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ORIGINAL RESEARCH

STUDY ON THE EFFECTS OF AQUATIC VS. DRY LAND COMBINED CONTRACTIONS ON MUSCLE STRENGTH FOR THE STUDENTS IN PHYSICAL EDUCATION AND SPORT

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Abstract:

Researchers in our country have examined only the dry land effects of combined contractions on muscle strength. Thus, there was conducted a study during an academic year (October 2008 - May 2009), which aimed to develop and experiment some training programs through schemes of aquatic and dry land combined contractions, and test of 5 power indicators on 24 students - boys second year in the Faculty of Physical Education and Sport of Pitesti, aged 18-20 years who were selected voluntarily and divided into two experimental groups (aquatic $n = 12$ experimental group and dry land $n = 12$ control group) to compare the results of muscle strength development. The same training, testing facilities and methods were used for each assessment and lesson. Each lesson took between 65-70 minutes, three days a week. Tests were performed using Quatro Jump Kistler platform, Bosco Protocol Version 1.0.9.2., and provided information about both jump height and power and data on neuro-motor ability (fast fibers), volunteer effort, fatigue, the stretching effect or muscle elasticity. The results of the experiment showed that the experimental group improved their power indices compared with control group, which used the same dry land-adapted programs, with a value between: 2.47 and 8.47%.

Keywords: *muscle strength, aquatic, dry land, programs*

Introduction

Aquatic exercises popularity is growing. Aquatic exercises have been used initially as a means of recovering injured athletes. Sports medicine experts found that floating in water, water resistance and therapeutic massage help accelerate the healing process. Water, acting as a giant pillow, decreases muscle and tendon fatigue and protects joints. Working in water using only water resistance is in our favor because it minimizes the risk of injuries usually occurred during exercises performed on land due to impact with hard surfaces (classical fitness room floor). Water pressure acts as a muscle massage, helping the elimination of lactic acid accumulated in muscles. Water resistance is much higher than the air; aquatic exercises engage several muscles and also are more difficult to achieve. Due to unstable environment water exercises require participation of all muscle groups in an attempt to maintain our position in the water. Bodies "lose" weight in water, have an apparent weight that can be adjusted continuously up to floating (to create conditions of weightlessness).

Benefits of aquatic activities are both internal and external, short and long term. Various studies have shown that all body systems benefit from doing regular exercises in water: circulatory, cardio- respiratory and musculoskeletal system. All musculoskeletal aspects of physical training can be improved by aquatic exercises.

Due to water resistance, both muscles are working in a pair while the body is stretched and expanded. During exercises on land, only the agonist is working.

As an environment exercise, water is 6 to 15 times more resistant than air. Strength improves any movement in any direction when the body is submerged in water. Studies indicate that water resistance property, possibly facilitates the development of muscle force and resistance to inactive participants, while maintaining strength in competitive athletes. (Krawitz, 1997).

The therapeutic effects of water have been appreciated since ancient times by ancient civilizations like Greeks, Romans, Babylonians and Egyptians. Dry land exercises have shown negative effects as well: vertebrae compaction, hernias, bone and cartilage disorders, tachycardia, etc.

They are caused by the high intensity exercises on the one hand, and the shortcomings of people's training, on the other hand. Thus, doctors and trainers had to find a "softer" means to mitigate such possible damage. Water creates a "non-impact environment," as stated by Politino, McCormick and Jeffery in 1995, producing a small request to muscles, bones and connective tissue compared with land-based activities. Water also provides buoyancy that reduces weight, anyway, movement in water increases resistance, as concluded by Sovia in 1992 and Troup and Berger in 1994. Training in the aquatic environment allows individuals to train almost all body muscles and joints simultaneously, while it dissipates heat better than air. (Case, 1997; Ruoti, Troup and Berger 1994). Any movement at any speed, in any direction slows down due to water resistance.

Balan V, in 2007, stated that "water is acting on the submerged body through hydrostatic pressure, which acts on the body as long as it is sunk on all sides."

Because water is denser than air, the muscles work harder in water than in air or soil. Water is, in effect, a natural weight training machine, which can be instantly adjusted: the harder it pushes, pulls and strikes in water the more resistance it encounters.

On land, such resistance (opposition) can increase body temperature. But water dissipates heat faster than air, so water freshness keeps the body cool and fresh, as if massaged.

