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THE RELATIONSHIP BETWEEN SHORT DISTANCE SWIMMING PERFORMANCE AND REPEATED SPRINT ABILITY IN SWIMMERS

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Abstract:
The aim of this study is to investigate the relationship between short distance swimming performance and repeated sprint ability in swimmers. 12 male swimmers between the ages of 14-18 from Denizli Pamukkale University Swimming Sports Club Performance team voluntarily participated at this study. Freestyle swimming time of the subjects was measured by using Casio stopwatch. 8x15-m, 25-m, 50-m and 100-m freestyle swimming degrees of swimmers were recorded. The ideal sprint time (IS), the total sprint time (TS) and the performance decrement (PD) were determined after repeated sprint test (RST). Lactate levels were recorded at the end of each test. The Borg scale was used to determine the perceived difficulty level. For the statistical analysis Pearson's correlation was used to determine the correlations between 25-m, 50-m and 100-m freestyle swimming time and swimming times obtained at the end of RST (IS, TS, PD). Significant relationships were found between the 25-m, 50-m and 100-m swimming performance ($p<0.01$). Significant correlations were found between the IS and the TS and the 25-m and 50-m swim results ($p<0.01$) and also the 100-m swim results ($p<0.05$). Significant relationships were found between obtained lactate values end of the 25-m, 50-m and 8x15-m RST ($p<0.05$). Significant correlations were found between the 50-m lactate values and 25-m lactate values ($p<0.05$); also between 50-m lactate values and 8x15-m RST lactate values ($p<0.01$). There was no significant relationship between 100-m lactate values and 25-m, 50-m and 8x15-m RST lactate values ($p>0.05$). Significant relationships were found between 8x15-m RST lactate values and 25-m lactate values ($p<0.05$). Moreover, strong relations were found between the 8x15-m RST lactate values and 50-m lactate values ($p<0.01$). The findings of the present study indicated that repeated sprint ability as well as higher anaerobic capability as

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reflected by the short distance. The results also indicated that repeated sprint ability is strongly related to swim sprint performance.

Keywords: swimming, repeated sprint ability, short distance swimming performance

1. Introduction

In recent years, the use of repeated sprint tests has gained popularity among coaches and athletes as a method of evaluating repeated sprint ability. Such tests involve repetitions of short sprints (mainly running and cycling), with variable short recovery periods between the sprints. According to Glaister (2005) and Spencer et al. (2005) a high level of aerobic fitness is a prerequisite for enhanced performance during repeated-sprint activities. However, the correlation between aerobic fitness (e.g., VO2 max) and indices of repeated sprint ability has been inconsistent. While some authors have reported significant correlations between the two (Aziz and Chia, 2000; Dawson et al., 1993), others have failed to do so (Castagna et al., 2007; Wadley and Le Rossignol, 1998). Further research is therefore required, especially with swimming as the exercise mode, as most repeated-sprint studies have employed running (Aziz and Chia, 2000; Meckel et al., 2009) or cycling (Bishop et al., 2004; Fitzsimons et al., 1993). To the best of our knowledge, little studies (Meckel et al., 2012; 2013) have investigated indices of RST in swimming.

In contrast to the single, continuous efforts typically performed in individual sports, such as track and field or swimming, team sports are usually characterized by intense intermittent activity; that is, repeated short-duration, high-intensity efforts, interspersed with brief recovery periods. Such tests involve repetitions of short sprints (mainly running and cycling), with variable short recovery periods between the sprints. Different protocols for this test consist, for example, of 8 to 10 5-second sprint repetitions starting every 30 seconds (Aziz and Chia, 2000), six 40-m maximal sprints starting every 30 seconds (Fitzsimons et al., 1993), or twelve 20-m sprints starting every 20 seconds (Wadley and Le Rossignol, 1998). The specific test protocol can be easily adapted to suit the specific needs and movement patterns of intermittent-type sports or activities. Therefore, repeated sprint tests are most commonly used in multi-sprint sports such as soccer, basketball, and hockey and have been reported to be both valid (Bishop et al., 2001,14) and reliable (Fitzsimons et al., 1993, Spencer, 2006).

