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Comparison Between Two Methods of Power Training on Swimming Performance

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Abstract: The aim of the research is to a comparison between two methods of power training, strength-speed and speed-strength on the performance of 50-meter freestyle swimming. The experimental method was applied to a sample of 12 adult swimmers (mean +/-SD: 16 +/-1 year, 172.2+/-3.2cm, 78.2+/-2.3kg) divided into two experimental groups, group A (strength-speed) and group B (speed-strength) by applying pre-and post-measurements,1RM bench press, 1RM squat, medicine ball chest throw, vertical jump, stroke length (SL), stroke rate (SR) and 50-meter freestyle tests was applied on the subjects respectively, Statistical Analyses Repeated-measures analysis of variance (ANOVA) was used to compare 50-meter freestyle trial time performance after the 2 different power training methods. Statistical significance was accepted at ($p < 0.05$), ($p < 0.01$). A 6-week power training program was applied 3 times a week, results show significant differences between pre and post-measurements in stroke length (t=3.64) and stroke rate (t=7.00) in group A, 1RM squat (t=3.60), vertical jump (t=4.96), stroke length (t=6.76) and 50-meter freestyle (t=32.91) in group B, and non-significant differences in 1RM bench press (t=2.33), 1RM squat (t=2.22), chest MD ball throw (t=2.35), vertical jump (t=2.18), and 50-meter freestyle (t=1.93) in group (A),1RM bench press (t=2.61), chest MD ball throw (t=2.08) and stroke rate (t=1.40) in group (B) for post-measurements. Present results recommend that dry-land program training must include the two methods of power training, strength-speed, and speed-strength, based on the force-velocity relationship for sprint swimmers during a specific period, power training in these two methods improves stroke length, and stroke rate and it leads to enhance swimming performance in sprint events.

Keywords: Power, Strength, Dry-Land, Stroke Length, Stroke Rate

1. Introduction

Swimming is one of the most classified sports among speed sports, especially 50 and 100-meter events which aim to cover the distance in the shortest time possible, so based on this aim the swimmers must train to improve all elements that affect their velocity/speed such as physiological, biomechanical, and physically elements.

Both dry-land and in-water strength training can be beneficial to swimming performance. Swimmers today include a wide variety of strength training practices in their preparation for competition, including dry-land warm-ups, circuit training, traditional strength, plyometrics, biokinetic swim bench, core training, resistive band, pull and drag suit training, eccentric overload, vibration, and instability training [18].

Swimming performance is highly dependent on muscular strength and power, upper-body and lower-body muscular strength and swimming power have been demonstrated to be well correlated with swimming velocity [22].

Strength training helps swimmers improve their muscular strength and power. This added strength can translate into more forceful strokes, greater propulsion in the water, and improved efficiency, allowing swimmers to move through the water with less effort.

The application of muscular force in swimming results in a horizontal displacement of the athlete at a velocity proportional to the magnitude, direction, and duration of the resulting force. The main aim of the mechanical work performed by a swimmer is to overcome hydrodynamic resistance, which increases proportionally with the square of velocity, whereas the metabolic power required is proportional to the cube of the velocity. Therefore, any increase in swimming velocity demands a proportional increment of muscular force to overcome active drag and increase propulsive force, suggesting that muscular strength could be considered a performance-determining factor in swimming [29].

Given the beneficial effects of strength training on anaerobic performance, a better understanding of the relationship between strength training, anaerobic factors, and middle- and long-distance performance in endurance events in general and swimming events in particular. A better understanding is also needed regarding the influence of strength training duration.

Swimming velocity is the product of stroke length and stroke rate and has an important role to play in improving swimming performance. Factors such as training, intensity, physiological capabilities, race distances, sex, and swimming technique influence the relationship between stroke length and rate [7, 17].

Stroke length maintains swimming propulsive forces in the horizontal direction, improves swimming efficiency, and determines swimming velocity [8, 23].

Stroke rate has a great impact on swimming velocity over shorter duration events, such as 50 m performance [9, 12, 30].