Previous studies supported the introduction of water activities in training programs to increase muscle strength (Weinstein, LB 1986, Martin MM 1992, Binkley HM 1996, White, T. and Smith, BS 1999), while reducing fever - muscle pain (Woods D.A , 1989). Beasley (1988) said that "the main advantage of water activities is the effect of buoyancy and water resistance of the body, as it has a minimum application on joints and muscles." It is an area that was not explored enough thus requiring investigations on the results regarding muscle strength, that it may have if we apply training programs based on the combination of muscle contractions in water.

Research Assumptions

Combining the various schemes of muscle contraction has been a constant preoccupation of specialized authors whose studies have shown the usefulness of various combinations with a view to achieve a more complex training. The preparatory muscle training can be improved, one direction being the combination of contraction schemes which are specified and approached by famous experts (Cometti G., 2005, etc.) in materials of outstanding importance.

The assessment of the materials shows that using combinations of contraction schemes is better than using each scheme separately.

Following the research carried out on land to detect the best combination of contraction schemes, on subjects of 13-14 years and 16-18 years respectively, we found out that among the six contraction combinations, the isometric-plyometric pair best contributed qualitatively and quantitatively to a greater muscle training for both upper and lower limbs.

Comparison of changes on plyometric training performance on land and water was made only for a short period of eight - twelve weeks.

Training in water allows individuals to train almost all the muscles and joints of the body simultaneously, while it dissipates heat better than air. (Case, 1997; Ruoti, Troup and Berger 1994). Politino & Co (1995) reveals that water produces resistance in all directions, 12 times more compared to the activity on land. For these reasons, conducting exercises in water may be more appropriate than using them on land as regards strength development.

Combining contraction schemes in water, plyometric – concentric for lower limbs and concentric - eccentric for upper limbs in subjects of 18-20 years has not been analyzed yet.

Research purpose

This research aims to optimize muscle training through the development and enhancement of programs using a combination of contraction schemes for students (18-20 years) in the field of physical education and sports in water.

Research hypothesis

Increasing the strength indicator by using specific exercises based on contraction combination requires their harmonious combination with methods and means specific to aquatic environment. Therefore, using aquatic muscle training programs can obtain conclusive results on the development of strength in comparison with those performed on land.

The research importance

This paper examines the effects of a "new" form of muscle training (in the aquatic environment) through contraction combination, which can cause physical adaptation such as muscle strength development.

Material and methods

The experiment used the following research methods: measurement and testing method, educational experiment, statistical-mathematical method of data processing, comparative analysis and graphical method. Six samples were selected to assess muscle training : Squat Jump and Squat Jump with additional weight equal to body weight (SJ and SJbw) which shows the Bosco index, Countermovement Jump (CMJ), Bent Leg Jump Continuous Reference (CJbref) Continuous Jump Straight Legs (CJs) and Continuous Jump Bent Legs (CJb 30s) for the lower limbs through which we evaluated the level of training and progress of the experimental and control groups according to the means used in the preparation. To assess the sport students' muscle strength of the lower limbs we used the testing method through Bosco protocol applied to Kistler Quattro Jump 9290AD force platform measurement. Data were analyzed using Microsoft Excel, 2003.

To test the research hypothesis, dependent variables were first compared using paired t test for each group (experimental and control) to determine whether there are differences between muscle training in the aquatic environment and force training on land. We used unpaired t test to examine comparative developments of somatic, functional and motric indicators in experimental and control groups, both in initial and final testing.

The experiment was conducted inside the Olympic Basin in Pitesti, the sample experimental group consisting of 12 second year students (18-20 years) at the Faculty of Physical Education and Sport of Pitesti. The control group was represented by 12 second year students, at the Faculty of Physical Education and Sport of Pitesti, who worked in the fitness room inside the faculty. The pedagogical experiment conducted during an academic year (October 2008 - May 2009) consisted in the application of muscle training programs through combined contraction schemes in water on an experimental group and we compared the results with a control group who worked on land following the same adapted programs.

Periodization of Muscle training in the aquatic environment

The annual cycle of muscle training in the aquatic environment is divided into four main periods: initial period, passing period, peak period, and active rest period.

These training periods were divided into smaller structures (mesocycles, microcycles) that had specific objectives derived from the general objectives of the annual plan.

During the academic year 2008-2009, there were 95 training sessions, which meant 105.75 hours of muscle training in the aquatic environment.

In order to meet objectives regarding muscle preparation in water we combined contraction schemes, namely the concentric-plyometric combination for the lower limbs.

Results

The six tests that were performed using the measurement platform of Kistler Quattro Jump Bosco Protocol Version 1.0.9.2. force, gave us information about both jump height and power and data on neuromotor recruitment capacity (fast fibers), volunteer effort, fatigue, stretching or muscle elasticity.

