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Influence of water gymnastics on strength development
Influenţa gimnasticii în apă asupra dezvoltării forţei

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Abstract

Background. The carrying out of physical activities in various environments, terrestrial and aquatic, through the influences they imprint on the effort made, coupled with the technological innovation of materials, can trigger positive responses of the body, with connotations on the movement ability.

Aims. Improvement of the conditional movement ability parameters by implementing within the physical education classes of first year students from non-sportive specialties, water activities: aquagym and aqua-pullpush-gym.

Methods. The study was conducted during the academic year 2012-2013 and comprised three groups: 2 experimental groups (E1 - Aquagym and E2 - Aqua-pullpush-gym) made up of 24 subjects each and a control group (C) composed of 48 female students. The movement tests targeted the back muscle strength and the abdominal muscle strength.

Results. Following the research performance and the statistical-mathematical analysis of the individual values, it was observed that all research indicators in the two testing sessions recorded obvious progress between the two tests, but the experimental groups' progress was higher than the figures related to the control group. Considering the difference between the average values of the tests, the Aqua-pullpush-gym E2 group recorded when assessing the back muscle strength a significant progress, namely 4.54 executions, and 4.34 executions for the abdominal muscle strength, due to additional demands for the exclusive handling of the pullpush plates. The Aquagym E1 group recorded a progress of 3.16 executions related to back strength and 2.50 executions for the abdominal muscle strength, lower than the E2 group but higher than the control group, whose values were 1.63 executions and 1.83, respectively.

Conclusions. Practicing water gymnastics in its various forms: aquagym and aqua-pullpush-gym, using technological innovation in terms of materials, contributes to improving the components of the conditional ability.

Key words: water gymnastics, aquatic environment, movement ability, strength.

Rezumat

Premize. Desfăşurarea de activităţi fizice în medii variate, terestru şi acvatic, prin influenţele pe care acestea le imprimă efortului depus, corelate cu inovaţia tehnologică a materialelor, pot oferi răspunsuri pozitive ale organismului, cu conotaţii asupra capacităţii motrice.

Obiective. Îmbunătăţirea parametrilor capacităţii motrice condiţionale prin implementarea în cadrul orelor de educaţie fizică a activităţilor acvatice: aquagym şi aqua-pullpush-gym, la studenţii anului I de la neprofil.

Metode. Cercetarea s-a desfăşurat pe parcursul anului universitar 2012-2013 şi a cuprins 3 eşantioane: două experimentale (E1: aquagym şi E2: aqua-pullpush-gym), formate din câte 24 de subiecţii şi unul control (C), format din 48 de studente. Testele motrice aplicate au vizat: forţa musculaturii spatelui şi forţa musculaturii abdominale.

Rezultate. În urma desfăşurării cercetării şi a analizei statistico-matematice a valorilor individuale, se remarcă faptul că toate eşantioanele cercetării la cele două teste au înregistrat progrese evidente între cele două testări, dar progresele grupelor experimentale au fost superioare celei de control. Luând în considerare diferenţa valorilor mediei dintre testări, grupa E2 - aqua-pullpush-gym a înregistrat la evaluarea forţei musculaturii spatelui un progres semnificativ de 4,54 execuţii, iar a musculaturii abdominale de 4,34 execuţii, datorită solicitărilor suplimentare în manevrarea exclusivă a plăcilor pullpush. Grupa E1 - aquagym a înregistrat un progres de 3,16 execuţii la forţa spatelui şi de 2,50 execuţii la forţa musculaturii abdominale, inferior grupei E1, dar superior grupei control, a carei valori au fost de 1,63 execuţii respectiv 1,38.

Concluzii. Practicarea gimnasticii în apă sub diferitele ei forme, aquagym şi aqua-pullpush-gym, care utilizează inovaţile tehnologice în cadrul materialelor, contribuie la îmbunătăţirea componentelor capacităţii condiţionale.

