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Effects of repeated sprint swim training with restricted arm muscle blood flow on strength and 50-meter swimming performance

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Abstract
Repeated sprint training is typically used in various sports, but there is little information on the intense reaction to this sort of training when combined with blood flow restriction in the arm region, and especially in swimming. This study aims to determine the impact of repeated sprint swim training with restricted arm muscle blood flow on muscular strength and hypertrophic responses in upper arm muscles for swimmers in pace of 50 m freestyle. Twenty swimmers were divided into two groups for the current investigation. These were five sets of eight maximum sprints done three days a week for six weeks. Strength (1-RM bench press and half-squat) and swim 50 meters performance measurements were tested before the beginning of the study and two days followed by the training programm period. The bench press upper maximal strength and the swimming performance variable showed a slight increase in the results (ES 0.2 to 0.5). and a significant improvement in maximum lower body strength (half-squat). In comparison, the CG group reported a small increase only in the 50m swimming performance (ES = 0.49), otherwise trivial effect size observed in other variables. In comparison, the t-test reported a significant difference between both groups ($p < 0.05$) after the repeated sprint training with blood flow restriction on the upper and lower body maximum strength. The study concluded that swimming athletes' muscular strength and aerobic performance may change if they combine repeated sprint training with BFR training while swimming short distances.

Keywords: Blood flow restriction, strength, and vascular occlusion

1. Introduction

Swimming is a branch of sports requiring muscular force and endurance and the winner is determined with only seconds even with split seconds. A good swimming performance is affected not only from exercise, genetic or physical fitness which is also agreed as a key element on sportive performance [1].

The blood flow restriction (BFR) training background depends on a reducing of arterial blood flow to muscles, whilst occluding venous return [2]. The using of swimming specific exercise during 10 sessions of 12 - 20 × 25 m freestyle sprint with recovery of 15 s at a pace of 200 m freestyle allowed to improve 100, 200, and 400 m freestyle swimmers performance [3].

Because it may affect the extent of sport-specific fitness profile improvements, repeated sprint swim training necessitates sport-specific acclimation and exercise load selection. It may also call for some sport-specific adaptations and exercise mode selection. [4].

Additionally, researchers think that extra metabolites (lactate and H+) are created as muscles are forced into a hypoxic state by BFR training. Hence, during low intensity resistance training with BFR, the persistent hypoxic environment within the occluded area enhances metabolite synthesis and increases muscle fiber recruitment [5].

Many studies have documented stronger, unoccluded muscles after exercise as a result of BFR training (i.e., increases seen in arms when legs under BFR). It is believed that the primary elements promoting muscle hypertrophy with BFR training are elevated levels of noradrenaline, growth hormone (GH), and insulin-like growth factor-1 (IGF-1) [6].

Programs of low-intensity BFR training have shown to build muscular strength in a variety of populations [7-10]. Thus, in swimming, it is an important for swimmers to improves the arm strength frequency and ability during the short distance swimming as 50 meters.

In this context, low intensity, low resistance to load BFR programs may allow athletes (or groups who are deconditioned) to train at lower intensities while still seeing the same strength improvements as high intensity training [11, 12].

BFR should be used with caution because it is still a new training technique. If done correctly, the training may result in a gain in muscular strength, which is likely brought about by an increase in hormone levels and greater activation of fast-twitch muscle fibers during low-intensity body weight exercises [13, 14].

A practical BFR training strategy has not been published for swimmers with restricted arm training, despite BFR training having been introduced into the training of many types of athletes. Owing to the specialization of swimming, dryland training's contribution is probably useful but constrained. As a result, it is uncertain how effective they could be at enhancing sport-specific, in-water performance.

While some studies revealed that dryland training didn't improve in-water performance, others found that dryland training when combined with in-water sprint training demonstrated in-water success [15, 16]. Currently, to improve muscle strength structure, many swimmers include dryland training in their seasonal training plans. For this reason, the novelty of BFR training may be appealing, especially if it is included in a seasonal training plan.

Appendicular muscles are the only muscles that can benefit from the limited blood flow because the BFR requires the use of an elastic cuff that is positioned at the limbs in the end proximal position. As a result, earlier research in the field of BFR training has focused on the physiological adaptations of the appendicular muscles. The impact of repetitive sprint swim training with reduced arm muscle blood flow, particularly for swimmers, has not yet been investigated. Thus, the purpose of the current study was to determine the impact of repeated sprint swim training with restricted arm muscle blood flow on muscular strength and hypertrophic responses in upper arm muscles for swimmers in pace of 50 m freestyle.

