Coaching Applications

The Correlation Between Strength and Power Measures with Sprint Freestyle Performance in Division 1 Collegiate Swimmers

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ABSTRACT

The purpose of this study was to investigate the relationship between dryland strength and power measures with sprint freestyle performance in Division 1 collegiate swimmers. Ten males (Age, M = 20.1 yrs., SD = 2.2) and eight females (Age, M = 19.4 yrs., SD = 1.3) with an average of 12.4 years of competitive swimming experience participated in the study. Dryland measures were a one-repetition maximum (1-RM) weighted pull-up test in kilograms, a non-countermovement jump (NCMJ) in centimeters, and a barbell back squat velocity test in meters per second designed to test upper body and leg strength and power. The swim task was a maximal-effort 45.72-meter freestyle swim. To normalize the data, Z-scores were computed for each variable and for the sum of the three-dryland tests. The data were analyzed using Pearson product-moment correlation analysis. In males, an inverse association was observed between the sum of the three-dryland performances and the sprint swim time ($r = -0.77$, $p < 0.05$). In females, correlations were significant between the sum of the three-dryland performances, the weighted pull-up, the back squat velocity, and the NCMJ height with the sprint swim time ($r = -0.86$, $r = -0.66$, $r = -0.67$, $r = -0.75$; $p < 0.05$, respectively. The results showed the importance of dryland strength and power in male and female competitive swimmers for successful sprint swimming performance.

Introduction

Some ambiguity exists between various dryland training modalities and swimming performance. Exercises such as the weighted pull-up, squat, and jumps are often utilized, but little is known about its efficacy on sprint swimming performance.

The purpose of this study was to investigate the relationship between upper body strength and lower body power measures with sprint freestyle performance.

Methods

Participants

The study recruited members of the Arizona State University Swimming Team from the 2017-2018 season. Ten males and eight females participated in the study. The study excluded breaststroke specialists.

Design

A correlational study design was used to determine the relationship between dryland performance measures and 45.72-meter freestyle performance. Dryland measures included a one repetition maximum (1-RM) weighted pull-up, a non-countermovement jump (NCMJ) height, and back squat barbell velocity test. The subjects completed one study visit after the end of their collegiate swim seasons.

Descriptive Data

The subjects read and completed a questionnaire that identified the subjects' age in years, gender, academic, and athletic year. The questions for swimming experience included average meters swam in a usual practice session in meters per practice and age they began competitive swimming. The questions for dryland training experience included number of years participating in dryland activities and self-estimated 1-RM for a weighted pull-up in kilograms.

45.72-meter freestyle test

A 45.72-meter freestyle swim test was utilized to test sprint swimming ability. The subjects began the swim testing session with a warm-up consisting of a 500-yard freestyle swim at their own pace followed by 4 x 25-yard swims consisting of 12.5-yards of maximum speed and 12.5-yards of slow swimming. The subjects rested 30 seconds between each 25-yard swim. The warm-up ended with subjects taking one practice start off the starting blocks. To measure the swim performance, subjects completed two 45.72-meter sprint performances from the starting blocks. The study timed each swim test using a Daktronic timing system (SD, USA). Following each sprint swim, subjects completed a recovery swim of 300-yards. The subjects did not wear a textile fabric-racing suit.

1-RM weighted pull-up

A 1-RM weighted pull-up test was utilized to test upper body pulling strength. Prior to performing the 1-RM weighted pull-up, the subjects completed a warm-up consisting of the following: five repetitions using a latissimus pull-down machine (Power-Lift, Iowa, USA) at 80% of their BW, one repetition at 100% of their BW, and one pull-up with their BW only. The subjects started the 1-RM weighted pull-up test at 80% of their self-estimated maximum-weighted 1-RM as identified on the demographic and swim training questionnaire. To complete the 1-RM weighted pull-up test, the subjects incrementally increased the weight by approximately 2.5 kilograms for women and approximately 5 kilograms for men until they were no longer able to perform a pull-up as instructed. A research assistant administered a one-minute rest period between each attempt. To account for differences in BW between subjects, investigators assigned a relative pull-up score for data analysis by using the formula: ((BW + total weight pulled)/BW).

Non-countermovement vertical jump (NCMJ)

A NCMJ was utilized to test lower body power. Prior to performing the NCMJ test, the subjects completed a warm-up consisting of two NCMJs with submaximal effort. To complete the test, the subjects descended to a self-selected depth and paused for one second, counted aloud by a research assistant, before initiating the concentric phase of the jump. The hip and knees remained extended during the duration of the flight phase. The arms remained akimbo, during the duration of the jump. A Just Jump System Jump-Mat (Perform Better, RI, USA) placed under the subjects' feet measured the vertical jump height. The research assistant administered a one-minute rest period between each attempt.

Back squat barbell velocity

A back squat barbell velocity test was utilized to measure lower body strength and power. Prior to performing the squat test, the subjects completed a warm-up consisting of two barbell back squats with submaximal effort. The subjects were required to descend in the squat until their hip crease reached below the top of their knee. The depth of the squat was predetermined with an elastic rope placed in the frontal plane behind the subject. The subjects were required to touch the rope with their buttocks to ensure a standardized squat depth. The weight of the barbell was determined by using half of the subjects' BW in pounds. A Tendo Power Analyzer (Tendo Sports Machines, Trencin, Slovak Republic) was attached to the barbell to measure the average concentric barbell velocity in meters per second. The research assistant administered a one-minute rest period between each attempt.

