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Original Article

Effects of aquafitness with high intensity interval training on physical fitness

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Abstract:
The aim of the study was to investigate the effect of a 10-week aquafitness program with the inclusion of high intensity interval training on selected biological and motor parameters of female college students. Sixteen volunteers (age: 21.1± 3.2 years, body height: 171.0 ± 5.6 cm and body mass: 60.62 ± 5.5 kg) were randomly divided into two groups. A control group (CG, n=8) continued with their regular daily activities without involvement in any physical exercise program. An experimental group (EG, n=8) completed a 10-week shallow water training program with a frequency of 50-minute sessions twice per week. Three blocks of HIIT (Tabata format) were included into the continuous aerobic training unit. The physical activity intensity level was measured by the heart rate monitor (Polar RS400). EG showed a significant decrease in waist circumference, body fat percentage, waist to hip ratio, resting heart rate, an improvement of static balance, flexibility of the hamstrings and lumbar spine (p 0.05) and dynamic balance (p 0.001). Aquafitness with inclusion of HIIT can offer significant benefits in physical fitness of female college students.
Key Words*:* aquafitness, high intensity interval training, biological parameters, motor parameters, female

Introduction

In the overall adult population, current recommended amount of physical activity is 150 minutes per week of moderate continuous exercise or 75 minutes per week of vigorous exercise [1]. Adaptation processes lead to morphologic and functional changes, depending on type and range of physical load, age, gender and external conditions [2]. Level of physical fitness depends on frequency, intensity, time and type of physical activity [3]. Aquafitness is a motional activity of mostly aerobic character, performed in water environment with or without the music [4]. Suggested length of an aquafitness unit is 20 – 60 min, depending on the training level of individuals and program purpose. Aquafitness types are divided according to training methods into continuous training with constant load intensity, circuit training (training stations) and interval training consisting of high- and low-intensity intervals [5]. Medium to high exercise intensity is recommended for majority of adult population and low to medium for non-trained people [6]. In order to attract more participants, aquafitness went through several changes [7]. Beside new types of equipment, new streams of aquafitness have been established. High intensity interval training (HIIT) with intermittent physical loading is defined as a repetition of high intensity bouts followed by varied recovery times [8]. Many studies used the repetition of short (less than 30 sec) and long (up to 3 min) intervals of high intensity alternated with active or passive recovery intervals where the work to recovery ratio is 1:1, 2:1, 1:2 [8-10]. HIIT provide similar advantages to continual endurance training, but in shorter period of time [8,11]. HIIT workout lasts for 20 – 60 minutes. Various protocols of interval training have been included into water fitness programs, e.g. Tabata [9].

Efficient aquafitness program results from 2-3 training units per week with 1-2 resting days in between [3,12,13]. Less than two training units are insufficient for achievement of functional changes [4]. Interval training is considered an effective way to improve overall and exercise intensity, which may be beneficial for adults. Continuous water training session should reach the intensity load of 50-85 % VO2max or 77-90 % HRmax [14]. Subjective evaluation using Borg scale of 6-20 [15] points should reach the level of 12-16 points [45]. However people with higher performance ability are recommended to include intermittent physical loading into training session, which can contain high intensity intervals reaching 85 % VO2max or 80-95 % HRmax [8,716]. According to Borg scale it should reach the level of 15-19 points. Maximum continuous and intermittent exercises with great fraction of anaerobic load are safe and may be included in training session for healthy population group [17]. Many research studies of aquafitness commonly practiced by older adults have concluded the positive changes in heart rate, body composition, cardiorespiratory endurance, strength, and range of motion [18-22] as well as improvements in the level of quality of life, well-being and cognitive function [23-25]. Furthermore, the effectiveness of aquafitness programs with inclusion of intermittent physical loading of high intensity was confirmed by positive changes of physiological and psychological indicators of special populations as well as people with various health disorders in previous studies [26-28].

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Additionally, some authors [29-31] have concluded the benefits of continuous aquafitness training of young adults. There were just a few studies that verified the effects of aqua HIIT on various variables of young adults [32,33]. However do the HIIT sequences included into a continuous aquafitness lesson provide the benefits in untrained young individuals?

