.

Initially, 39 women were enrolled and purposive-randomly assigned to either the exercise group (EG, n = 20) or the control group (CG, n = 19). The EG participated in a 10-week combined training program with four exercise sessions per week: two Aerobics sessions and two Aquafitness sessions. To ensure consistency, participants in this group were required to complete at least 95% of the training sessions. They were also asked to limit any additional physical activity to no more than 20 min per session, twice a week, outside of the program.

Before and after the study, participants completed a survey assessing their habitual physical activity, including work-related tasks, household chores, leisure activities, and commuting. While the EG maintained strong motivation and engagement throughout the study, the CG experienced a decline in participation due to reduced motivation, self-initiated exercise, or emerging health concerns. As a result, nine CG participants were excluded for failing to adhere to the inactivity requirements or due to health complications. Ultimately, 30 women completed the study according to the established protocols. The CG did not participate in any formal physical activity program for the 10-week period and were instructed to refrain from structured exercise exceeding 20 min per session, more than twice a week. The higher dropout rate in the CG resulted in a smaller final sample size for this group, whereas the EG maintained stable participation throughout the study. All participants provided informed consent by signing a formal document outlining their involvement in the research project. The research was part of a grant project VEGA no. 1/0427/23 supported by the Ministry of Education, Science, Research and Sport of the Slovak Republic. The research was approved by the FPES CU Committee of Ethics in Bratislava (ref 9/2023) and adhered to the Declaration of Helsinki established by the World Medical Association.

Training protocol

The experimental group participated in a 10-week combined exercise program, consisting of two consecutive exercise sessions twice per week. The first session was a 50-min Aerobics class held in a gym, while the second session was a 50-min Aquafitness class conducted in a pool with a water temperature of 30 °C. The intervention consisted of 40 exercise sessions. Each session followed a structured format, including a preparatory phase (warm-up and stretching), a main phase (aerobic and strength exercises), and a concluding phase (cool-down and post-stretch). The Aerobics session focused on low-impact aerobic exercises combined with bodyweight resistance training (Table 1). The main phase included fundamental aerobic movements such as squats, V-steps, cha-cha, side-to-side steps, marching, and step touch. Strength training was performed in

Table 1 Structure of the Aerobics training unit

Training unit component	Duration (min)	Characteristics
Warm-up	10	Cardiorespiratory warm-up + pre-stretch.
Conditioning and endurance phase	32	Short aerobic block – choreography consisted of basic movements of low impact Aerobics, (rating of perceived exertion 5–6 at the Borg scale) Long strength training block of controlled, dynamic power (60% of one-repetition maximum, 8–15 repetitions, 3 series) – standing up with own weight, and floorwork strength training of lower body, glutes, upper body (arms, shoulders), abdominal and back muscles
Cool-down	8	Cardiorespiratory cool-down + post-stretch

Table 2 Structure of the Aquafitness training unit

Training unit component	Duration (min)	Characteristics
Warm-up	10	Thermal warm up (raising body temperature through aerobic exercises, as people often feel cold when entering the pool) + pre-stretch + cardiorespiratory warm-up
Conditioning and endurance phase	35	Long aerobic block – choreography consisted of basic Aquafitness movements (rating of perceived exertion 3–4 at the Borg scale) Short strength training block of dynamic power in endurance (20–40% of one-repetition maximum, 15–40 repetitions, 3 series) – strength training of lower body, upper body (arms, shoulders), abdominal and back muscles
Cool-down	5	Cardiorespiratory cool-down + post-stretch

both standing and floor positions, targeting major muscle groups, including the lower body (e.g., squats, lunges), core, back, and upper limbs. The session concluded with stretching exercises to relax and lengthen the muscles most engaged during training. The Aquafitness session followed a similar structure (Table 2). The warm-up phase lasted 10 min and included aquatic running, jumps, kicks, and twists at different intensities and directions, followed by dynamic stretching exercises targeting major muscle groups. The main phase consisted of a strength endurance block using water noodles, with exercises focused on strengthening the upper and lower limbs and core. This was followed by an aerobic block incorporating Aquafitness movements and dance choreography, ensuring symmetrical engagement of both body sides to enhance cardiovascular endurance. The 35-min main phase was concluded with a 5-min cool-down, including light basic aquafitness movements and stretching exercises.

Procedure

Participants underwent measurements and testing within the same controlled environment over the course of a single week. They were instructed to avoid strenuous exercise the day before testing and to arrive well-rested and properly hydrated. Anthropometric parameters and aerobic fitness were assessed 24 hours before the motor tests. To ensure data reliability, each motor test was performed twice. Prior to the initial testing session, participants attended a preparatory session to learn the correct execution of each exercise. Additionally, identical equipment was used for both pre- and post-program measurement sessions.