Therefore, improvements in strength and power may result in higher maximum force per stroke, subsequently in higher swimming velocities, specifically in sprint distances, Dry-land strength training aims to increase maximal power outputs through an overload of the muscles used in swimming, Strength training is employed to manipulate the force-velocity curve and the ability to apply large amounts of muscular force under sport-specific conditions [22].

$$\text{Power} = \frac{\text{Work}}{\text{Time}} = \frac{\text{Force} \cdot \text{Displacement}}{\text{Time}}$$

$$\text{Power} = \text{Force} \cdot \frac{\text{Displacement}}{\text{Time}}$$

$$\boxed{\text{Power} = \text{Force} \cdot \text{Velocity}}$$

Figure 1. *Equation of power formula.*

To understand the main training attributes that contribute to maximal power output, it is important to understand the basic definition of power and how it is mathematically calculated. Mechanical power is often referred to as the rate of doing work and is calculated by multiplying force by velocity. Based upon these mathematical equations, it is evident that the 2 central components that impact the athlete's ability to generate high power outputs are the ability to apply high levels of force rapidly and express high contraction velocities. The basic inverse relationship between the force a muscle can generate and the velocity at which it contracts is often depicted by a characteristic curve "Figure 1". in which the amount of force that can be generated by a concentric muscle action decreases as the velocity of movement increases.

Generally, there seem to be 3 main schools of thought when attempting to maximize power output. The first school suggests that using lower-intensity efforts (50% of 1 repetition maximum [RM]) is optimal for the development of power generating capacity, whereas the second school proposes that higher loads (50–70% 1RM) are required [11].

2. Methods

The present study compared the effect of two different methods of training power (strength-speed) and (speed-strength) on the performance of 50-meter freestyle swimming, the experimental method was used on a sample of twelve adult swimmers of Alhawar sports club (mean +/- SD: 16 +/- 1 year, 172.2+/- 3.2cm, 78.2+/- 2.3kg) in this study divided to two experimental groups, group A (strength-speed), group B (speed-strength) by Appling pre and post measurements 1RM bench press, 1RM squat, medicine ball chest throw, vertical jump, stroke length (SL), stroke rate (SR) and 50-meter freestyle tests. The subjects were informed about the testing procedure as a group to be sure that they all got the same instructions.

2.1. Subjects

Two power training methods were used, the first is strength-speed, which is a classification for exercises that are not deemed to deliver peak power output, nor peak force, as relatively high intensities are used within this zone (80, 90% of 1RM), it leans more towards strength rather than speed – hence the 'strength'-speed. The strength-speed zone requires an athlete to produce optimal force in a shorter time frame than the maximal strength, it is able to achieve higher movement velocities. Group two is speed-strength, which Peak force would be expected to be even lower here compared to strength-speed due to the greater restriction on time available; however, movement velocities will be higher. As relatively high velocities are used within this zone (30-60% of 1RM), it leans more towards speed rather than strength – hence the 'speed'-strength.

2.2. Procedures

The experimental procedures were performed during the specific preparation phase, with twelve swimmers divided into two groups, group one applied the training method of strength-speed, and Group two applied the training method of speed-strength, 6 weeks of the training program, 3 sessions per week, swimmers completed pre-measurements during three days before the training program, day one swimmer tested body composition, stroke length, stroke rate and 50-meter freestyle time-trials, day two medicine ball chest throw and vertical jump, day three 1RM bench press and 1RM squat.

Program training: the six-week power training program was applied three times per week during the specific preparation phase, and the strength-speed training program load between (80-90% of 1RM), 4 sets, 3 reps, and 5 minutes rest, the speed-strength training program load between (30-60% of 1RM),4 sets, 6 reps, and 5 minutes rest.

