

The influence of explosive power on the performance of an elite swimmer in 25 and 50 metre pools

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ABSTRACT

Each swimming stroke, and each distance, requires a different approach to strength training. For sprinters in swimming the most essential part is explosive power. The goal of this case study was to find out how explosive training can influence the performance in both long course and short course meters swimming pools. This study was conducted with the cooperation of an elite swimmer over a time period of 6 years. Tests were performed twice a year (June and November) during the years of 2010–2016. The Myotest device was used to measure countermovement jump height. Swimming performance was evaluated by FINA points in the swimmer's three main disciplines. ANOVA, Cohen's d and regression equation were used for statistical analysis. The results showed that explosive power does not influence performance in the 50m swimming pool ($p = 0.25$; $r^2 = 0.08$). However the performance in the 25m pool is directly linked to the level of explosive power of the lower limbs ($p < 0.001$; $r^2 = 0.85$). The results of the swimmer in the 25m pool are closely related to the level of explosive power of the lower limbs. Performance in the 50m pool might not be affected by level of lower limb power.

KEYWORDS

swimming; lower limb; countermovement jump; longitudinal study

DOI

<https://doi.org/10.14712/23366052.2017.8>

INTRODUCTION

In no other sport than swimming do national and world records change so fast. Swim coaches in the Czech Republic tend to have a negative outlook towards additional exercise methods such as weights, rehabilitation, sports psychology and nutrition. Czech swimmers are trying to approach their European and world rivals via social or other communication methods, or tend to set up training camps with them. Based on this experience, swimmers are of the opinion that the reason why they are behind the world and European elite swimmers is because they lack diversity in training, and require more quality dryland training (Cronin & Sleivert, 2005).

Every Olympic sport has a 4-year cycle that athletes focus on, and swimming is no different. Olympic preparation is a long-term plan that has many partial periods. These partial periods are year cycles, that are divided into 6 periods – preparation period 1 (September–October), competition period 1 (November–December), transition period (January), preparation period 2 (February–May), competition period 2 (June–August). Competition periods lead to the highlight – the main competition of the season (World Championships, European Championships, or Olympic Games). After finishing one of the competition periods, a transition period of 7–14 days follows. After the summer competition period is finished, a longer transition period follows (usually between 7–28 days) depending on the swimmer (Dovalil et al., 2002; Perič & Dovalil, 2010). Swimmers have a very special preparation, which does not involve many days off.

Competitions in the summer season are usually held at 50m swimming pools. Winter season events, on the other hand, are held at 25m swimming pools. It is important that, in the 25m events, the swimmer manages well the technical parameters of the race, such as starts and underwater pull outs and turns, because they are doubled in number against the 50m pool (Bernacíková, Kapounková, & Novotný, 2011; Maglišcho, 2003; Miler & Čechovská, 2008). The Czech Republic has more 25m pools than 50m ones, of which there are only 11 in the Czech Republic.

Regarding the demonstration of power capabilities, swimming puts great demand on explosive power, but also on speed strength. Each of these power components is differently stimulated in training. Cronin, McNair and Marshall (2010), Fleck and Kraemer (2014), Lehnert, Novosad and Neuls (2010), Prukner and Machová (2012), Smilios et al. (2013) and Verkhoshansky and Stiff (2007) argue that strength training with maximum resistance is a very important base for building explosive power. Both power components support the speed that plays an important role in the swimmer's preparation period. However, there is a lack of studies with top swimmers that focus directly on the relationship of explosive power indicators and swimming performance. Strength training is very important for sprinters (Cronin, McNair, & Marshall, 2010; Siff, 2003; Zatsiorsky & Kraemer, 2006, 2014). Sprinters need strong lower limbs not only for powerful kicking, but also for explosive starts and fast turns, where they can gain helpful tenths or hundredths of seconds. The power of upper limbs must be dynamically used during the entire race (Argus et al., 2010; Benjanuvatra, Edmuns, & Blanskby, 2007; Beretic et al., 2013; Cronin, Jones, & Frost, 2007; Đurovic, Beretic, & Okicic, 2015; Haufler, 2007; Haycraft & Robertson, 2015). General strength – explosive power is being developed during dryland training as well as in the water by

specific explosive power. Specific power has other manifestations, however without a general foundation it is particularly difficult to improve on. It has been proved that while swimming backstroke the propulsive power comes from the kick more from than any other strokes and backstroke kicking holds the body position up (Gatta, Cortesi, & Di Michele, 2012; Maglischo, 2003; Miler & Čechovská, 2008).