In fact, although some studies reported significant correlations between aerobic capacity and RST performance indices (Bishop and Edge, 2006; Bishop and Spencer, 2004; Glaister, 2007; Glaister, 2005), others have failed to do so (Aziz et al., 2007; Bishop et al., 2003; Castagna et al., 2007). Moreover, the ability to perform repeated sprints was also closely related to anaerobic attributes such as anaerobic glycolysis (Glaister, 2008), the ability to buffer hydrogen ions (Bishop et al., 2004; Edge et al., 2006) and muscle glycogen concentration (Gaitanos et al., 1993). In addition, we examined the relationships between RST indices and the swimmers' best single short-distance results. We hypothesized that, swimming RST indices would correlate with short-distance swim results (as indicators of anaerobic and aerobic capacity respectively).

2. Material and Methods

2.1 Participants

Twelve male swimmers (age 15.5 ± 1.93 y, height 173.91 ± 11.40 cm, body mass 76.58 ± 5.46 kg) specializing in 100-m swim distances, all members from Denizli Pamukkale University Swimming Sports Club Performance team A, participated in this study. Standard calibrated scales and stadiometers were used to determine the height and body mass. Participants had several years of training and competitive experience. Training experience of the swimmers was similar (average 7.0 years each). Testing sessions were performed upon completion of the preparatory training period, prior to the beginning of the competitive season. During this period an average of 10 swimming sessions were performed by the swimmers every week, covering distances of about 40-50 km·week^{-1}. Out of that, about 50% was devoted to long-distance aerobic-type training, 25% to interval training and 15% to sprint training. The swimmers also spend some time practicing special technical drills (about 10% of total distance) in the water. In addition, the swimmers had 3-4 sessions of strength training every week that included mainly weight lifting of different forms. The swimmers were informed of the experimental procedures and signed an informed consent form. All the procedures were conducted in accordance with the standards of the Institutional Ethics Committee.

2.2 Procedures

The participants performed four tests with a 4-5 days' break between each test. The first test consisted of a 25-m swim, the second consisted of a 50-m swim, the third consisted of a 100-m swim, and the fourth consisted of the swimming repeated sprint test (RST) protocol. All four tests were performed in the afternoon, using indoor swimming pools: the 25-m, 50-m, 100-m test was performed in a 50-m Olympic-size pool and the RST in a 25-m x 15-m pool. The water temperature was 26°C and the air temperature was 26-28°C during all tests. In order to prevent the effects of fatigue on the study results, swimmers were instructed to avoid intense activity for 24 h before each test. The participants were also instructed to drink 500 ml of water 30 minutes before each testing session. None of the participants were taking any food supplements. Prior to each test, the swimmers performed a standard warm-up that included an 800-m swim and 4x15-m sprints, and then rested 15 min before starting the test. A handheld stopwatch (Casio HS-80TW-1EF) with an accuracy measurement of 1/1000 s, was used for recording time during each swim. The front crawl swimming style was used in all tests.

2.3 Repeated sprint test

All the swimmers completed 8 repetitions of a 15-m all-out sprint (8x15m), each separated by a 30-second rest interval. The swimmers started each sprint in the water with a two-legged push away from the wall. The swimmers were instructed to start swimming immediately after the feet disengaged from the wall and to avoid diving under the water, as usually occurs when jumping off starting blocks. During the rest periods between the sprints, the swimmers swam back slowly to the starting point at an intensity corresponding to about 50% of their maximal 100-m speed. This speed was familiar to the swimmers, because they routinely used it for recovery during interval training sessions. This speed is also considered to be the slowest speed possible with the use of a proper swimming technique (Toubekis, 2006). After returning to the starting point, the swimmers took the starting position for the next sprint.

Blood lactate was taken from a earlobe 3 minutes after the completion of the 25-m, 50-m, 100-m and RST using a portable lactate analyzer (Lactate Plus, Nova Biomedical, USA). Rating of perceived exertion (RPE) was determined using the modified 1-10 (1 being the easiest and 10 the hardest) Borg scale (Borg, 1982) immediately upon the completion of the RST. The three measures of the RST were the ideal swim time (IS), the total swim time (TS) of the 8 sprints, and the performance decrement (PD) during the test. Ideal sprint time was calculated as the fastest 15-m swim time multiplied by 8. The total sprint time was calculated as the sum of all sprint times. Performance decrement was used as an indication of fatigue and was calculated as ([TS/IS] X 100) - 100 (Fitzsimons et al., 1993).

The 25-m, 50-m and 100-m swim trials were performed according to official competition rules to determine the best performance time for these distances. The swimmers started each trial jumping off starting blocks into the water. To simulate competitive-like conditions, the swimming trials were performed with groups of 4-5 participants according to the swimmers' personal records and current fitness level.