From a practical perspective, the moderate continuous exercise requires a relatively large time commitment. From a psychological perspective, post exercise pleasure and enjoyment are higher during HIIT than during continuous exercise [34,35]. Moreover, proper and enjoyable selection of activities motivates to participate in physical activity and build up a positive and long-lasting relationship to it [4]. The present study was designed in order to answer whether the specific training program used, induced adaptations in body balance, body composition, flexibility and resting heart rate, compared to doing nothing in previously untrained young individuals. Thus, the aim of the study was to investigate the effect of a 10-week shallow water aquafitness program with inclusion of HIIT in the continuous protocol on selected biological and motor parameters of female college students.

Material & methods

Participants

The participants consisted of 16 female students of Comenius University in Bratislava (age: 21.1± 3.2 years, body height: 171.0 ± 5.6 cm, body mass: 60.62 ± 5.5 kg and BMI 20.5 ± 1.02 kg.m-2) divided into two groups: 1) an experimental group (EG, n = 8), where a 10-week shallow water aquafitness program with inclusion of HIIT was applied, 2) a control group (CG, n = 8), where subjects continued with their regular daily activities (school, studying, part-time job, housekeeping) without involvement in any physical exercise program for 10 weeks. All the women were healthy university students, previously untrained, conducted similar activities in the daily life (checked once a week, randomly). They were instructed not to modify their behavior or diet and EG was instructed not to do any other type of physical exercise except aquafitness for the duration of the study. The participants completed physical activity and health history questionnaire and signed informed consent forms. The research was granted an ethical approval by The FPES CU Committee of Ethics in Bratislava (ref 6/2016) and was in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki). The study was completed in April 2016.

Training protocol

The EG completed a 10-week aquafitness program with water depth up to central chest area (impact level 1) and up to shoulder (impact level 2), with a frequency of two training units per week. Combined aquafitness program included three blocks of high intensity intervals (Tabata formula) separated with continuous parts. One training unit lasted 50 minutes and was performed in the pool at Faculty of Physical Education and Sports, Comenius University in Bratislava. Water temperature was set to 28° C. Building up the structure of training units, we followed the suggestions of authors of previous studies [5,16,36,37]. The structure of training unit (Table 1) consisted of the warm-up, conditioning and endurance phase (HIIT - Tabata bouts alternated with continuous part of training) and finishing with the cool-down. Tabata consisted of 20 s of high intensity exercise, followed by 10 s of rest. This cycle was repeated 8 times for a total of 4-minutes. Each of our three Tabata bouts contains two different preferably bilateral exercises (e. g. kicks, run, jumping jack, jumps, scissors, arm patterns) performed for times each with as many repetitions as possible and always maintaining the proper technique. Continuous part of training unit consisted of strength endurance exercises of main muscle groups (basic aquafitness movements and combinations), with the purpose to maintain the moderate intensity load at aerobic training zone. All subjects exercised at target heart rate intensity appropriate to the part of training unit.

Table 1 The structure of training unit

Training unit components	Duration	Characteristics
Warm-up	10 min	Basic movements and combinations for thermal warm, prestretch and cardiorespiratory warm-up (e.g. run, kicks, jumps, jacks in various directions and planes).
Conditioning and endurance phase	4 min	HIIT - Tabata: 2 exercises of 4 rounds each one (e. g. kicks, run, jumping jack, jumps, scissors or arm patterns), 8 x 20 s of high intensity, 2:1 work to passive rest ratio.
	12 min	Continuous part: strength endurance exercises of main muscle groups of moderate intensity. Moement combinations: lower limb flexors + extensors (e.g. combinations of front and back kicks), chest + back (e.g. push and pull arm patterns), abs + plyo (e.g. double front kicks + jumps).
	4 min	HIIT - Tabata: 2 exercises of 4 rounds each one (e. g. kicks, run, jumping jack, jumps, scissors or arm patterns), 8 x 20 s of high intensity, 2:1 work to passive rest ratio.
	12 min	Continuous part: strength endurance exercises of main muscle groups of moderate intensity. Movement combinations: lower limb abductors + adductors (e.g. combinations and alternations of side kicks) with arm patterns, abs + plyo (e.g. double side kicks + jumps.
	4 min	HIIT - Tabata: 2 exercises of 4 rounds each one (e. g. kicks, run, jumping jack, jumps, scissors or arm patterns), 8 x 20 s of high intensity, 2:1 work to passive rest ratio.
Cool-down	4 min	Cardiorespiratory cool down and the poststretch.