Table 1. *6-weeks power program training group one (strength-speed).*

exercises	Group one (strength-speed)											
	Week 1&2				Week 3&4				Week 5&6			
	Sets	RPs	Intensity	Rest	Sets	RPs	Intensity	Rest	Sets	RPs	Intensity	Rest
Bench press	4	3	90 @1RM	5min	4	5	85 @1RM	5min	4	6	80 @1RM	5min
Straight arm pulldown	4	3	90 @1RM	5min	4	5	85 @1RM	5min	4	6	80 @1RM	5min
Hip thrust	4	3	90 @1RM	5min	4	5	85 @1RM	5min	4	6	80 @1RM	5min
Overhead press	4	3	90 @1RM	5min	4	5	85 @1RM	5min	4	6	80 @1RM	5min
Barbell thruster	4	3	90 @1RM	5min	4	5	85 @1RM	5min	4	6	80 @1RM	5min

Table 2. *6-week power program training group two (speed-strength).*

exercises	Group two (speed-strength)											
	Week 1&2				Week 3&4				Week 5&6			
	Sets	RPs	Intensity	Rest	Sets	RPs	Intensity	Rest	Sets	RPs	Intensity	Rest
MB flutter kick	4	20 sec	BW	5min	4	30 sec	BW	5min	4	40 sec	BW	5min
Broad jump	4	3	BW	5min	4	5	BW	5min	4	6	BW	5min
MB bench Press throw	4	3	MB	5min	4	5	MB	5min	4	6	MB	5min
Standing slam	4	3	MB	5min	4	5	MB	5min	4	6	MB	5min
Wall ball	4	3	MB	5min	4	5	MB	5min	4	6	MB	5min

3. Results

3.1. Group One (Strength-Speed)

Table 3. *Means, Standard Deviation, and t-test of the measured variables (n=6).*

Variables	Pre-measurements		Post-measurements		t	significance level
	Mean ±	Stdv.	Mean ±	Stdv.		
1RM bench press (BP)	46.50	7.33	48.25	8.34	2.33	0.102
1Rm squat (S)	60.75	20.16	63.13	22.02	2.22	0.113
medicine ball chest throw (MBCT)	3.74	0.63	4.45	1.02	2.35	0.101
Vertical jump (VJ)	60.50	13.60	62.75	15.52	2.18	0.117
Stroke length (SL)	2.65	0.55	3.03	0.64	*3.64	0.036
Stroke rate (SR)	37.75	8.54	36.00	8.29	*7.00	0.006
50-meter freestyle	28.04	1.76	27.40	1.36	1.93	0.149

*Significant at ($p<0.05$)

The main results observed were as follows: Table 3 showed the statical significant differences in stroke length (SL) between the pre-and post-measurements (t= 3.64), ($p<0.05$) for the post-measurements. and statical significant differences in stroke rate (SR) between the pre- and post-measurements (t= 7.00), ($p<0.05$) for the post-measurements. and non-statistically significant differences in 1RM bench press (BP) between the pre-and post-measurements (t= 2.33), ($p<0.05$) for the post-measurements. non-statistically significant differences in 1RM squat (S) between the pre-and post-measurements (t= 2.22), ($p<0.05$) for the post-measurements. non-statistically significant differences in medicine ball chest throw (MBCT) between the pre-and post-measurements (t= 2.35), ($p<0.05$) for the post-measurements. non-statistically significant differences in the vertical jump (VJ) between the pre-and post-measurements (t= 2.18), ($p<0.05$) for the post-measurements. non-statistically significant differences in 50-meter freestyle between the pre-and post-measurements (t= 1.93), ($p<0.05$) for the post-measurements.

3.2. Group Two (Speed-Strength)

Table 4. *Means, Standard Deviation, and t-test of the measured variables (n=6).*

Variables	Pre-measurements		Post-measurements		t	significance level
	Mean ±	Stdv.	Mean ±	Stdv.		
1RM bench press (BP)	29.50	9.04	30.75	8.85	2.61	0.080
1Rm squat (S)	37.63	9.46	39.75	10.44	*3.60	0.037
medicine ball chest throw (MBCT)	2.74	0.63	3.03	0.74	2.08	0.129
Vertical jump (VJ)	39.50	17.79	41.50	17.69	*4.90	0.016
Stroke length (SL)	2.13	0.30	2.45	0.39	*6.79	0.007
Stroke rate (SR)	40.50	11.00	33.50	12.15	1.40	0.256
50-meter freestyle	27.98	0.82	27.03	0.86	*32.91	0.000