Cuvinte cheie: gimnastica în apă, mediul acvatic, capacitatea motrică, forţa.

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Introduction

There is a direct interrelation between the physiological capacity mechanisms and the practice level of physical exercise, which is influenced by a series of factors, of which environment and its characteristics are the most important.

The introduction of technological innovations in materials and sports facilities induces multiple effects such as: various efforts to carry out motor tasks, increasing the attractiveness and active involvement of students in performing motor tasks, diversification of programs, etc., all in response to modern trends of efficiency increase in education.

Water activities can be rigorously defined as a package of "activities related to water environment, which can be united into programs with clear objectives, adapted to the age and characteristics of the persons who perform them" (Serrano & Rodriguez, 2009, cited by Moisés, 2010).

Bădău (2006) states that "human motor behaviour represents a complex system of movements, attitudes and postures, with the help of which the individual adapts to the different, ever-changing conditions of the environment".

According to Adami (2004), water activities are practiced to improve physical condition and "they use the water resistance and floatability in a creative manner so that the activity is carried out with low impact, combining entertainment with efficiency"; these are "appropriate for all ages and training levels, improving all physical condition components: endurance and muscular strength, body mass composition, aerobic capacity, flexibility and articular development, neuromuscular coordination".

Roseane et al. (2004) show that water activity contributes to physical condition improvement, with the mention that water exercises should be carried out regularly and systematically.

Water gymnastics is "focused on health improvement, organized in classes which include exercises with or without portable objects, with two distinct elements: performing them vertically and maintaining the head above the water. The objective of water gymnastics is to improve the motor and functional capacity, thus developing various components of physical abilities: strength, muscular endurance, respiratory capacity and segmental mobility. The methodology of water gymnastics is based on the water resistance, creating an overload on the trainee's locomotive system" (Teixeira & Barbosa, 2010).

According to studies, with the increase in the number of limbs involved in movement, an increase in the body's response to effort also occurs (Darby & Yaeckle, 2000; Barbosa et al., 2009).

We consider water gymnastics a system of exercises practiced analytically and globally within the water environment, which influences the locomotive system in a precise and selective manner, aiming towards a harmonious physical development, the development of motor, mental and physiological capacities, the improvement of health and implicitly, of the quality of life.

During water activities, support and traction forces are the most important (Prins, 2010).

Studies focused on segmental muscle strength and endurance by practicing forms of water gymnastics, carried out by Sanders, 2001; Colado & Moreno, 2001; Colado et al., 2002; Colado, 2002; Colado, 2003; Colado, 2004, found that systematic practice significantly influenced these motor skills.

Aquagym represents one of the modern trends of physical exercise practice through the combination of various simple and complex action systems, adapted to the positive influences of the water environment, and by using materials such as sticks, ankle sandbags (Bădău et al., 2012).

Aquagym represents an innovative method of motor education technology, being adaptable to particularities specific to age and training level, as well as to individual and group preferences, contributing to an optimal modification of behaviours and physical capacities.

Aquagym uses various aspects of gymnastics, swimming, stretching, dynamic games, all carried out in shallow pools; it brings comfort, stability and security in execution, with major results on muscular and joint recovery. In addition to these, it has a ludic and musical component, thus adding a recreational, entertaining note and ensuring the neuropsychic recovery of participants.

Aqua-pullpush-gym, a newly designed activity, involves a combination of various simple and complex action systems, adapted to the individual particularities and water environment, with complex impact on physical condition and health, combining simple movements with complex movements of body segments or the entire body, using pull-push paddles and fixopié accessories.

Aqua-pull-push gym represents an innovative activity of water gymnastics, consisting of complex movements of body segments, by using exclusively the pull-push paddle, with the view to improve health and physical condition as well as to increase muscle toning.

This method is intended for persons above 18 years of age, regardless of sex, weight or physical training. The basic movements consist of push and pull actions, lift, bring down, stretch and bend moves.