Procedure

The participants were measured in the mornings of the same week, in a controlled environment with constant temperature. Participants were asked to abstain from vigorous exercise the day before testing days, encouraged to rest the evening prior, and to arrive to the lab in a hydrated state, after personal hygiene. The biologic parameters were measured 24h before the physical tests. All motor tests were measured two times in the same week to minimize learning effects and to obtain reliability data. The participants attended one session before the pre- and post- motor tests, to learn proper technique. All pre- and post- measurements used the same techniques and identical equipment for all participants.

Biological parameters assessment

The body weight were measured using Omron BF511 (Omron Inc. Osaka, Japan) portable digital scale and body analyzer with accuracy of 0.1 kg, while standing in the middle of the scale, with the minimum possible clothes. To measure body height (BH), participants were barefoot and their heads, shoulder blades, buttocks and heels were touching the wall, to which the tape was fixed. Waist circumference (WC), hip circumference (HC), right arm circumference (RAC), left arm circumference (LAC), right thigh circumference (RTC), left thigh circumference (LTC) were measured to the nearest 0.5 cm [38]. The body fat (BF) percentage was measured by bioimpedance analysis by OMRON BF511. For percent body fat estimation the standard error of the estimate (SEE) of the device is 3.5% (instruction manual, OMRON BF511, technical data). We established body mass index (BMI) and waist to hip ratio (WHR) values before and after the training. Baseline resting heart rate (RHR) was obtained manually at enrolment with one radial pulse measurement during 60 s with the patient in the sitting position [39]. Before the beginning of the training program, we calculated Kruel aquatic heart rate deduction for each participant and determined individual's heart rate training zones [45]. An integrated telemetric monitor (Polar RS400) was used for the measurement of load heart rate (HR) and to check the effectiveness of the training unit content. Observed functional HR curves, according to values reached, were evaluated individually in the range of the five HR training zones (Table 2) [40,41].

Table 2 HR training zones [40,41]

Zone	**Exercise intensity**
1 (50 – 59% $HR_{reserve}$)	Very light intensity - health & aids recovery
2 (60 – 69% $HR_{reserve}$)	Light intensity aerobic exercise
3 (70 – 79% $HR_{reserve}$)	Moderate intensity aerobic exercise
4 (80 – 89% $HR_{reserve}$)	Mixed aerobic-anaerobic intensity / lactatic anaerobic intensity
5 (90 – 100% $HR_{reserve}$)	Maximal intensity - lactatic anaerobic intensity

Motor parameters assessment

Postural balance parameters were measured by a computer based stabilographic system FITRO Sway check, Fitronic Slovakia. The system monitors the horizontal code of points (COP) movement based on the analysis of the distribution of vertical forces registered by means of 4 tensometric force sensors in corners of stabilographic platform at a frequency 100 Hz [42]. The mean velocity of COP was calculated from stabilographic curve. The subjects underwent two 30-second tests of : standing on one leg with eyes opened (S1EO), standing on two legs with the eyes opened (S2EO), standing on two legs with eyes closed (S2EC), performance tests of postural stability in medio-lateral (PTM-L) direction and performance test of postural stability in antero-posterior direction (PTA-P) [43]. Criterion for evaluation was mean value of two attempts [44]. Dynamic balance was measured by testing Tandem walking backward (TWB) for 6 meters [45]. Flexibility of backside thigh muscle and lower spine were examined by testing Sit-and-Reach (SR) test [46].

Statistical Analyses

Normality and homogeneity of the parameters were checked with Shapiro-Wilk test and Levene's test, respectively. Processing and evaluation of the collected primary data was completed using basic mathematical and statistical methods. Results are reported as means and standard deviations. The results obtained were evaluated statistically using the T- test for dependent participants - to opinion of differences between average in group, and T-test for independent participants – to opinion of differences between averages for independent groups. Differences at the level of $*p<0.05$ were accepted as significant. Effect size (ES) were calculated and defined as follows: small $d<0.5$, medium $d = 0.5–0.79$, large $d>0.85$ [47]. The SPSS statistical software package (version 23.0) was used to analyse all data.

Results

Acute heart rate response during the training unit

The results imply that continuous part of the training unit had light to moderate intensity character and high intensity character in HIIT parts. From the response of HR to HIIT, we conclude that participants moved in mixed zone. Fig. 1 provides the HR response of participant during the main part of the training unit.