*Significant at ($p<0.05$)

Table 4 showed the statical significant differences in 1RM squat (S) between the pre-and post-measurements (t= 3.60), (p<0.05) for the post-measurements. and statical significant differences in the vertical jump (VJ) between the pre-and post-measurements (t= 4.90), (p<0.05) for the post-measurements. and statical significant differences in stroke length (SL) between the pre-and post-measurements (t= 6.79), (p<0.05) for the post-measurements. and statical significant differences in 50-meter freestyle between the pre-and post-measurements (t= 32.91), (p<0.05) for the post-measurements. non-statistically significant differences in 1RM bench press (BP) between the pre-and post-measurements (t= 2.61), (p<0.05) for the post-measurements. non-statistically significant differences in medicine ball chest throw (MBCT) between the pre-and post-measurements (t= 2.08), (p<0.05) for the post-measurements. non-statistically significant differences in stroke rate (SR) between the pre-and post-measurements (t= 1.40), (p<0.05) for the post-measurements.

Table 5. *Percentage of effect between post-post measurements of the measured variables.*

Variables	Group one (strength-speed)					Group two (speed-strength)				
	Post-measurements					Post-measurements				
	Mean +	Stdv.	t	significance level	Percentage of improvement	Mean +	Stdv.	t	significance level	Percentage of improvement
1RM bench press (BP)	48.25	8.34	2.33	0.102	%3.76	30.75	8.85	2.61	0.080	%4.24
1Rm squat (S)	63.13	22.02	2.22	0.113	%3.92	39.75	10.44	*3.60	0.037	%5.63
medicine ball chest throw (MBCT)	4.45	1.02	2.35	0.101	%18.98	3.03	0.74	2.08	0.129	%10.58
Vertical jump (VJ)	62.75	15.52	2.18	0.117	%3.72	41.50	17.69	*4.90	0.016	%5.06
Stroke length (SL)	3.03	0.64	*3.64	0.036	%14.34	2.45	0.39	*6.79	0.007	%15.02
Stroke rate (SR)	36.00	8.29	*7.00	0.006	%4.64	33.50	12.15	1.40	0.256	%17.28
50-meter freestyle	27.40	1.36	1.93	0.149	%2.28	27.03	0.86	*32.91	0.000	%3.40

Table 5 shows the percentage of improvements between group one and group two in post-post measurements of the measured variables, which appears a high percentage of effect occurred in medical ball chest throw (MBCT) in group one while the percentage was (%18.98), and a high percentage of effect occurred in variables 1RM bench press (BP) (%4.24), 1RM squat (%5.03), vertical jump (VJ) (%5.06), stroke length (SL) (%15.02), stroke rate (SR) (%17.28), and 50-meter freestyle (%3.40) in group two.

4. Discussion

The primary aim of the current study is to examine changes and the effect between two methods of power training, method one (strength-speed), and method two (speed-strength) on 1RM bench press, 1RM squat, vertical jump, medicine ball chest throw, and swimming performance, stroke length, stroke rate, and 50-meter freestyle trial, in a group of elite sprint swimmers after six weeks our results in Table 3 showed improvements in stroke length (SL) and stroke rate (SR) after 6 weeks of the training program of (strength-speed) these improvements may be due to the protocol of (strength-speed) program which includes the performance of the exercises at a high load of 1Rm with slow repetitions which lead to representative of an increase in power-generating capacity, improvement in force production during the arm pull phase in swimming which lead to improving the stroke length (SL). [6, 14, 19, 20].

Also, a high load of 1RM works on the recruitment of a maximum number of muscle fibers and can significantly increase the ability to generate peak force and the rate of force development which leads to improving the rate of force production which improves the stroke rate (SR) and also the reduction of the slope within the stroke-cycle produced a shorter time to reach the peak [6, 14, 16, 20].