"The exercises with portable objects will amplify the effects of the regular physical exercises, allowing a more precise control over the segments movement and of the entire body" (Bădău & Bădău, 2011).

Di Masi (2000) added that by increasing the speed of execution of the movements, the water flow increases, thus preventing the advance in this area of reduced pressure. Rapidly changing the direction of movement requires overcoming water inertia and turbulence, because in the turbulence flow, resistance is twice the speed.

Objectives

The research focuses on the effects achieved by implementing programs with selected means of action, specific to aquagym - a classic water gymnastics activity, and aqua-pullpush-gym - an activity designed and developed by us. The programs were developed in accordance with a specific methodology adapted to the biomotor characteristics of the subjects, with the view to track the motor effects on students from non-sportive specialities.

Hypothesis

The hypothesis started from the assumption that aquagym and aqua-pullpush-gym practice will improve the selective motor capacity: the abdominal muscles and back muscles.

Material and methods

Research protocol

The study was approved by the Ethics Committee of the universities involved in research and the informed consent of the subjects was obtained. The materials adapted to water gymnastics programs have various shapes and dimensions and help achieve the objectives of the class by requiring additional efforts both in terms of load and handiness, having an ergonomic and modern design through their various shapes and colours.

The objects used in aquagym are built from materials less dense than the water, with a density below 1, which increases their floatability (Canderolo & Caromano, 2004).

The new aqua-pullpush-gym activity exclusively uses pull-push paddles, made by Decathlon, composed of SEBS and polypropylene, having a hydrodynamic flower shape, with five "petals" about 37 cm in diameter, with an ergonomic handle in the centre to hold, which is slightly rough to prevent slipping.

In order to execute exercises for the lower limbs, these also have an accessory called fixopié, which can be fixed to the soles and which looks like sandals, having two clips oriented in complementary directions in order to facilitate fixation with a twisting action.

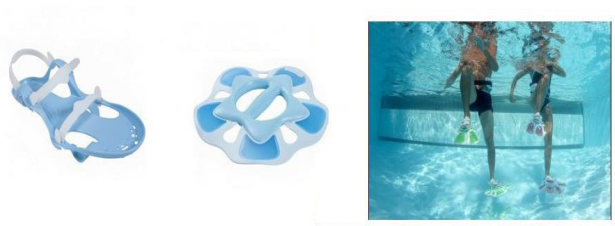

Fig.1 – Fixopié and pullpush paddle (1).

The main differences between the two activities consist of the materials used, their design and usage percentage during the class.

Thus, aqua-pullpush-gym uses the pull-push paddles during the entire *fundamental part*, around 35 minutes, when these are held in hands in order to work on the upper body, fixed on the soles for the lower body, or both held and fixed.

Aquagym has a compound structure for the fundamental part: *the aerobic part* of 15-20 minutes when free exercises are carried out, and the *localized part* of 10-15 minutes with the purpose to train the strength and endurance of muscle segments; various materials can be used to increase their efficiency.

a) Period and place of the research

Two independent variables were used for the experimental plan of the research. They included the educational strategy for the improvement of somatic indices, of motor and functional capacity, by selecting the methods and action means specific to water activities: aquagym and aqua-pullpush-gym.

The research took place throughout the entire university year 2011-2012 (October 2011-May 2012) and consisted of a 50 minute class, held once a week.

The reasearch comprised two tests:

- initial test: 10-21 October 2011;
- implementing the suggested ludic recreational water activities in the experimental group: 24 October 2011 - 11 May 2012;
- final test: 14 May-26 May 2012.

The operational aquagym and aqua-pullpush-gym programs were divided into three levels: beginners, intermediate and advanced, depending on the difficulty degree, on the intensity and complexity of the action systems.

b) Subjects and groups

The research was carried out on 95 subjects assigned to three groups: two experimental groups and one control group.