2. Material & Methods

2.1 Participants

Twenty swimmers participated in the current study (mean ± SD) age 21.3 ± 2.3 years; weight, 72.2 ± 3.7 kg; height, 171.2 ± 2.1 cm. The participants were swimmers at the swim La Vie swimming academy team and highly trained for about ~10 hours per week with average of 11 years of training swim experience. Swimmers were categorized into two groups randomly, experimental group (Training Group) with BFR (TG; n = 10) and control group (CG; n = 10). For the two groups, pre-tests were conducted prior to the training program, and post-tests were taken following its conclusion. Each swimmer was in good health and had no previous history of persistent injury. Before each swimmer volunteered for the current study, an informed permission form was collected from them. The Suez University ethics committee got ethical approval.

2.2 Training protocol and procedures

Each participant carried done 14 experiments (repeated sprint with arm blood flow restriction and repeated sprint without arm blood flow restriction), All training sessions were conducted at the similar time of the day. After a 20-min warm-up out and in the water that consisting of (stretching, repeated swim drills, squats out of the water, and repeated sprints), both groups performed the RST session in the pool, which consisted of 5 sets of 8 maximal sprints performed 3 days per week for 10 weeks during the period from 01.08.2022 to 09.10.2022. Intensities, repetitions, sets and pause variables of training were interspersed by 25-meter and 1-min rests, respectively. The training session was conducted using a shuttle running of 25 + 25 meters delimitated by lines in the pool. Participants were instructed to swim as quickly as possible. The (TG) was trained to wear the elastic cuffs (Kaatsu-Master, Sato Sports Plaza, Tokyo, Japan) at the proximal area of the arm prior to the training intervention. According to the participants' blood pressure during the resting phase, external pressure between (100 and 130 mm Hg) was chosen for the cuff during the familiarization period [17].

During the several sprint training sessions, the swimmers wore the elastic cuffs (Kaatsu-Master, Sato Sports Plaza, Tokyo, Japan) around the proximal region of both arms. The training regimen started with the cuffs being inflated to a pressure of 100 mmHg. Every training session of repeated sprint training results in an increase in pressure of 10 millimeters of mercury until the pressure reaches 160 mmHg. According to earlier research in this sector, the teaching and consideration of cuff inflation during this investigation were acceptable [17-20].

2.3 Procedures

Swimmers underwent testing sessions prior to the start of the study, and the training program time was followed by two days. First, the strength tests were completed, and then, after a day of rest, the 50-meter swim performance session. Every day of the testing session, measurements started at the same time after an uniform warm-up that comprised jogging, dynamic stretching, and several series of water sprints.

2.4 Test protocol

2.4.1 Strength measurement

Following a prescribed warm-up, the swimmers performed strength warm-up exercises employing (10, 6, and 3 repetitions) at intensities of 50%, 75%, and 85%, respectively. By using their most recent one repetition maximum 1-RM values, the warm-up was estimated. The swimmer's resistance was also fixed at a crucial level of 5% below the 1-RM during the period of particular strength warm-up, and it steadily increased after each successful trail until failure. Based on the subjects' recorded maximal weight lift, the 1-RM bench press and half-squat strength were determined [21, 22].

To complete the test, the bench press exercises were carried out from the up position with full elbow extension, dragged to the chest level for a brief pause, and then pushed back to the starting position. The foot and hand locations for each swimmer were selected during the familiarization session and were balanced during the entire testing. The swimmers were also not permitted to bounce the bar off to their chests. With the barbell held over the shoulders, the swimmer performs a back-squat exercise with free weights, bending his knees to a half-squat position where they appear to be roughly at a 90-degree angle. According to, the rest time between each trial for both strength tests was 3 minutes [23].

2.4.2 The 50 m maximal performance trial

The subjects were allowed to use bonnets and goggles, to sit, to stand, to walk, or to talk as might be done preceding a competitive event. Any motions including warm-up were not allowed behind block. The same lane was assigned to each subject at trials. Standard starting procedure was used for swimmers climbing dive block: the researcher's voice command (take your mark) after electronic bip sound time was started. The time was stopped when the participant touched swimming wall. During swimming, 2 persons followed each swimmer, and 2 chronometers were used for their swimming times. Average of the two chronometers was recorded as the best swimming time [24].

2.5 Statistical analysis

The descriptive data analysis was performed using mean and standard deviation (SD) as well as the Shapiro-Wilk test, which looked at the distribution's normality. Using Levene's test, the homogeneity of variances was investigated. After the training program was implemented, the intragroup changes were measured using an independent t-test. The statistical analysis conducted using the (SPSS 25, USA) and the significance level applied by α = 0.05.