Results

The male and female subjects had a combined average of 12.4 ± 2.1 years of competitive swimming experience, an average of 6.1 ± 2.6 years of dryland experience, and swam an average of 6222.2 ± 878.2 meters per practice in the previous 6 months. Scores for the dryland and swim performance can be seen in Table 1.

Significant correlations for male subjects were observed in:

- The sum of the 3 dryland performances and 45.72-meter freestyle performance

Significant correlations for female subjects were observed in:

- The sum of the 3 dryland performances and 45.72-meter freestyle performance
- The NCMJ height and 45.72-meter freestyle performance
- The relative pull-up score and 45.72-meter freestyle performance
- The back squat velocity and 45.72-meter freestyle performance

Significant correlations for all subjects were observed in:

- The sum of the 3 dryland performances and 45.72-meter freestyle performance
- The NCMJ height and 45.72-meter freestyle performance
- The relative pull-up score and 45.72-meter freestyle performance
- The back squat velocity and 45.72-meter freestyle performance

Table 1

Scores for the Dryland and Swim Performance

	Males (n=8) **MEAN**	**Females (n=10)** **MEAN**	**All (n=18)** **MEAN**
45.72-m freestyle swim time (seconds)	21.62 ± 0.75	24.81 ± 0.76	23.39 ± 1.79
NCMJ height (cm)	53.09 ± 3.96	41.23 ± 6.95	46.5 ± 8.29
Relative pull-up score (BW+ weight pulled)/BW))	1.33 ± 0.11	0.91 ± 0.49	1.09 ± 0.42
Back Squat velocity (meters/second)	1.07 ± 0.13	0.9 ± 0.13	0.97 ± 0.14

Discussion

The significant correlation between the sum of the dryland tests and swimming performance in both genders may highlight the importance of possessing both strength and power characteristics to be successful in sprint swimming.

A lack of relationship between each individual dryland test and swimming performance was observed in the male subjects, however it is possible, that the male results did not reach significance due to the low sample size (N = 8).

Relative Pull-up scores

- Correlations were lowest between the pull-up and swimming performance in males, females, and the combined sample (r = -0.54 to -0.66). This may be explained by the relative importance of maximal force production capabilities as compared with relative strength and power in water. Typically, a human's force capabilities increase as movement velocity decreases, but in an aquatic environment, water resistance increases as velocity of the body relative to the water increases. Therefore, during a typical swimming stroke, the muscle will not produce maximal force, suggesting a higher level of maximal strength may not be an asset to swimming performance. For swimmers, once a baseline of maximal strength is established, training power characteristics may become more important than training strength characteristics. While strength norms for the weighted pull-up have not yet been established, coaches should monitor the amount of time dedicated to achieving maximal upper body pulling strength.
- The correlation between the relative pull-up score and swimming performance was significant in females but not in males. Differences in maximal upper body strength between male and female swimmers may explain this observation. Males may have had sufficient baseline strength levels that did not further maximize swimming performance, while females had not yet reached their maximal strength range.

Lower Body Power

- The lack of relationship between the lower body measures and swimming performance in male subjects is surprising considering the start (0-15m) makes up approximately 30% of a 50-meter swim. This null relationship may be due to the lack of transfer of lower body power to skillful movements, such as the start and turn. It is also possible that the male subjects in the present study already possessed sufficient strength and power on land that did not further improve swimming performance and they may benefit more from swimming-specific training.
- In the present study, it is possible that the female subjects with higher jump heights and faster back squat velocities also displayed faster swim performances due to faster swimming starts and turns.

It is possible that the male subjects in the current study possessed greater relative upper body strength and lower body power due to their training experience. Although not statistically significant, the male subjects in this study reported higher mean values than females in years of performing dryland activities. Additionally, 50% of the female subjects were freshman, while only 37.5% of male subjects were freshman. This may have influenced the results, as swimmers typically do not begin strength training until their first year of collegiate swimming. The greater training experience in male subjects may have influenced the results of this study. Therefore, strength and power characteristics for each athlete should be monitored and training programs should be individualized to maximize swimming performance.

Recommendation

- For swimmers new to strength training or lacking in strength, training strength characteristics instead of power, could be beneficial for improving swimming performance. Additionally, swimmers with little strength training experience may benefit from training strength and power characteristics, while swimmers with high levels of strength training experience may benefit from training power characteristics while maintaining strength characteristics. General dryland training recommendations in accordance to the results of this study are presented in Table 2.

Table 2

General Dryland Training Recommendations

Dryland Training Level	**Strength**	**Power**	**Notes**
Novice	Priority	Development/ Maintenance	Quality movement fundamentals should also be prioritized
Intermediate	Priority	Priority	Individual variation will be necessary. Strength and power characteristics should be monitored
Advanced	Maintenance	Priority	Individual variation will be necessary. Strength and power characteristics should be monitored

Conclusion

Inverse relationships between three measures of strength and power and sprint swimming performance were observed in females but not males. For female subjects in this study, the increased strength and power measures may have contributed to faster swimming times. A combination of the three strength and power measures were inversely related with sprint swimming performances in males and females. This suggests that possessing both upper body strength and lower body power might be important for successful sprint swimming performance, especially in females. To enhance performance coaches should monitor their swimmers' strength and power characteristics carefully and develop individual training programs based on their specific strength and power characteristics. Further research is necessary to establish optimal strength and power value norms for swimmers.