Body height was measured from the highest point of the head to the ground using a rectangular ruler placed against a wall-mounted height scale, with results recorded to the nearest 0.1 cm. Body weight (BW) was assessed using an Omron BF 511 (Omron, Kyoto, Japan) scale. Waist circumference (WC) and hip circumference (HC) were measured to the nearest 0.5 cm. Body mass index (BMI) and waist-to-hip ratio (WHR) were then calculated and recorded. Aerobic fitness was evaluated using the 2 km walk test (2KMWT; Zakariás et al., 2003). Resting heart rate (RHR) was measured in the morning immediately upon waking, before getting out of bed. It was palpated using the fingertips of the second, third, and fourth fingers on the carotid artery, lateral to the trachea. The pulse was counted for 10 s and multiplied by six to determine beats per minute (Neuman et al., 2005). Lower limb muscle endurance was assessed using a modified squat test (CST; American College of Sports Medicine, 2021) performed for 1 min, with chair height adjusted to maintain a 90° knee angle. Upper limb muscle endurance was measured using the push-up test (PUT), counting the maximum number of push-ups performed in 1 min (Baumgartner et al., 2002). Abdominal strength endurance was evaluated with the crunch test (CT), recording the number of repetitions completed within 1 min (Nieman, 2007). Dynamic balance was assessed using the tandem walking backwards (TWB) test over six meters (Nelson et al., 1994).

Statistical analysis

All data analyses were conducted using IBM SPSS statistical software (Version 23 for Windows; IBM, Armonk, NY, USA). The Shapiro-Wilk test indicated a non-normal distribution of the observed variable; therefore, non-parametric procedures were applied. The Mann-Whitney U test was used to compare the experimental and control groups at baseline (pre) and after the intervention (post) for all variables. To assess within-group differences (experimental and control), Wilcoxon signed-rank tests were performed. Effect size (r) was calculated and interpreted as follows: .1 was considered a small effect, .3 a moderate effect, .5 a large effect, and .7 or greater a very large effect (Cohen, 1994; Maher et al., 2013). Differences were considered statistically significant at $p < .05$ and highly significant at $p < .001$.

Results

Baseline comparisons revealed no significant differences between the EG and CG for BW (p = .95), WC (p = .66), HC (p = .66), BMI (p = .71), RHR (p = .36), 2KMWT (p = .54), PUT (p = .73), CT (p > .99), or TWB (p = .46). However, significant differences were observed at baseline between the EG and CG for WHR (p < .001) and CST (p < .001). Post-intervention, no significant between-group differences were found for BW (p = .73), WC (p = .90), HC (p = .76), BMI (p = .71), RHR (p = .54), 2KMWT (p = .57), PUT (p = .73), CT (p = .15), or TWB (p = .86). However, significant differences persisted between groups for WHR (p < .001) and CST (p < .001).

As shown in Table 3, the EG significantly reduced their BW (p < .001, r = .54), WC (p < .001, r = .60), HC (p = .002, r = .49), BMI (p < .001, r = .54), and 2KMWT (p < .001, r = .54) after completing the intervention program. There were no significant changes in WHR or RHR in either the exercise or control group, with both groups showing a trivial effect size, suggesting no meaningful or practically significant effect. There were no significant changes in BW, WC, HC, BMI, WHR or 2KMWT within the CG, as indicated by trivial effect sizes, suggesting no meaningful or practically significant effect. Table 4 shows significant improvements in the EG for CST (p = .003, r = –.47), CT (p < .001, r = –.62), and TWB (p < .001, r = .62). There were no significant changes in CST, CT and TWB within the CG, as indicated by trivial effect sizes, suggesting no meaningful or practically significant effect.

Discussion

Our 10-week combined training program significantly improved several anthropometric parameters, including body weight, waist circumference, hip circumference, and BMI. These findings align with existing research on both land- and water-based training programs. Significant reductions in body weight were confirmed in a study by Colado et al. (2012), while changes in waist circumference were reported in research by Torlaković et al. (2010). Improvements were also observed in studies on Aquafitness, which examined different exertion methods and varying program durations. For instance, the study by Abadi et al. (2019) found significant changes in body weight, BMI, and WHR parameters. Similarly, Kim and O'Sullivan (2013) reported reductions in body weight and body fat, while Kantyka et al. (2015) demonstrated BMI improvements. Additionally, Hallage et al. (2010) highlighted positive effects on body composition through land-based aerobic training, as evidenced by reductions in BMI and waist circumference.