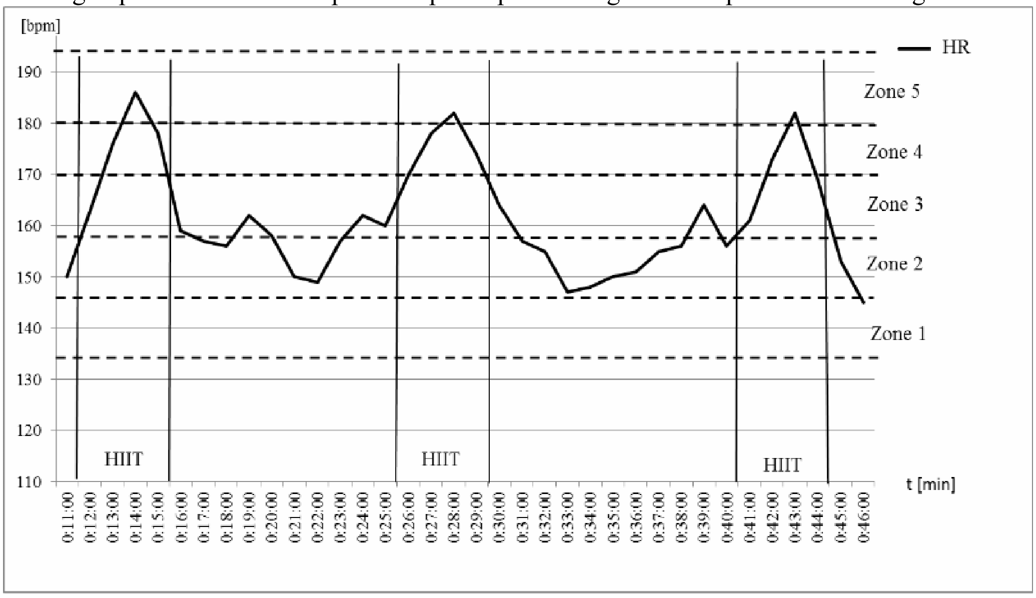


Fig. 1 The course of the HR curve during the main part of training unit of the participant

Acute HR reaction of participant during main part of training unit ranged 37.14 % of time (13 min) in light intensity exercise zone, 32.86 % of time (11min and 30 sec) in moderate intensity exercise zone, 22.9 % of time (8 min) in mixed intensity zone, 7.14 % of time (2 min and 30 sec) in maximal intensity zone. According to the individual water HR training zones (Table 3), the HIIT sequences of the participant included moderate to maximal load intensity (70 – 95.87 % HRreserve).

Table 3 Individual water HR training zones of participant

Zone	HR_{water} [bpm]	Exercise intensity
1 (50 – 59% $HR_{reserve}$)	134 – 145	Very light intensity
2 (60 – 69% $HR_{reserve}$)	146 - 157	Light intensity
3 (70 – 79% $HR_{reserve}$)	158 – 169	Moderate intensity
4 (80 – 89% $HR_{reserve}$)	170 – 180	Mixed intensity
5 (90 – 100% $HR_{reserve}$)	181 - 194	Maximal intensity

Effects of intervention in selected biologic variables

As shown in Table 4, the EG significantly decreased their WC ($p < 0.05$, d = 0.313), BF volume ($p < 0.05$, d = 1.132), WHR index ($p < 0.05$, d = 0.687) and RHR ($p < 0.05$, d = 0.602). Somatic and functional variables did not prove significant changes and show trivial effect size in the CG.