Statistical-mathematical analysis of the power indicators in water and on land.

Table 1. Dynamics of power indicator evolution in the lower limb muscle in initial-final testing – experimental group

Nr	Name and First name	Bosco Index %		CMJ Power W/kg		Cjbref Power W/kg		CJs W/kg		CJb 30s Power W/kg	
		TI	TF	TI	TF	TI	TF	TI	TF	TI	TF
1.	Boştinaru Dragoş	45.5	47.8	22.3	24.5	21.2	23.1	41.1	42.7	20.2	22.1
2.	Burciu Eduard	33.1	40.7	27.5	30.1	22.1	23.4	43.5	45.5	20.6	23.7
3.	Burhan Valentin	37.4	43.1	27.8	30.2	22.4	24	37.5	40.8	19	22.8
4.	Călin Gabi	37.2	42.5	23.1	24.9	22.2	25.8	45.3	46.9	19.7	21
5.	Firicel Ionuţ	41.1	45.2	21.8	23.7	23.3	25.4	29.4	34.8	19	21.9
6.	Iordache Vlad	35.1	45.4	27.1	30.6	27.4	28.5	45.6	49.6	19.4	23.7
7.	Mihăilă Marius	37.2	52.1	22.6	22.7	24.3	26.2	38.1	43.7	19.1	22.4
8.	Pleşa Alexandru	38.1	43.1	24.7	25.4	23.2	25.7	35.3	40	17.9	21.2
9.	Sârbu Mihai	37.5	40.6	25.7	28.7	24.4	28.5	41.2	44	21.7	22.2
10	Stănescu Liviu	29.4	45.3	28.5	30.9	25.2	28.8	45.5	48.4	22.7	26
11	Veselu Ovidiu	38.2	43.5	28.5	30.1	27.1	28.8	36.9	41.1	21.1	24.5
12	Vlad Andrei	47.3	51.8	24.7	25.6	25.9	28.5	50	56.9	20	24.7
	x	38.09	45.09	25.35	27.28	24.05	26.39	40.78	44.53	20.03	23.01
	S	4.86	3.79	2.50	3.07	2.01	2.18	5.65	5.60	1.32	1.52
	Cv	12.77	8.41	9.87	11.27	8.38	8.26	13.85	12.58	6.63	6.60
	t test calculated		5,468		6,785		8,318		7,692		8,564
			<0.001		<0.001		<0.001		<0.001		<0.001

Evolution of power factor jump in the experiment group (Table 1.)

Bosco Index- During the experiment, the experimental group average value on this indicator increased from 38.09 in initial testing to 45.09 in final testing with a significant difference of 7, critical t value = 2.179 < t calculated = 5.468, p < 0.001. The null hypothesis is rejected. Homogeneity of results remains very good, CV = 12.77% in initial testing and 8.41% in final testing.

Power in Counter Movement Jump (PCMJ) - this indicator average increased from 25.35 in initial testing to 27.28 in final testing with a difference of 1.93 causing a significant change, critical t value = 2.179 < t calculated = 6.785, p < 0.001. The null hypothesis is rejected. Performance homogeneity remains very good Cv = 9.87% in initial testing to 11.27% in final testing.

Power in Continuous Jump with Bent Legs Reference (PCJbref) - Experimental group average values increased from 24.05 in initial testing to 26.39 in final testing with a significant difference of 2.34, critical t value = 2.179 < t calculated = 8.318, p < 0.001. The null hypothesis is rejected. Homogeneity of results remains very good, Cv = 8.38% in initial testing to 8.26% in final testing.

Power in Continuous Jump with Straight Legs (PCJs) - experimental group average values for PCJs indicator increased from 40.78 in initial testing to 44.53 in final testing with a significant difference of 3.75, t critical values = 2.179 < t calculated = 7.692, p < 0.001. The null hypothesis is rejected. Homogeneity of results remains good, CV = 13.85% to 12.58% in initial and final testing.

Power in Continuous Jump with Bent Legs (PCJb 30 s) – experimental group average values for PCJ 30s indicator increased from 20,03 in initial testing to 23,01 in final testing with a significant difference of 2,98, critical t value = 2,179 < t calculated = 8,564, p < 0,001. Null hypothesis is rejected. Homogeneity of results remains good, Cv = 6,63 % in initial testing and decreases to 6,60 % in final testing.