Our 10-week combined training program also led to statistically significant improvements in aerobic fitness; however, resting heart rate remained unchanged. In contrast, studies focusing on Aquafitness, such as those by Broman et al. (2006) and Pinto et al. (2014), reported significant improvements in both resting heart rate and aerobic fitness. Similar findings have been observed in numerous land-based training studies, particularly those focusing on Aerobics (Hallage et al., 2010; Porcari et al., 1995; Zuzda et al., 2019).

The program also resulted in significant improvements in lower limb muscle endurance, abdominal muscle endurance, and dynamic balance. However, no significant changes were observed in upper limb muscle endurance. This aligns

Table 3 Means, standard deviations, and differences in body weight, waist circumference, hip circumference, body mass index, waist to hip ratio, resting heart rate, and aerobic fitness

Variable	Experimental group		Control group	
	Pre-test	Post-test	Pre-test	Post-test
Body weight (kg)	80.80 ± 14.67	79.35 ± 14.58**	82.00 ± 15.76	82.00 ± 15.80
Waist circumference (cm)	93.30 ± 11.02	91.25 ± 11.06**	90.30 ± 13.46	90.60 ± 13.86
Hip circumference (cm)	107.70 ± 12.27	106.20 ± 11.83*	109.60 ± 14.57	109.60 ± 14.94
Body mass index (kg/m²)	28.48 ± 4.89	27.97 ± 4.87**	30.09 ± 5.84	30.09 ± 5.87
Waist to hip ratio	0.87 ± 0.08	0.86 ± 0.08	1.22 ± 0.07	1.21 ± 0.07
Resting heart rate (beats/min)	65.70 ± 3.70	65.50 ± 3.41	64.60 ± 2.27	64.90 ± 2.28
2 km walk test (s)	1240.70 ± 90.45	1208.08 ± 77.32**	1262.09 ± 60.10	1259.67 ± 64.39

Note. Asterisks indicate a statistically significant within-group difference (*p < .05, **p < .001) between Pre- and Post-test.

Table 4 Means, standard deviations, and differences in lower and upper limb muscle endurance, abdominal strength endurance and dynamic balance within each group

Variable	Experimental group		Control group	
	Pre-test	Post-test	Pre-test	Post-test
Chair squat per minute test (reps/min)	40.05 ± 6.16	42.70 ± 7.29*	30.60 ± 4.50	30.70 ± 5.10
Push up per minute test (reps/min)	11.15 ± 8.94	11.90 ± 8.22	11.30 ± 3.83	11.00 ± 3.23
Crunch per minute test (reps/min)	21.65 ± 7.70	24.55 ± 7.86**	23.70 ± 7.60	23.50 ± 7.32
Tandem walking backward (s)	13.78 ± 2.72	12.90 ± 2.32**	12.64 ± 1.88	12.66 ± 1.91

Note. Reps = repetitions. Asterisks indicate a statistically significant within-group difference (*p < .05, **p < .001) between Pre- and Post-test.

with findings from various studies on Aquafitness training programs, which have reported similar improvements. For example, Avelar et al. (2010) observed enhancements in both static and dynamic balance, while Moreira (2004) reported improvements in abdominal and upper limb muscle endurance. Kim and O'Sullivan (2013) found increased balance and lower limb strength, while Pinto et al. (2014) documented improvements in overall strength in both the upper and lower limbs. Land-based Aerobics studies, such as those by Hallage et al. (2010), have also reported significant improvements in motor parameters, including enhanced dynamic balance and muscle endurance in both upper and lower limbs. Additionally, research on combined land- and water-based exercises (Colado et al., 2012; Torlaković et al., 2010) has yielded similar results. Notably, our findings regarding lower limb and abdominal muscle endurance are consistent with the conclusions of Colado et al. (2012).

This study has several limitations. The relatively small sample size and certain challenges within the control group limit the generalizability of the findings. Additionally, the study duration was relatively short, and the lack of detailed information on participant adherence and baseline fitness levels restricts the depth of the conclusions. Future research should address these limitations by incorporating larger sample sizes, longer intervention periods, and more comprehensive participant assessments to strengthen the evidence base.

Conclusions

Our findings, along with existing research, suggest that incorporating combined training programs may offer significant benefits for women with sedentary occupations. Such programs can integrate land-based activities, such as Aerobics, with Aquafitness to enhance physical fitness. Our 10-week training program, which combined Aerobics and Aquafitness, demonstrated positive effects on anthropometric parameters, aerobic fitness, muscle endurance, and dynamic balance in middle-aged women. These improvements are likely to contribute to increased overall fitness, enhanced daily functioning, and potentially improved health outcomes. The structured training content is well-suited for women with sedentary jobs and can be readily implemented in practical settings.

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Conflict of interest

The authors report no conflict of interest.

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