Table 4 Changes in selected biological variables

	EG				**CG**			
Dependent Variables	**Pre-Test Mean ± SD**	**Post-Test Mean ± SD**	**P value**	**ES d**	**Pre-Test Mean ± SD**	**Post-Test Mean ± SD**	**P value**	**ES d**
BW (kg)	60.36 ± 6.9	60.15 ± 6.59	0.388	0.031	60.9 ± 3.96	61.0 ± 4.38	0.854	0.021
WC (cm)	70.18 ± 4.46	68.79 ± 4.41	0.014*	0.313	70.1 ± 3.67	70.4 ± 3.87	0.42	0.083
HC (cm)	95.19 ± 5.46	95.13 ± 4.91	0.922	0.012	95.1 ± 5.65	95.3 ± 5.53	0.685	0.034
RAC (cm)	25.75 ± 2	26 ± 1.81	0.227	0.131	25.5 ± 1.69	25.6 ± 1.48	0.735	0.039
LAC (cm)	25.81± 1.81	26.12 ± 1.78	0.217	0.174	25.4 ± 1.22	25.6 ± 1.24	0.442	0.153
RLC (cm)	52.44 ± 3.97	53.06 ± 2	0.445	0.198	53.1 ± 3.10	53.2 ± 3.32	0.611	0.039
LLC (cm)	52.25 ± 4.3	52.75 ± 2.12	0.598	0.147	53.0 ± 3.53	53.3 ± 3.72	0.154	0.097
BF (%)	19.18 ± 2.91	16.3 ± 2.38	0.002*	1.132	19.48 ± 2.06	19.56 ± 1.86	0.816	0.045
BMI ($kg.m^{-2}$)	20.5 ± 1.2	20.44 ± 1.23	0.472	0.051	20.8 ± 0.73	20.9 ± 1.09	0.710	0.067
WHR	0.73 ± 0.02	0.71 ± 0.01	0.014*	0.687	0.74 ± 0.04	0.74 ± 0.04	0.442	0.098
RHR (bpm)	75 ± 5.68	72 ± 4.18	0.002*	0.602	74 ± 6.32	74.75 ± 4.77	0.605	0.134

BW - Body Weight; WC - Waist Circumference; HC - Hip circumference; RAC - Right Arm Circumference; LAC - Left Arm Circumference; RLC - Right Leg Circumference; LLC - Left Leg Circumference; BF - Body

Fat; BMI – Body Mass Index; WHR – Waist to Hip Ratio; RHR - Resting Heart Rate; EG - Exercise Group; CG - Control Group; ES (d) – Effect Size (Cohen's d); SD - Standard Deviation; *p < 0.05 between Pre-Test and Post-Test in EG;

The EG was significantly better than the CG for the BF (p □ 0.05, d = 1.569) after the training program (Fig. 2).

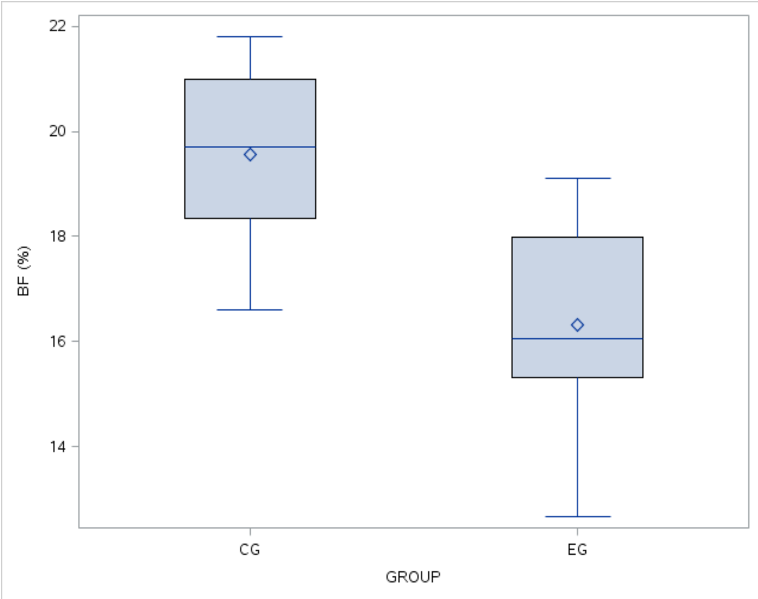


Fig. 2 Body Fat - Post-Test

Effects of intervention in selected motor variables

As shown in Table 5, the EG significantly decreased their static balance in tests S1EO (p □ 0.05, d = 0.78), S2EO (p □ 0.05, d = 0.71), S2EC (p □ 0.05, d = 0.38), PTML (p □ 0.05, d = 0.75), PTAP (p □ 0.05, d = 0.49). Static balance variables did not prove significant changes and show trivial effect size in the CG.