2.4 Statistical Analysis

The data are reported as means and standard deviations. Pearson linear correlation analysis was used to evaluate the relationships between each of the RST indices (IS, TS, and PD) and the 25-m, 50-m and 100-m swimming times. Pearson correlation was also used to evaluate the relationship between the 25-m, 50-m and 100-m swimming times and between blood lactate concentration responses end of the 25-m 50-m, 100-m and 8x15-m. All analysis was executed in SPSS for Windows version 17.0 and the statistical significance was set at $p < 0.05$.

3. Results

The participants' blood lactate concentration responses, RPE, 25-m 50-m and 100-m swim times, and performance indices from the swimming RST are presented in Table 1.

Table 1
The participants' blood lactate concentration responses, swimming times, RPE, and RST performance indices

25-m swim time (s)	13.49±1.06
50-m swim time (s)	28.82±2.02
100-m swim time (s)	58.71±1.67
8x15-m swim time (s)	7.94±0.03
Post 25-m blood lactate (mmol.L^{-1})	3.55±1.35
Post 50-m blood lactate (mmol.L^{-1})	7.3±3.14
Post 100-m blood lactate (mmol.L^{-1})	7.26±2.89
Post 8x15-m blood lactate (mmol.L^{-1})	3.05±2.48
RPE (1-10)	5±1.20
Ideal sprint time (s)	62.11±5.28
Total sprint time (s)	64.36±5.76
Performance decrement (%)	3.61±1.99

RST: repeated srint test; RPE: rating of perceived exertion
Values are given as mean ± SD

Table 2 shows the correlations between 25-m 50-m and 100-m swim times are presented. Significant relationships were found between the 25-m, 50-m and 100-m swimming performance ($p<0.01$).

Table 2

Correlations between swimming times

Distance	25-m (s)	50-m (s)	100-m (s)
25-m (s)	1	0.894(**)	0.799(**)
50-m (s)	0.894(**)	1	0.855(**)
100-m (s)	0.799(**)	0.855(**)	1

** p< 0.05; ** p<0.01*

Table 3 shows the relationships between RST performance indices (IS, TS, and PD) and 25-m, 50-m and 100-m swimming times of the study participants are presented. Significant correlations were found between the IS and the TS and the 25-m and 50-m swim results (p<0.01) and also the 100-m swim results (p<0.05).

Table 3

Relationship between RST performance indices and 25-m, 50-m and 100-m swimming times

Distance	Ideal sprint time (s)	Total sprint time (s)	Performance decrement (%)
25-m (s)	0.723(**)	0.894(**)	0.050
50-m (s)	0.713(**)	0.713(**)	0.118
100-m (s)	0.605(*)	0.669(*)	0.409

** p< 0.05; ** p<0.01*

Significant relationships were found between obtained lactate values end of the 25-m, 50-m and 8x15-m RST (p<0.05). Significant correlations were found between the 50-m lactate values and 25-m lactate values (p<0.05); also between 50-m lactate values and 8x15-m RST lactate values (p<0.01). There was no significant relationship between 100-m lactate values and 25-m, 50-m and 8x15-m RST lactate values (p>0.05). Significant relationships were found between 8x15-m RST lactate values and 25-m lactate values (p<0.05). Moreover, strong relations were found between the 8x15-m RST lactate values and 50-m lactate values (p<0.01), as it can be seen in Table 4.

Table 4

Relationship between 25-m, 50-m 100-m and 8x15-m blood lactate measurements

Blood lactate (mmol.L^{-1})	25-m	50-m	100-m	8x15-m
25-m	1	0.652(*)	0.455	0.610(*)
50-m	0.652(*)	1	00300	0.829(**)
100-m	0.455	0.300	1	-0.011
8x15-m	0.610(*)	0.829(**)	-0.011	1

** p< 0.05; ** p<0.01*

4. Discussion

The study examined the relationship between short distance swimming performance (25-m, 50-m and 100-m) and the performance indices of repeated sprint test (RST) in swimmers. Significant relationships were found between the 25-m, 50-m and 100-m swimming performance. The correlations between the IS and the TS and the 25-m and 50-m swim results and also the 100-m swim results were significant.