The experimental groups included 24 first-year female students from the University of Medicine and Pharmacy in Targu Mures, aged between 19 and 23 years. The first group (E1) executed a specific program of aquagym activities, while the second experimental group (E2) executed a specific program of aqua-pullpush-gym, a newly elaborated activity.

The control group (C) consisted of 47 first-year female students from the Transylvania University of Brasov, aged 19-23, from non-sportive specialties; the subjects attended physical education classes held in the gym, where they practiced the following activities: applied exercises, freestyle exercises for general physical development, exercises with portable objects and dynamic games.

c) Tests applied

Two tests were applied:

- The first test for *abdominal muscle strength* - lying on the back with bent legs, ankles stabilized by a partner, arms folded, hands behind the head, executing lifts of the torso for 30 seconds; estimation was related to the subjects' age and number of executions, according to the following scale: excellent: > 43; good: 37-43; above average: 33-36; average: 29-32; below average: 25-28; low: 18-24; very low: < 18
- The second test targeted *back muscle strength* - lying face down, arms folded, hands behind the head, ankles stabilized by a partner, executing trunk extensions for 30 seconds. The number of correct executions carried out in the allocated time interval was recorded.

Content examples of the programs applied in the two experimental groups (Tables I, II)

d) Statistical processing

For statistical calculations, we used SPSS 20.0 for Windows; we calculated Pearson's correlation, as well as the mean and standard deviation, based on which the t test for independent samples was applied.

Results

Table I

Group E1 - *Aquagym – intermediate level.*

Link/ duration	Content	Batch
Aerobic part 25 min.	1. PI: Standing position. Runs: back and forth swings with arms outstretched, palm facing backwards and fingers close.	2x8
	2. PI: Standing, arms folded, hands on the trunk, palms down, arranged one above the other at a distance of 10-15 cm. Small circles are executed in the abdominal area, from left to right and vice versa.	2x8
	3. PI: Standing position, arm straight ahead, left arm backwards. Runs: arm balancing along the body.	2x8
	4. PI: Standing position, arms bent at the torso, palms facing inward. Runs: simultaneously zoom-in and out the arms to the body, back and forth.	2x8
	5. PI: Standing position, arms on the side, submerged below water surface. Taking the arm forward and dynamically lowering the left arm. Return to starting position, similar moves but on the opposite direction.	2x8
	6. PI: Standing position, arms forward, submerged below water surface, palms facing outward. Runs: carrying arms forward to backward, followed by return to initial position.	2x8
	7. PI: Standing anteroposteriorly with right leg forward, arms on the lateral right, submerged below water surface. Runs: carrying arms from right to left return to starting position. Similarly, on the opposite direction.	2x8
	8. Normal running, on the spot or with shift.	Active break
	9. Running with knees up or sideways on the spot or shift.	30 secs
	10. Running step, skipped shift.	2x30 secs
	11. PI: Standing, arms bent forward. Jump with legs landing on the side and return.	2x30 secs
	12. PI: Standing with arms folded forward. Jumps with knees up.	2x30 secs
	13. PI Standing. Jumps with knees up and sideways.	2x30 secs
Localized part 10-15 min.	*Exercises with sand bags attached to ankles*	
	1. Running versions: normal running on the spot; running with knees up or sideways, on the spot; running while swinging leg forward, on the spot; running with swinging leg backwards on the spot; running with added step; running crossed step; running step, skipped shift.	2x40 secs
	2. PI: Standing. Lifting legs alternatively through leap.	2x8
	3. PI. Standing, arms above as a crown. Lifting the right leg, bent on the side with the descent of the arm on the same side, behind the knee, followed by a return to the original position; the same movements on the opposite side.	2x8