3. Results & Discussion

The data variables in the pre and post testing are reported as (mean and SD) (Table. 1). The findings show that post-test effect size rate and a significant difference between the two groups following the training program period.

Table 1: Mean ± SD and observed changes (mean ± 95% CI) values of measured variables at pre and post training programm of BFR and Control groups

	Training Group			**Control Group**			**Groups diff**		
	Pre-Test	**Post-Test**	**Changes**	**Pre-Test**	**Post-Test**	**Changes**	**Mean (± 95% CI)**	**p value**	**Effect size**
	Mean ± SD	**Mean ± SD**	**(± 95% CI)**	**Mean ± SD**	**Mean ± SD**	**(± 95% CI)**			
Strength Tests									
1RM bench press (kg)	75.5 ± 6.0	86.3 ± 6.9	10.8 ± 1.8	73.8 ± 5.5	83.1 ± 6.6	7.3 ± 1.3	5.2 ± 6.3	0.07	0.78
1RM half-squat (kg)	126.5 ± 10.1	149.1 ± 10.6	22.7 ± 3.0	125.0 ± 7.3	139.4 ± 7.5	14.4 ± 0.7	9.8 ± 8.1	0.02	1.09
Swim Performance									
50 m Time (Sec)	33.3 ± 0.7	33.1 ± 0.8	-0.3 ± 0.1	33.5 ± 0.6	33.3 ± 0.6	-0.2 ± 0.1	-0.3 ± 0.7	0.25	0.49

The training group reported a small increase in upper maximum strength (bench press) and swimming performance variable (ES 0.2 to 0.5). and a large increase in lower body maximum strength (half-squat). In comparison, the CG group reported a small increase only in the 50m swimming performance (ES = 0.49), normally insignificant effect size was seen in other factors. Following repeated sprint training with blood flow restriction, the t-test revealed a significant difference between the two groups (p 0.05) in the maximum strength of the upper and lower bodies.

The aim of this study was to conduct research in the field of blood flow restriction training in the swimming. The results indicated that training group was better than control group in the strength training with changes improvements of 10.8 Kg in the 1RM bench press and 22.7 Kg in the 1RM half-squat. In the swim performance the control group gathered a best score in the 50m Time when compared to the control group, that done the standard training sessions with the traditional training concepts for the strength Training. The results indicated a significance difference between the groups to the training group with the blood restriction training that improved the strength ability for the swimmers, especially the arm strength that influenced the frequencies of the arm strokes during the swimming pace of 50 meter.

In context of strength improvement based on using of BFR training, the current results consist with the studies of [25, 26], that after low intensity exercise (20% 1RM) combined with BFR, the lower body gained more strength. The mechanisms underlying these effects were not examined in the current study, although earlier research points to the possibility that weariness brought on by metabolic buildup may be a significant factor. To give an example, metabolic buildup combined with a low oxygen environment might result in more type II (higher threshold) muscle fiber recruitment.

In the other hand the swimming performance improved over the impact of strength ability via BFR training that’s led a power and ability during the swimming pace of 50 meter, this results also reported by [27], that reported the sprinting times and muscle volume were evaluated. Findings showed significant variations in lactate, pyruvate, L/P ratio, CK, and muscle volume between the experimental group and the control group. The sprinting timings and LDH did not differ much. It has been determined that band restriction of blood flow results in muscle growth and hyperplasia.

Thus, the study concluded that that merging repeated sprint training with BFR training for swimmer during small pace distances might alter muscular strength and aerobic performance in swimming sport. This findings supported by [28], who reported that the 100-meter swimming time trial performance showed a 1.65-second improvement. This shows that BFR training combined with light resistance training might be an efficient training strategy for swimmers. According to recent research, adding BFR training to a regular resistance training regimen was beneficial for boosting hypertrophy and swimming performance in a trained swimmer over the course of three weeks. Athletes who are wounded or recovering from injuries, at times of de-loading or during hard training blocks in the competition phase, might also benefit from this type of training.

4. Conclusions

According to the study's findings, combining frequent sprint training with BFR training for swimmers traveling short distances may affect their muscular strength and aerobic performance, but there was little to no change in their anaerobic performance. All variables in both study groups showed improvement, with a tendency for larger gains in upper body strength in response to blood flow restriction training and applied occlusion with pressure increased to 160 mm Hg.

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