Also, results show non-significant in 1RM bench press, 1RM squat, medicine ball chest throw, vertical jump, and 50-meter freestyle in group (A) (strength-speed) some studies apparent max strength increases did not yield performance enhancement [5, 6, 27]. the expiation of this is that may the 6-week training not be enough to improve the max strength or power, the number of swimmers in the sample is low, and some studies reported that the velocity must not be assessed as a negative effect on swim performances because this velocity represents the ratio between power output and force [2, 10].

Our results in Table 4 show improvement in 1RM squat, vertical jump (VJ), and 50-meter freestyle after 6 weeks of the training program of (speed-strength) these improvements may be due to the protocol of (speed-strength) program which includes performing exercises with high-speed repetitions by a low-strength load of 1RM, which working on enhance the rate of generating power output, and, the sprint swimming performance was strongly correlated with the maximum upper and lower body strength, and the 1RM bench press and squats explained 45–62% of the variance in the sprint swimming performances (50-m and 100-m front crawl). The increase in SR led to a faster swim and, thus, better sprint swimming performance. In addition, it can also be concluded that a dry land resistance program, including the BP and MBT concurrent to in-water resistance with WP and HD, is effective in improving the maximum strength muscle, kinematics (SR and V) and, ultimately, sprint swimming performance [1, 2, 15, 16, 18, 21, 24-27].

Also, the improvement of vertical jump (VJ) leads to an improvement of reaction time of start which directly leads to enhancement of the 50-meter freestyle trial, swimmers that possess the capacity to generate high levels of force have the ability to swim faster to 10 m. and these results are these results correspond to Marques 2020 study which reported that improvements in lower-and upper-limbs strength, as well as jumping and swimming performance is possible during a long competitive cycle by using a combination of strength exercises with low volume, low loads, low frequency and high-velocity regimen [4, 13, 18-20].

also, results show non-significant in 1RM bench press (BP), medicine ball chest throw (MBCT), and stroke rate (ST), some reason for these results may reflect the protocol of (the speed-strength) program which includes performing exercises with high-speed repetitions by a low-strength load of 1RM and also the short duration of the program, for stroke rate the relationship between stroke length and stroke rate is an Inverse relationship, in another way, a swimmer's stroke rate will decrease as his or her stroke length increases and vice versa, and other reason is this could be the reason that swims specific frequencies during dry-land and muscle load are different from the movement pattern in the water and the CNS fatigue which results from the speed of repetition may lead to a negative effect on throw power in dry-land and stroke rate in pool. [2, 3, 5-13, 27, 28].

Table 5 shows the comparison of the effect between the (strength-speed) training and (speed-strength) training on tests, 1RM bench press, 1RM squat, vertical jump, medicine ball chest throw, stroke length, stroke rate, and 50-meter freestyle trial, in general, these findings show that power training has a direct effect on the physical performance, stroke biomechanics, and swimming performance. Our findings revealed a large main effect of percent for 1RM bench press, 1RM squat, vertical jump, stroke length, stroke rate, and 50-meter freestyle trial were in group two which training by (speed-strength) method, and the percentages of effect were (%4.24) in 1RM bench press, (%5.63) in 1RM squat, (%5.06) in the vertical jump, (%15.02) in stroke length, (%17.28) in stroke rate, and (%3.40) in 50-meter freestyle trial, while the revealed a large main effect of percent for medicine ball chest throw was in group one which training by (strength-speed), the percentage of effect was (%18.98) in medicine ball chest throw. [1, 2, 4, 5, 15, 16, 19-21, 24-26].

5. Conclusion

However, further studies are needed to investigate the effect of different methods of power training on different ages and variables such as physiological variables, The findings of this study suggest that the different power training protocols are safe (i.e., no injuries occurred), The different loads of power training protocols all seem to be beneficial to improve swimming performance and, therefore, based on the findings, strength and conditioning trainers should consider including different power training methods to promote physical fitness and ultimately improve swimming performance, some limitations of this study should be mentioned, such as the sample size, the lack of studies in swimming with similar characteristics that enable the comparison of results.

Conflicts of Interest

The author declares no conflicts of interest.

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