Table II

Group E2 - *Aqua-pullpush-gym – intermediate level.*

Link/ duration	Content	Batch
Fundamental part	*Exercises with plates kept in hands*	
	1. PI: Standing, arms bent at 90 degrees, forearms ahead, plates submerged in water and oriented forward. A pushing motion is executed with alternative push of the arms forward, before returning to the starting position.	2x8
	2. PI: Standing, arms on the lateral, plates vertically immersed in water. Executing a simultaneous movement to carry arms forward.	2x8
	3. PI: Standing, arms bent at 90 degrees on chest level, with pullpush plates placed on the water surface. Executing an alternative pushing motion of the arms downwards.	2x8
	4. PI: Standing, right arm stretched forward, left arm backwards, plates on the water surface. Executing a rocking motion of the arms alongside the body.	2x8
	5. PI: Standing, arms forward, the plates resting on the water surface. Executing torso twisting while carrying arms sideways, opposite the twisting movement of the trunk.	2x8
	Exercises with plates attached to soles	Active break 30 secs
	1. PI: Standing, hands on hips, plates attached to soles. T1 – lifting the right leg bent forward, T2, 4, 6, 8 - return to the original position T3 – lifting right leg straight laterally. T5 - lifting the right leg and extension of arms on the side T7 - lifting right leg bent backwards.	2x8
	2. PI: Standing widely anterior-posterior, right foot forward, and arms bent with hands on hips, plates attached to soles. Executing anterior-posterior track by stepping with the left leg forward and return to start position.	2x8
	3. PI: Standing, arms bent, forearms facing forward. Executing alternative leg crossing forwards.	2x8
	4. PI: Standing sideways, fixed plates, right arm bent grabbing the edge of the pool, left arm bent, hand on hip. T1 - lifting left foot forward, T2, 4, 6 - return to starting position, T3 – lifting foot on the side, T5 - lifting leg backwards, torso tilted forward. The same movements on the opposite side.	2x8
	Exercises with plates held in hands and attached to soles	Active break 30 secs
	1. PI: Standing with plates attached to soles, arms bent forwards, the plates positioned horizontally below the water surface. Executing an alternative lifting movement of the leg on the side simultanesouly with pushing down the arms, forwards.	2x8
	2. PI: Standing with plates attached to soles, arms bent sideways, plates positioned vertically oriented outwards. Executing an alternative motion of lifting bent legs backwards, simultaneously pushing the arms on the sideways.	2x8
	3. PI: Standing with plates attached to soles, arms bent at 90 degrees, forearms forward, plates positioned below the water surface, facing down. Executing an alternative lifting of legs bent back simultaneously pushing down the arms.	2x8
	4. PI: Standing, plates attached to soles, hands sideways, plates positioned below the water surface, face down. Executing alternative lifts of legs bent forward at the same time lowering down the arms sideways.	2x8
	5. PI: Standing, plates attached to soles, hands sideways with plates positioned below the water surface, face down. Executing alternative lifts of legs bent forward at the same time lowering down the arms on the side, plates face to face.	2x8

a) Abdominal muscle strength

Table III

Abdominal muscle strength - summary of results.

Group	Motor activity	Average (X)		Difference	CV (%)	
		Ti	Tf	Tf-Ti	Ti	Tf
E1	Aquagym	20.83	23.33	2.50	2.77	2.53
E2	Aqua-pullpush-gym	20.08	24.42	4.34	2.35	2.30
C	DFG+EA+JD	20.81	22.19	1.38	1.97	1.91

DFG - exercises for general physical development;
EA - applied exercises; JD - dynamic games;

Table IV

Analysis of statistical results - Student t test.

Group	Test	T	p
E1 - C	Ti	0.04	.965
	Tf	2.12	.037
E2 - C	Ti	1.37	.175
	Tf	4.31	.000

p>.05*; p<.05**; p<.01***

b) Back muscle strength

Table V

Back muscle strength - summary of results.