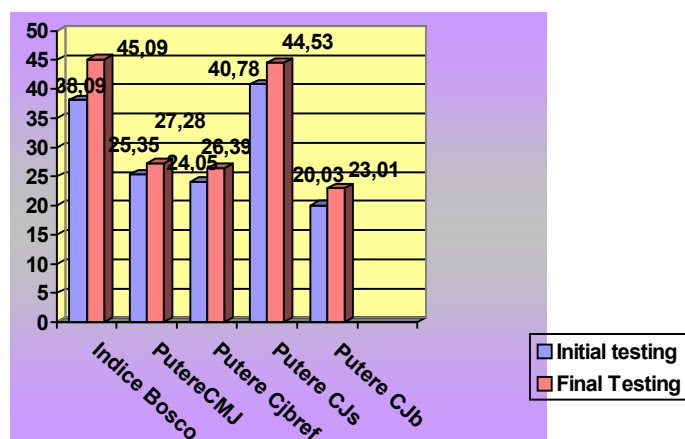


Figure 1. Dynamics of power indicator evolution in the lower limb muscle in initial-final testing – experimental group

Putere CJb – CJb Power

CJs Power

Cjbref Power

CMJ Power

Bosco Index

Table 2. Dynamics of power indicator evolution in the lower limb muscle in initial-final testing –control group

Nr	NAME AND FIRST NAME	Bosco index %		CMJ Power W/kg		Cjbref Power W/kg		CJs Power W/kg		CJb 30s Power W/kg	
		TI	TF	TI	TF	TI	TF	TI	TF	TI	TF
1.	B.A.	41.8	41.9	20.4	20.9	20.2	20.8	39.3	40.5	18.5	18.7
2.	N.E.	34.6	34.2	25.6	26.3	21.3	22	40.2	40.9	19.9	20
3.	R.D.	35.4	35.8	27.3	27.7	22.5	22.6	36.7	36.3	19.8	20.3
4.	B.I.	38.3	39.1	22.9	23.2	20.6	21.5	43.4	43.9	19.4	19.8
5.	U.A.	39.2	39.8	21.9	22.2	20.5	20.6	30.5	30	18.1	18.6
6.	P.C.	34.8	34.5	26.8	27.2	26.5	26	43	44.1	19.1	20.7
7.	A.I.	36	36.7	21.8	21.3	21.8	22.3	37.3	37.9	18.7	19
8.	S.R.	37.7	38.6	24.1	24.5	23.9	23.7	34.8	35	17	17.7
9.	L.A.	37.2	37.3	24.2	24.5	23.8	23.9	40.6	40.7	20.3	20.6
10	G.V.	30.1	31.9	26.7	26.4	24.2	25.8	41.7	41.2	21.9	21.4
11	C.I.	37.8	37	27.8	28	26.9	26.6	37	37.7	20.4	20
12	D.R.	43.9	44.7	25	25.6	24.9	25.6	45.9	46.3	19.8	20.1
	x	37.23	37.6	24.54	24.81	23.09	23.45	39.2	39.54	19.40	19.74
	S	3.56	3.50	2.41	2.46	2.30	2.13	4.22	4.47	1.26	1.04
	Cv	9.56	9.31	9.82	9.93	9.96	9.08	10.76	11.32	6.49	5.31
	t calculated		1,934		2,747		2,103		2,038		2,172
	Critical t value		>0.05		<0.05		>0.05		>0.05		> 0.05

Evolution of power factor jump in the control group (Table 2)

Bosco Index – During the experiment the control group average values on this indicator increased from 37.23 in initial testing to 37.6 in final testing with an insignificant difference of 0.37, critical t value = 2.179 < t calculated = 1.934, $p > .05$. The null hypothesis is accepted. Homogeneity of results remains very good, Cv = 9.56% in initial testing to 9.31% in final testing.

Power in Counter Movement Jump (PCMJ) - this indicator averages increase from 24.54 in initial testing to 24.81 i final testing with a difference of 0.27 causing an significant change, critical t value = 2.179 < t calculated = 2.474, $p < 0.05$. Null hypothesis is rejected. Performance homogeneity remains very good $C_v = 9.82\%$ to 9.93% in initial testing and 9.93 in final testing.

Power in Continuous jump with Bent Legs Reference (PCJbref) - control group averages increased from 23.09 in initial testing to 23.45 in final testing with an insignificant difference of 0.36, critical t value = 2.179 > t calculated = 2.103, $p > .05$. Null hypothesis is accepted.

Homogeneity of results remains very good $C_v = 9.96\%$ in initial testing and 9.08% in final testing.