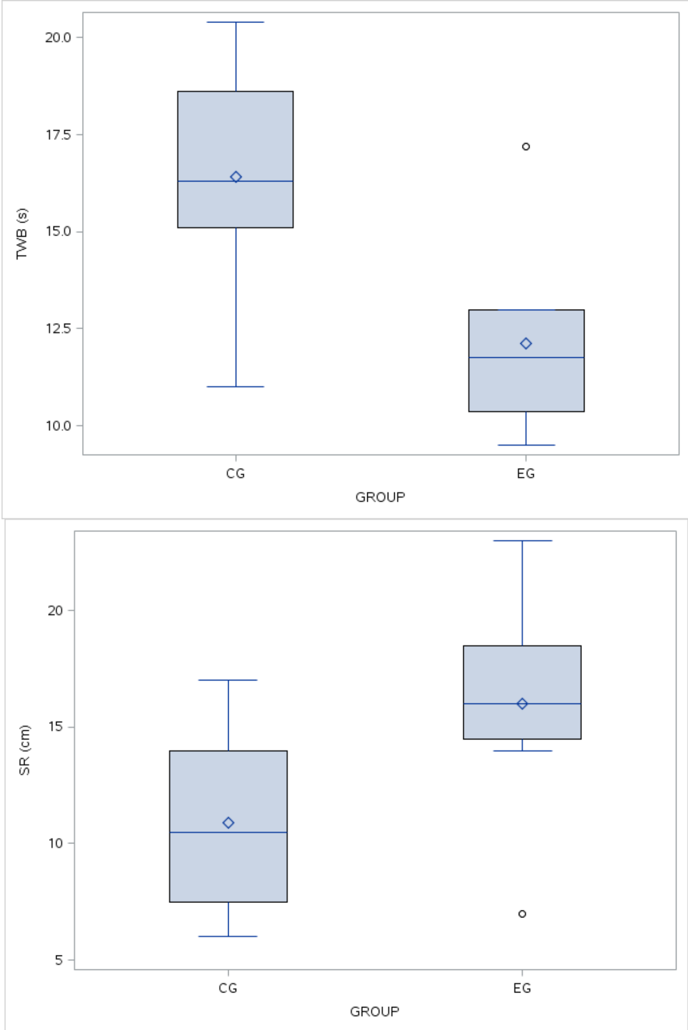
Significant improvement was observed in the case of dynamic balance in test TWB (p □ 0.001, d = 1.214), backside thigh muscle flexibility and lower spine in test SR (p □ 0.05, d = 0.621) in the EG. The variables of dynamic balance and backside thigh muscle flexibility and lower spine did not prove significant changes and show trivial effect size in the CG.

Table 5 Changes in motor variables

	EG				**CG**			
Dependent Variables	**Pre-Test Mean ± SD**	**Post-Test Mean ± SD**	**P value**	**ES d**	**Pre-Test Mean ± SD**	**Post-Test Mean ± SD**	**P value**	**ES d**
S1EO ($mm.s^{-1}$)	29.99 ± 8.5	26.28 ± 7.76	0.013*	0.78	30.25 ± 8.68	30.13 ± 7.74	0.895	0.015
S2EO ($mm.s^{-1}$)	10.2 ± 2.31	8.6 ± 2.17	0.014*	0.71	10.33 ± 2.71	10.21 ± 2.63	0.767	0.042
S2EC ($mm.s^{-1}$)	13.25 ± 4.46	11.64 ± 3.89	0.01*	0.38	12.95 ± 3.82	12.61 ± 3.02	0.464	0.088
PTML(mm)	16.84 ± 1.58	15.76 ± 1.28	0.015*	0.75	17.61 ± 3.48	17.53 ± 3.45	0.873	0.025
PTAP (mm)	17.14 ± 3.07	15.61 ± 3.17	0.027*	0.49	17.41 ± 2.84	17.65 ± 1.61	0.783	0.103
TWB (s)	15.35 ± 3.22	12.12 ± 2.42	< 0.001**	1.214	16.59 ± 2.15	16.43 ± 2.93	0.637	0.062
SR (cm)	12.88 ± 5.44	16 ± 4.6	0.003*	0.621	11.19 ± 2.8	10.88 ± 3.91	0.685	0.092

S1EO - standing on one leg with eyes opened; S2EO - standing on two legs with the eyes opened; S2EC - standing on two legs with eyes closed; PTML - performance tests of postural stability in medio-lateral direction; PTAP - performance test of postural stability in antero-posterior direction; TWB - Tandem walking backward; SR - Sit and reach test; EG - Exercise Group; CG - Control Group; ES (d) – Effect Size (Cohen's d); SD - Standard Deviation; *p < 0.05 between Pre-Test and Post-Test in EG; **p < 0.001 between Pre-Test and Post-Test in EG

The EG was significantly better than the CG for dynamic balance in TWB test (p □ 0.05, d = 1.603) and backside thigh muscle flexibility and lower spine in SR test (p □ 0.05, d = 1.266) after the training program (Fig. 3).



