IOSR Journal of Sports and Physical Education (IOSR-JSPE)
e-ISSN: 2347-6737, p-ISSN: 2347-6745, Volume 8, Issue 2, (Mar. – Apr. 2021), PP 08-12
www.iosrjournals.org

Reverse periodization with additional resistance training improves performance of middle distance freestyle swimming.

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Abstract:
Background*: Different studies reported the importance of muscular strength and power propulsion generated by the action of the arms and legs, in swimming speed. Due the aim of the present research was to study effects of eight weeks resistance training, and their effects in swim performance of 200 and 400m.*
Materials and Methods*: In this study, there were 14 volunteer participants divided in two groups of seven swimmers per group; control group with characteristics of: 16.2 ± 1.1 years; 162.03 ± 5.49 cm; 59.59 ± 2.94 kg; and the experimental group with characteristics as: 16.1 ± 1.3 years; 164.36 ± 5.30cm; 62,57 ± 5.34 kg. Both groups trained a program of reverse periodization planning. Additionally to the swim training program; the intervention group performed three sessions per week the resisted swimming training attached to elastic ropes. Repeated-measures analysis of variance (ANOVA) was acceptable and used to compare responses among groups in variable of 200m crawl (t200c), 400m crawl (t400c), full stroke (FS); isolated arms-stroke (IA); and isolated kick (IK) across the 8 weeks training.* ***Results****: At the group per moment comparison after eight weeks significant ($p \leq 0.05$) difference between groups are showed at the variables: t200; t400 and FS.*
Conclusion: *Results suggests that the intervention protocol performed in this investigation may be useful, well-recommended and easy to train swimmers for short and middle distances. Moreover, this research supports the reverse periodization planning to improve competitive swimming performance.*
Key Word*: Strength-training, Power-training, Intensity, Specificity.*

Date of Submission: 10-03-2021 Date of Acceptance: 25-03-2021

I. Introduction

Swimming is a popular competitive sport, considered high influenced by the technique, endurance and strength training. Since swimming races being decided by only fractions of a second, various training methods have been devised to improve performance. [1]

Different studies reported the importance of muscular strength and power propulsion generated by the action of the arms and legs, in speed tests and the shortest distance event of 50m freestyle. [2] Resistance training is a specialized strength training program, utilizing a range of resistive loads and a variety of training modalities designed to enhance health, fitness, and muscle-strength. [1-2-3-4]

Resistance training has been used in a wide variety of sports and frequently in swimming. Some examples of specific resistance training on swimming is to swim dressed with drag-suit, shorts, attached to a parachute or elastics bands and the method more trustworthy and very extended into coaches and researches atmosphere is it swimming attached to external loads.[1-2] This is a workout designed to swimmers to increase strength while performing specific pattern of movements. [1-2-3-4]

Due, there have been only a limited number of studies addressing resisted training in competitive swimming and most of the researches are focused to the effects of resisted training in sprint events of 50 to 200m. The aim of the present research was to study effects of eight weeks resistance training, and their effects in swim performance of 200 and 400m.

II. Materials and Methods

Participants

The participants were recruited by national competitive program with average eight years of experience training for a competition. In this study, there were 14 volunteer participants divided in two groups of seven swimmers per group; control group with characteristics of: 16.2 ± 1.1 years; 162.03 ± 5.49 cm; 59.59 ± 2.94 kg; and the experimental group with characteristics as: 16.1 ± 1.3 years; 164.36 ± 5.30cm; 62,57 ± 5.34 kg. Subjects did not report any characteristics that would impede their participation in high intensity swimming training.

Each participant and his parents were informed about the porpoise of the study and possible risks before start the investigation and signed an informed consent document approved by Viña del Mar University's ethics research committee. All procedures were in accordance with the Declaration of Helsinki.

Procedure

The test application order for data compilation (Pre and Post) followed the order of: a) Test of specific swimming resisted training. b) Rest and recovery day (> 24 hours). c) Swimming test in official competition pool to obtain swimming performance variables. All subjects performed familiarization testing with the various tests and assessment tools one week before the first test. Before application tests a standard warm-up was performed before each test session; this included: 800m free swimming followed by 4 x 50m high intensity training and 200m recovery of low intensity training.