Power in Continuous Jump with Straight Legs (PCJs) - control group averages increase from 39.2 in initial testing to 39.54 in final testing with an insignificant difference of 0.34, critical t value = 2.179 > t calculated = 2.038, $p > .05$. Null hypothesis is accepted. Homogeneity of results remains very good $C_v = 10.76\%$ in initial testing and 11.32% in final testing.

Power in Continuous Jump with Bent Legs (PCJb 30s) - control group average increased from 19.40 in initial testing to 19.74 in final testing with a insignificant difference of 0.34, critical t value = 2.179 > t calculated = 2.172, $p > .05$. Null hypothesis is accepted. Homogeneity of results remains very good $C_v = 6.49\%$ in initial testing and 5.31% in final testing.

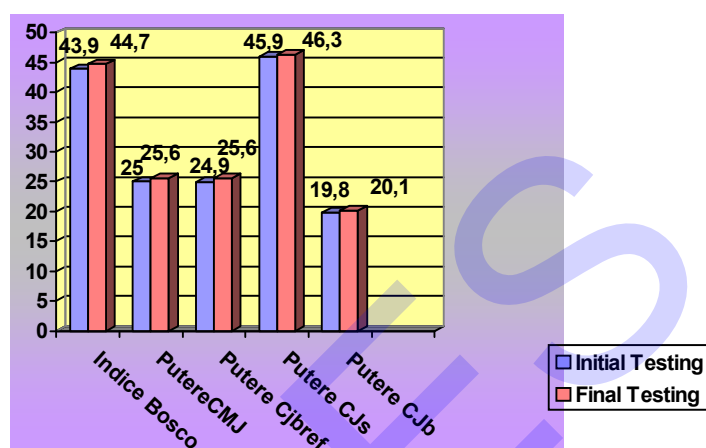


Figure 2. Dynamics of power indicator evolution in the lower limb in control group

Conclusions:

1. Earlier research in our country, have examined only the land effects of combined contraction schemes regarding strength development.
2. Due to unstable water environment and its resistance, aquatic exercises involve all muscle groups in an attempt to maintain the vertical position of the body, and the execution speed is fast and explosive, all of which are an effective way to develop strength.
3. Using muscle training programs in the aquatic environment, we have obtained efficient results regarding the power indicator for the experimental group. Data on lower limbs power assessment through Bosco Protocol applied on the measurement platform of Kistler Quatro Jump Bosco Protocol Version 1.0.9.2 form were as follows:

- Bosco index - shows a significant difference of 7 (before = 38.09, after = 45.09). This rejects the null hypothesis and accepts alternative hypothesis. (Table 1).
- Power in Counter Movement Jump (PCMJ) - shows a difference of 1.93 causing a significant change (before = 25.35, after = 27.28).
- Power in Continuous Jump with Bent Legs Reference (PCJbref) - presents a significant difference of 2.34 (before = 24.05 after = 26.39). This assumption rejects null hypothesis and accepts alternative hypothesis (Table 1).
- Power in Continuous Jump with Straight Legs (PCJs) - presents a significant difference of 3.75 (before = 40.78, after = 44.53). This rejects null hypothesis and accepts alternative hypothesis (Table 1).
- Power in Continuous Jump with Bent Legs (PCJb 30 sec) - presents a significant difference of 2.98 (before = 20.03, after = 23.01). This rejects null hypothesis and accepts alternative hypothesis (Table 1).

4. Given the comparative analysis of motric indicators evolution in experimental and control groups - initial testing indicates that all the five dynamic indicators of experimental group compared to the control group had

significant differences for significance level $p < 0.05$, at the beginning of the experiment which shows the original homogeneity of the two samples.

5. After using aquatic training programs, the experimental group improved their power indices compared with control group, which used the same land-adapted programs, with a value between: 2.47 and 8.47%. This rejects the null hypothesis and accepts the alternative hypothesis.

Comparative evolution of experimental and control groups in final testing

Table. 3

	Control group	Experimental group	Difference	t - calculated	p – significance level
Bosco Index %	37.625	45.09167	8,47	5.008294	p < 0,001
CMJ Power W/kg	24.81667	27.28333	2,47	2.167624	p < 0,05
Cjbref Power W/kg	23.45	26.39167	2,93	3.34283	p < 0,01
CJs Power W/kg	39.54167	44.53333	4,99	2.410562	p < 0,05
CJb 30s Power W/kg	19.74167	23.01667	3,27	6.143967	p < 0,001

It appears that the experimental group had significant increases in all five dynamic indicators, compared to control group, for the significance level $p < 0.001$ (two indicators), $p < 0.01$, (one indicator) and $p < 0.05$ (two indicators), which demonstrates the superior means used by the experimental group.

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