(a) (b)

Fig. 3 Post-Tests (a) Tandem walking backward; (b) Sit and reach.

Dicussion

This is the first work that uses combined aquafitness program in female university students with the aim of improving their physical fitness and body composition. The most noteworthy findings of this investigation are that aquafitness program with TABATA sequences included into the continuous lesson was effective for female university students with improvement of more biological and motor variables.

Acute HR reaction during TABATA sequences showed that the maximal values of subject reached 95 % HR reserve. From the reaction of HR to TABATA, we conclude that participants moved in mixed zone in HIIT parts, where the load intensity is aerobic-anaerobic. Our findings are in accordance with previous authors' recommendations [16,17] that intermittent exercises of high intensity could be included into aquafitness programs for healthy female students.

Based on the results of this study, we observed a positive effect at the end of 10^{th} week in the EG. The EG decreased their WC, BF volume and WHR index (p□0.05, d = 0.687) from somatic variables. Previous study has also found improvements in WC and WHR in older women [48]. Other study has reported a significant 5 cm reduction in WC and a 3.2 % decrease in WHR with no change in BMI or BW after 12 weeks of deep-water circuit training in older overweight women [49]. However only one study that confirmed our results used methods of assessing somatic variables similar to those used in our work, including selecting a participants from the same sector of the population [22]. There were works which observed no significant differences for body composition indices for group of trained male runners [31] and for group of female students [50]. Comparison of input and output values of BW, HC, RAC, LAC, RLC, and LLC in EG did not prove significant changes. We assume that no significant changes in BW, HC, RAC, LAC, RLC, and LLC are influenced by consequential increase of active body mass - muscular volume and decrease of passive body mass - body fat volume [51]. The different results in previous studies may be due to selecting a participants of population group, differences in duration and intensity of training, the differences in baseline levels of WC, BMI or WHR and the addition of caloric restriction.

Among functional parameters, the EG decreased the RHR (p□0.05, d = 0.602). RHR reduction and improvement of heart economy due to a slight increase in the total volume of circulating blood may occur in just a few weeks or months due to endurance training [2].

In performance test of postural stability, we noticed a significant decrease of centre of gravity motional deviation from the centre in the medio-lateral direction in EG. Testing the dynamic balance by TWB test showed significant time improvement. These results showed that 10 weeks of aquafitness with the inclusion of high intensity interval training can improve static and dynamic balance. Our results are in agreement with the findings of studies [52,53] who found the improvement of balance after the 12 weeks of aquafitness. The study [54] has shown that the period of six weeks is sufficient to develop static and dynamic balance in water environment. Compared to the results of previous studies that obtained balance improving of older adults, we were able to obtain similar results with younger population group of university female students.

Test Sit-and-Reach resulted in statistically significant improvement in flexibility of backside thigh muscle and lower spine in EG. These results are consistent with the findings of the previous study [9], who found the improvement of flexibility after an 8-week aquatic treadmill running Tabata interval-training program. In another study [53] was improved flexibility after the 12-week continuous endurance aquatic training with older women. Therefore, our training protocol was sufficient to obtain similar results with younger adults.

In summary, this study has implications related to the practical applications of this class format as well as the need to further continue this line of research. According to the largest effect size respectively, the combined aquafitness program with the inclusion of high intensity intervals (TABATA) may be an effective way to improve dynamic balance, flexibility of backside thigh muscle and lower spine, body fat, waist to hip ratio and resting heart rate of female college students. However, it remains necessary for further studies to address this issue specifically.

Regarding the design of this study, we should highlight the lack of literature about combined training in a water environment with younger adults to compare with. Secondly, some tests of previous studies were not carried out with the devices used in this study and therefore we lacked a point of reference. Additionally, it would be interesting to compare this in future studies with greater participants and long-term study.

Conclusions

Based on the results, we may conclude that effectiveness of aquafitness program with HIIT was confirmed by positive changes of various somatic, functional and motor indicators. Deeper analysis of HR response to included HIIT blocks pointed to the possibility of load intensity increase in shallow water, which leads to more complex training development.

Our construction of training program in shallow water implies the possibility of improvement of numerous physical fitness indicators. Based on the reported results we can recommend the inclusion of High Intensity Intervals (TABATA format) into aquafitness programs as a safe instrument for developing physical fitness of female college students.

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