Both groups trained identical program of swimming in terms of volume and intensity. The control group (CG) did perform solely swimming training. The experimental group (RT) includes into their practice a designed plan of swim resisted training. This research lasted eight weeks. Assessments were made at baseline (Pre) and post-tests (Post) after eight weeks of treatment.

Data collection

a) Resisted Swimming

In each application of the tests all swimmers performed a standard (aforementioned) warmup. To obtain the variables of resisted swim training was required a dynamometer (PCE-CS 5000N. Stuttgart, Germany). The test´s protocol follows the next procedure previously described by Arellano et al. (2011). Each participant used a belt connected to the dynamometer by non-elastic cable, the swimmer should start into the pool in a supine position, without any force applied to the wall they should swim 10 seconds maximum effort, participants resting in passive form (>4 minutes) between each repetition. To this test where obtained the variables of full-stroke resisted swim (FS); isolated arms-stroke (IA); and isolated kick (IK).

b) Day off of complete recovery.

c) Swimming Performance.

After a standard warmup; Participants take a rest period of 30 minutes to dress a competition suit before the swim tests. The test consisted in a maximal 200 and 400m front crawl with official block-start, performed in an indoor 50m swimming pool. Data times of 200m crawl (t200c) and 400m crawl (t400c), were recorded with a Colorado Timing System (Loveland, CO, USA) consisting in Infinity Start System INFSSM; Aqua grip touchpad (188.5 x 90 cm) TP188.5G and System 6 timing Console SYS6, and data was imported to a personal laptop with the Meet-Manager program of competition.

Training and assessment protocols

Both groups trained a program of reverse periodization planning. [2-6-7-8] The program began on the development of specific race pace training, three practices at week high-intensity interval training (HIIT) each one interspersed by a recovery day with practice of Low Intensity training (LIT) with a total of six practices of week for a period of three weeks. The second mesocycle (Three weeks) consisted in one practice of specific race pace training to hold the stimuli of the previous mesocycle; plus two practices of aerobic moderated intensity training (MIT) and three practices of LIT. The last mesocycle or taper consisted in two week of active recovery where the volume of training was reduced 40% holding one day practice of MIT; two days practice of HIIT and three days practice of LIT for a period of two weeks.

Additionally to the swim training program; the intervention group performed three sessions per week the resisted swimming training attached to elastic ropes [1] (StrechCordz Gürtel Slider, S11875YL. Stuttgart, Germany) 10 meters length with an elastic capacity to extend up to 25 meters, although for the intervention, the training was programmed to extend the resistance only to 20 meters; i.e. 6 x 20-m with 3 ~ 4 minutes break pre practice one day crawling full stroke; one day isolated arms stroke; and one day isolated kick; twenty four sessions for the total of the eight weeks treatment; example of procedures for data collection and training are exhibit in the figure 1. The assessments to data compilation where applied at the week prior to start the treatment (Pre) and at the ninth week (Post); the week just after ending the training protocol.

Statistical analysis

All statistical variables were processed using the SPSS statistical package v. 20.0 (SPSS, Inc. Chicago, IL, USA). The Shapiro-Wilk's test checked normality and Levene's test was used to analyze the homogeneity of variances for 200m crawl (t200c), 400m crawl (t400c), full stroke (FS); isolated arms-stroke (IA); and isolated kick (IK). All variables presented normal distribution and homoscedasticity ($p < 0.05$). Then Student's t-tests were used to identify pre to post differences within group, reverse periodization (RP) as control group and

reverse periodization with additional resisted training (RP^{ART}) as well intervention group. Therefore the use of 2 x 2 repeated-measures analyses of variance (ANOVA) was acceptable and used to compare responses among groups in each variable across the 8 weeks. Pre to post differences were described as percentage differences and presented in Table 1. The effect size Cohen's *d.* [5] was calculated for all variables between pre and post-testing. The thresholds for small, moderate, and large effects were set as: 0.20, 0.50, and 0.80, respectively (Cohen 1988). An alpha of $p \leq 0.05$ was accepted for statistical significance.