Group	Motor activity	Average (X)		Tf-Ti	CV (%)	
		Ti	Tf		Ti	Tf
E1	Aquagym	28.92	32.08	3.16	3.47	3.09
E2	Aqua-pullpush-gym	27.88	32.42	4.54	2.64	2.24
C	DFG+EA+JD	28.94	30.57	1.63	3.37	3.22

DFG - exercises for general physical development;
EA - applied exercises; JD - dynamic games.

Table VI

Analysis of statistical results - Student t test.

Back muscle strength			
Group	Test	T	p
E1 – C	Ti	.023	.982
	Tf	1.89	.063
E2 – C	Ti	1.36	.177
	Tf	2.50	.007

Discussions

As a result of the research, regarding the testing of abdominal muscle strength, by calculating the arithmetic mean difference between the two tests, the control group registered a progress of only 1.38 executions, a value inferior to the one achieved by the experimental groups.

The experimental groups who carried out operational programs specific to ludic-recreational water activity showed greater differences compared to the control group: the Aquagym E1 experimental group recorded a mean difference of 2.50 executions and the Aqua-pullpush-gym E2 experimental group registered 4.34 executions, as it can be seen in Table III.

If we relate to the mark-value correlation grid, in the case of the trial targeting abdominal muscle strength in women, it can be seen that at the initial testing, all groups involved in the experimental research were at a *low* level. After performing the programs of the suggested activities, the control group and the Aquagym E1 experimental group remained at the same level of assessment, registering slightly improved results, while the Aqua-pullpush-gym E2 experimental group achieved more progress, reaching a *below the average* level on the grid, with a mean value of 24.42 executions.

By applying the Student t test and calculating the p correlation index, all values were significantly lower than 0.05 and p index values compared to the control group highlight the following: the mean performance at the initial testing was *significantly different* compared to the mean performance recorded at the final testing for the Aquagym E1 experimental sample and *highly significantly different* for the Aqua-pullpush-gym E2 experimental group.

The practical application of the new aqua-pullpush-gym activity required the design and development of action systems using pullpush plates with the view to selectively process all body segments, to develop the main motor skills and to train motor skills.

Following the research and the statistical-mathematical analysis of individual values, in the case of the back muscle strength testing, all research samples registered noticeable progress between the two tests, but the progress of the experimental groups was higher than that of the control group, according to Table V.

The Aquagym E1 experimental group obtained at the initial testing an arithmetic mean of 28.92 executions and 32.05 executions at the final testing, with a progress of 3.16 executions.

The Aqua-pullpush-gym E2 experimental group registered a difference of arithmetic means of 4.54 executions between the tests, which resulted from the mean value of 27.88 executions at the initial testing and the arithmetic mean of 32.42 executions at the final testing.

The arithmetic mean of the control group at the initial testing was 28.94 executions and at the final testing 30.57 executions, with a mean difference of 1.63, indicating a lower progress as compared to the two experimental groups.

The analysis performed using the Student t test for paired samples highlights a statistically *non-significant* difference between the control group and the Aquagym E1 experimental group: p <0.063 is higher than 0.05, which leads to the acceptance of the null hypothesis.

By comparative analysis between the control group and the Aqua-pullpush-gym E2 experimental group, the Student t test shows a statistically *significant* difference, p <0.007, much lower than 0.05, resulting in the rejection of the null hypothesis, thus supporting the alternative hypothesis of the research.

The use of equipment called pullpush paddles in aquagym activity, presenting superior technological features, allowed precise grading of muscle contractions, a suitable dosage and processing of the main muscle groups, all of which were in relation to the influence of water environment properties, training objectives, age particularities, training level and preferences of subjects.

Conclusions

1. In the case of the abdominal muscle strength trials, the progress of the experimental groups was significantly higher compared to the control group, due to the influence of the independent variables of the research**.**

2. The evaluation of back muscle strength highlights the fact that the two experimental groups who performed ludic-recreational water activities obtained a significantly higher progress compared to the control group who performed a classical program in the gym - terrestrial environment.

Conflicts of interests

There are no conflicts of interest.

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