Meckel et al. (2012) failed to find any significant relationships between 100-m swim times (an index of anaerobic performance) and the RST performance indices, even when combined in a multilinear regression model. This may be related to the fact that the 55-60 s 100-m swim relies largely on the glycolysis energy system, while the 11-12 s 25-m swim relies mostly on the ATP-CP phosphagen system for energy supply. Moreover, it has been documented that in a competitive event such as the 400-m run, with a performance time similar to the 100-m swim time (~50 seconds), the aerobic system contributes up to 40% of the total energy requirements (Duffield et al., 2005). This is in contrast to a previous study that reported significant correlations between RST performance indices and anaerobic power (Dawson et al., 1993). A possible explanation for this discrepancy is that although Dawson et al. (Dawson et al., 1993) used short anaerobic tests (10- and 40-m running time, lasting, 10 seconds), the 100-m swim time that was used in this study lasted about 56 seconds. Thus, although further research is required, RST (in both swimming and running) may be more strongly correlated with ‘’anaerobic power’’ (all-out tests lasting, 10 seconds) than with ‘’anaerobic capacity’’ (all-out tests lasting 30-60 seconds). This could be assessed in our research by correlating the performance indices derived from the current RST protocol with a 25-m sprint time.

Meckel et al. (2013) were found significant correlations between the 25-m swim time and the TS or the IS. These findings are in line with other RST studies that have investigated the relationships between repeated sprint ability and anaerobic capabilities (Dawson et al., 1993; Mendez-Villanueva et al., 2007; 2008; Wadley and Le Rossignol, 1998). This may emphasize the important contribution of anaerobic metabolism to these exercise types in swimmers. These relationships, however, depend on specific performance variables, such as length and number of intervals, rest time, mode of exercise and the type of aerobic/anaerobic measure.

Significant relationships were found between obtained lactate values end of the 25-m, 50-m and 8x15-m RST. Significant correlations were found between the 50-m lactate values and 25-m lactate values; also between 50-m lactate values and 8x15-m RST lactate values. There was no significant relationship between 100-m lactate values and 25-m, 50-m and 8x15-m RST lactate values. Significant relationships were found between 8x15-m RST lactate values and 25-m lactate values. Moreover, strong relations were found between the 8x15-m RST lactate values and 50-m lactate values. Meckel et al. (2012) were found their study the mean peak blood lactate level after the present swimming RST (5.5 $mmol.L^{-1}$) was also lower than the level found in previous running (10-14 $mmol.L^{-1}$) (Meckel, 2009) or cycling (9-12 $mmol.L^{-1}$) (Fitzsimons et al., 1993) RST. In line with this, blood lactate concentration was found to be as low as 3 $mmol.L^{-1}$after forty 25-m swims at a 100-m race pace in highly trained swimmers (Gullstrand, 1987). Once again, the lower lactate values are likely, at least partially, attributed to the recruitment of a smaller muscle mass during swimming.

The extent to which an individual can maintain swimmers' sprint performance is known as "repeated sprint ability" (RSA) (Dawson et al., 1993) which is largely dependent on the extent of Phosphocreatine (PCr) resynthesis (Bogdanis et al, 1996) and the removal of hydrogen ions (H+) from the muscle during recovery between bouts. It has previously been proposed that an individual's RSA may be aided by their aerobic capacity (Aziz, 2000) as an enhanced aerobic capacity may increase the ability to tolerate, remove, and buffer H+ from the working muscle (Sahlin, 1984) and also enhance PCr and adenosine triphosphate (ATP) resynthesis from inorganic phosphates post-exercise.

Mujika et al. (2009) investigated the age-related differences in repeated-sprint ability and blood lactate responses in 134 youth football players. They examined repeated sprint ability and lactate concentration. They were found significant correlations between peak lactate concentration was moderately correlated with sprint time (r=0,78, p=0,001). This results show us in lactate find answers indirectly allows us to be able to have information on anaerobic performance shows repeated sprint test may be used.

In conclusion, this study has shown that repeated sprint ability as well as higher anaerobic capability as reflected by the short distance. It is possible that aerobic performance is not main factor that has effect on repeated sprint test. The results also indicated that repeated sprint ability is strongly related to swim sprint performance.