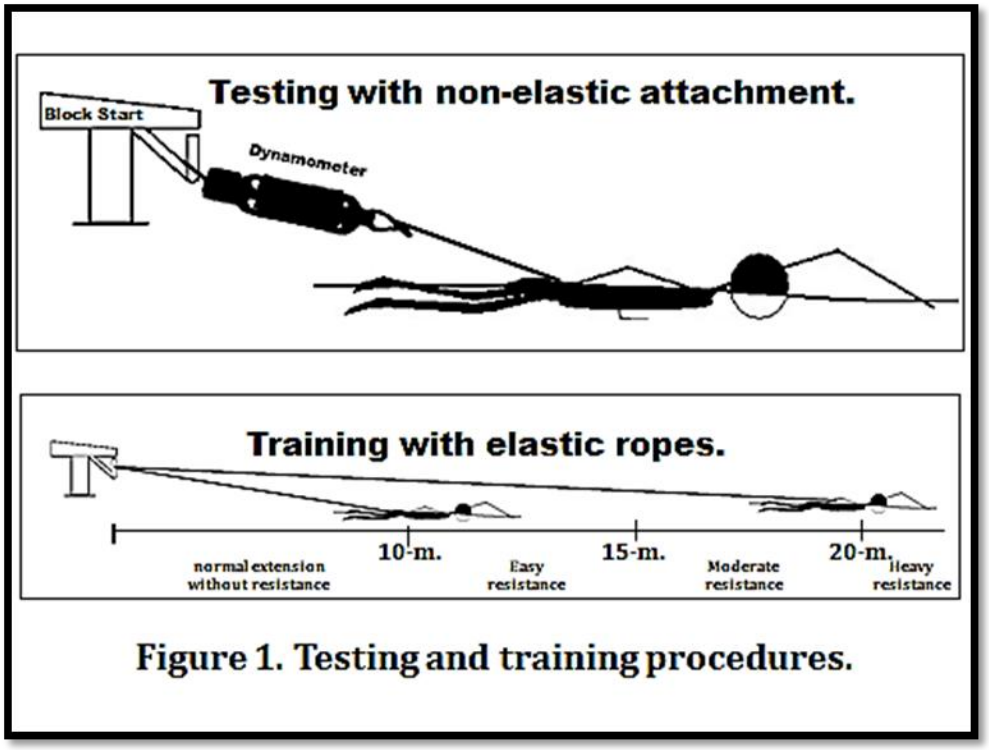

Figure 1. Testing and training procedures.

III. Results

After eight weeks training, both groups show significant within changes ($p \leq 0.05$) at the variables t200; t400 and FS. At the group per moment comparison after eight weeks significant ($p \leq 0.05$) difference between groups are showed at the variables: t200; t400 and FS.

Table 1. Summary of eight weeks assessments.

Variable	Groups	Pre	Post	Δ%	*d*
t200c (seconds)	RP	147.73 ± 07.88	144.78 ± 07.11*	2.68	0.22
	RP^{ART}	140.58 ± 03.64	133.13 ± 04.35*	5.59**	0.29
t400c (seconds)	RP	304.61 ± 20.26	300.13 ± 19.08*	1.49	0.78
	RP^{ART}	290.14 ± 07.59	273.66 ± 07.20*	6.02**	0.71
FS (Newtons)	RP	130.28 ± 30.18	142.00 ± 25.76*	8.99	0.32
	RP^{ART}	148.14 ± 29.46	181.57 ± 29.43*	22.56**	0.85
IA (Newtons)	RP	101.57 ± 29.25	107.43 ± 21.71	5.76	0.14
	RP^{ART}	108.57 ± 31.47	131.29 ± 39.03	20.92	0.80
IK (Newtons)	RP	52.29 ± 09.92	57.86 ± 11.82	10.65	0.54
	RP^{ART}	64.57 ± 13.66	76.14 ± 19.62	17.91	0.39

The values were expressed by mean ± standard error of the mean; t200c = 200m crawl; t400c = 400m crawl; FS = full stroke; IA = isolated arms-stroke; IK = isolated kick; RP = reverse periodization; RP^{ART} = reverse periodization with additional resisted training; Pre = baseline evaluation; Post = evaluation after eight weeks of training. * = Significant statistical difference within-group relation Pre-Post; Δ% = differences Pre-Post in percentage; ** = significant statistical difference between groups after eight weeks of training. *d* = effect sizes. Significance level was accepted at $p \leq 0.05$.

Both groups showed tending large effect size at the variable of t400c; for the control group the effect size is slightly higher *(dCohen = 0.78)* than values observed for the experimental group *(dCohen = 0.71).* Large effect size were observed for the experimental group at the variable FS *dCohen = 0.85)* and IA *(dCohen = 0.80).*at the IK effect size were superior for the control group with moderate *(dCohen = 0.54)* above tending moderate effect size *(dCohen = 0.39)* for the experimental group. The rest of values don't change significantly (Table 1).

IV. Discussion

This research aimed to examine changes in swimming performance and specific strength effects of eight weeks resistance training. The very close effect size after eight weeks training at the variables of t200c and t400c, show how reverse periodization is a good planning to prepare swimmers for short and middle distance events; and where the significant differences among groups is the logic result of the free variable, in this case the resistance training. This suggests that the intervention protocol performed in this investigation may be useful, well-recommended and easy to train swimmers for short and middle distances.

In case of the control group, the results for t200c and t400c, confirms the efficacy of the reverse periodization planning to prepare competitive swimmers; and that has shown superiority to improve competitive performance, and to increase the levels of strength and oxygen consumption associated with athletic performance when compared to traditional [2-6-8] or block periodization. [2-7-8]

The specific strength for the variables related to resisted training for both groups show different tendencies; in case of the control RP group FS improved 8.9%; IA was the lower change with 5.7% and the highest improvements take place in IK with 10.6%. On the other side for RP^{ART} the highest improvements where for the variable of FS with 22.5%; followed for the improvements in IA with 20.9% and the lower improvements were for IK with 10.6%. this different trends would be attributed in case of the experimental group to the performed program where each week the first resisted training practice was set at the beginning of the week and the second resisted training was for to train IA with last practice at the end of the week for the IK resisted training; and where it is observed that the improvements of greater change were elicited for the full-stroke stimulation, carried out every week after a complete physical recovery from the day off; while the stimulation for isolated kick was performed within this protocol at the end of the week when an accumulation of fatigue was already observed. [9-10]

Perhaps, the most significant benefit of resisted training could be the appropriate training at high-intensity anaerobic zone, with sufficient recovery which allows for maintaining high-intensity workouts without overstressing the musculoskeletal system; which reflects in positive adaptations in anaerobic power values. [11] Maglischo (2011) has evidenced that resisted training is the most recommended way to stimulate fast-twitch muscle fibers related to the generation of muscle strength; the same author explained how these improvements come from the nervous system's adaptations during speed or strength intensive training. Both the transmission from the central nervous system and responses such as a reflex-type level of the spinal cord with an increase of an agonist muscle activation and antagonist muscle relaxation[12] this fact may explain the increases in the specific strength for the RP^{ART} group.

A crucial effect of resisted training is the high stimulation of one of the major regulators of mitochondrial biogenesis in the muscle, the activated receptor gamma peroxisome proliferator (PGC-1α) [13-14] being the essential factor of stimulation to produce the PGC-1α through exercise intensity. [13-15]

Otherwise, it is crucial to note that the specific strength improvements exhibited to our experimental group are higher with 22.5% improvements, compared to the findings of previous research (+10%) where specific strength training was included as treatment [2] but with a group of swimmers junior ages of 15-18 years old. The differences may be attributed to the profile of the participants in this study; and the exclusive use of the moderate resistance at this research.

This study confirms previous researches where resistance training using tethered swimming with concentric tools [16-17] or elastic ropes [1] come-up as one of the most specific swimming training, as it simulates at the swimmers physical environment the stroke mechanics, enabling swimmers to train using in-water exercises with added resistance, while performing any of the 4 basic swim strokes and with relevant results for a middle distances events. Furthermore, this research are very relevant in the current time, where for health reasons related to the viral control of COVID-19 it requires optative spaces for domestic training. Therefore, the authors can widely recommend as optative use of elastic bands for resisted swimming, even when domestic pools do not meet the official standards for 25 and 50m competition.

V. Conclusion

The results of this research support the organization of reverse periodization in the preparation of swimmers specialist in middle distances. In addition, resistance training with elastic bands can represent an easy-to-use tool with broad benefits for competitive performance and specific strength training.

Conflict of interest: The authors reported no conflict of interest.

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RIAÑO-RAMÍREZ, J.C. " Reverse periodization with additional resistance training improves performance of middle distance freestyle swimming." *IOSR Journal of Sports and Physical Education (IOSR-JSPE,) 8*(2) (2021): 08-12.