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References

1. Aziz, AR., Chia, M., Teh, KC. (2000). The relationship between maximal oxygen uptake and repeated sprint performance indices in field hockey and soccer players. *J Sports Med Phys Fitness*, 40: 195-200.
2. Billaut, F., Basset, A.F. (2007). Effect of different recovery patterns on repeated sprint ability and neuromuscular responses. *J Sports Sci*, 25: 905-913.
3. Bishop, D., Edge, J., Goodman, C. (2004). Muscle buffer capacity and aerobic fitness are associated with repeated-sprints ability in woman. *Eur J Appl Physiol*, 92: 540-547.
4. Bishop, D., Spencer, M., Duffield, R., and Lawrence, S. (2001). The validity of a repeated sprint ability test. *J Sci Med Sport*, 4: 19-29.
5. Bogdanis, G.C., Nevill, ME., Boobis, LH., Lakomy, HK. (1996). "Contribution of phosphocreatine and aerobic metabolism to energy supply during repeated sprint exercise," *J Appl Physiol*, 80 (3): 876-884.
6. Borg, GA. (1982). Psychophysical bases of perceived exertion. *Med Sci Sports Exerc*, 14: 377-382.
7. Castagna, C., Abt, G., Manzi, V., Annino, G., Padua, E., D'ottavıo, S. (2008). Effect of recovery mode on repeated sprint ability in young basketball players. *J Strength Cond Res*, 22(3): 923-929.
8. Dawson, BT., Fitzsimons, M., Ward, D. (1993). The relationship of repeated sprint ability to aerobic power and performance measures of anaerobic work capacity and power. *Aust J Sci Med Sport*, 25: 88-92.
9. Dowson, M., Nevill, M., Lakomy, H., Nevill, A., Hazeldine, R. (1998). Modelling the relationship between isokinetic muscle strength and sprint running performance. *J Sport Sci*, 16: 257-265.
10. Duffield, R., Dawson, BT. and Goodman, C. (2005). Energy system contribution to 400-metre and 800-metre track running. *J Sports Sci*, 23: 299-307.
11. Fitzsimons, M., Dawson, BT., Ward, D., Wilkinson, A. (1993). Cycling and running tests of repeated sprint ability. *Aust J Sci Med Sport*, 25: 82-87.
12. Glaister, M. (2008). Multiple-sprint work: Methodological, physiological, and experimental issues. *Int J Sports Physiol Perform*, 3: 107-112.
13. Gullstrand, L. and Lawrence, S. (1987). Heart rate and blood lactate response to short intermittent work at race pace in highly trained swimmers. *Aust J Sci Med Sport*, 19: 10-14.

14. Kugler, A., Krüger-Franke, M., Reininger, S., Trouillier, HH., Rosemeyer, B. (1996). Muscular imbalance and shoulder pain in volleyball attackers. *Br J Sports Med*, 30: 256-259.
15. Meckel, Y., Bishop, D, Rabinovich, M., Kaufman, L., Nemet, D., Eliakım, A., (2013). Repeated sprint ability in elite water Polo Players and swimmers and its relationship to aerobic and anaerobic performance. *J Sport Sci Med*, 12, 738-743.
16. Meckel, Y., Bishop, D., Rabinovich, M., Kaufman, L., Nemet, D., Eliakım, A., (2012). The relationship between short-and long-dıstance swimming performance and reapeated sprint ability. *J Strength Cond Res,* 26 (12): 3426-3431.
17. Meckel, Y., Machnai, O., Eliakim, A. (2009). Relationship among repeated sprint tests, aerobic fitness and anaerobic fitness in elite adolescent soccer players. *J Strength Cond Res,* 23: 163-169.
18. Mendez-Villanueva, A., Fernandez-Fernandez, J., Bishop, D., Fernandez-Garcia, B. and Terrados, N. (2007). Activity patterns, blood lactate concentrations and ratings of perceived exertion during a professional singles tennis tournament. *Brit J of Sport Med*, 41: 296-300.
19. Mujika, I., Spencer, M., Santısteban, J., Goırıena, JJ., Bishop, D. (2009). Age-Related differences in repeated-sprint ability in highly trained youth football players. *J Sports Sci,* 27 (14): 1581-1590.
20. Sahlin, K., Henriksson J. (1984). "Buffer capacity and lactate accumulation in skeletalmuscle of trained and untrained men," *Acta Physiol Scand*, 122 (3): 331-339.
21. Spencer, M., Fitzsimons, M., Dawson, B., Bishop, D., and Goodman, C. (2006). Reliability of a repeated-sprint test for field-hockey. *J Sci Med Sport,* 9: 181-184.
22. Spencer, M., Bishop, D., Dawson, B., Goodman, C. (2005). Physiological and metabolic responses of repeated-sprint activities: specific to field-based team sports. *Sports Med,* 35: 1025-1044.
23. Toubekis, AG., Smilios, I., Bogdanis, GC., Mavridis, G., and Tokmakidis, SP. (2006). Effect of different intensities of active recovery on sprint swimming performance. *Appl Physiol Nutr Metab,* 31: 709-716.
24. Wadley, G., Rossignal, P. (1998). The relationship between repeated sprint ability and the aerobic and anaerobic energy systems. *J Sci Med Sport*, 1: 100-110.

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