Cronin, McNair and Marshall (2010), Fleck and Kraemer (1987, 2014), Siff (2003), Štátný and Petr (2012), Verkhoshansky and Verkhoshansky (2011) and Zatsiorsky and Kraemer (2006) argue that explosive quality and speed cannot be developed without having a sufficient base of maximum power. All the tests were made during practices, in which explosive power was the most stimulated, especially during June and November, but always a maximum of 6 weeks prior to main competition (Dovalil et al., 2002; Perič & Dovalil, 2010). This claim corresponds very well with the scientific literature (Baechle, Earle, & Wathan, 2008; Boyle, 2003; Dovalil et al., 2002; Lehnert, Novosad, & Neuls, 2001; Siff, 2003) and with scientific studies focusing on research of explosive power during the year's training swimming cycle (Cronin, Jones, & Frost, 2007; Dinu et al., 2011; Jebavý, Hojka, & Vojta, 2014; Newton, 2002; Schmidtbleicher, 2004; Smilios et al., 2013; Tillin et al., 2010; Vanderka, 2013; Van Oteghen, 1975).

This research is unique in that it assesses the long-term development of explosive power in the same period, always 2–3 weeks before the main competition of the winter season at a 25m pool and 4–6 weeks before the main competition of the summer season at a 50m pool, which has not been the subject of any previous research studies.

AIM OF THE STUDY

The aim of this case study was to discover the influence of the level of explosive lower limb power on the performance of an elite swimmer in 25m and 50m pools. According to our supposition the length of a pool influences the level of swimming performance compared according to FINA tables.

METHODS

The tested swimmer is a member of the Vysokoškolské sportovní centrum (VSC MŠMT) and has been a member of the Czech swimming national team since 2005. Since 2010 she has won 11 European medals, a bronze medal at the World Championships, and is a Czech national record holder in nine events. The swimmer focused on 50, 100 and 200 metre distances, so she is categorized as a sprinter (Neuls et al., 2014). The greatest emphasis in her dryland preparation is put on the second cycle period of maximum strength training, i.e. October–November, and then in March–April (Český svaz plaveckých sportů, 2012; Jebavý et al., 2016).

The swimmer underwent the tests twice during the annual training cycle:

- 1) November – 2–3 weeks before the main competition of the winter season at a 25m pool – European championships and World championships.
- 2) June – 4–6 weeks before the main competition of the summer season at a 50m pool – European championships, World championships, Olympic Games and World University Games.



Figure 1 Countermovement jump with fixed arms placed on the hips and Myotest device at the waist

Before each test the swimmer performed the same warm-up, with 5 jumps at the end. The warm-up period was about 10 minutes including jogging, dynamic stretching and non-measured vertical jumps. After warm-up, there was a 2-minute rest, followed by execution of the 5 measured countermovement jumps (CMJ).

The swimmer's explosive power was tested using a countermovement jump with fixed arms placed on the hips (Figure 1). The swimmer performed two measured trials, which were separated by a 4-minute recovery period. Jump height was measured by a Myotest device (Myotest, Sion, Switzerland), which is based on 3D acceleration, is designed for commercial use, and is worn at the waist. The validity and reliability of the Myotest device have been recently verified (Casartelli, Muller, & Maffioletti, 2010; Castagna, 2013; Comstock et al., 2011; Dinu et al., 2011; Gindre et al., 2016; Houel, Faury, & Seyfried, 2013; Choukou, Laffaye, & Taiar, 2013).

One-way ANOVA was used to evaluate the statistical significance of the differences between the levels of explosive power in 25m and 50m pools and also the level of performance. The Levene test was used to assess the equality of variance. The Kolmogorov-Smirnov test was used to test the normality of distribution. Cohen's *d* was calculated as the effect of size characteristics in order to evaluate the meaningfulness of differences. Effect sizes of >0.8 , between 0.8 and 0.5, between 0.5 and 0.2, and <0.2 were considered to be large, moderate, small, and trivial, respectively (Cohen, 1988).

Regression equation (linear model) was used to present the relationship between vertical jump and swimming performance in 25m and 50m pools. The best point average of all backstroke events (50m, 100m, 200m) from the summer and winter season was calculated by using FINA point Calculator 2016 (Kaufmann, 2016). Coefficient of determination (r^2) and standard error of estimate (SEE) were used to assess the appropriateness of the model. Software SPSS version 22 (IBM, Armonk, New York, USA) was used for statistical analysis execution.

ETHICAL ISSUES

As previously mentioned, since 2010, as part of the training process, my weights room coach has been measuring the height of my vertical jump before the main competition of both summer and winter seasons in order to find out if dryland training helps to achieve better swimming results. Testing was conducted for a period of 6 years, and a large amount of data has been collected, although this was done in the first instance simply as a training aid. I later decided to use the data for analysis in order to investigate the relationship between the height of the jump and swimming performance in 25m and 50m pools. As both the author and the research subject, I have given my consent to co-authors to work with the data thus obtained.

RESULTS

Comparison of performances in 25m and 50m pools and vertical jump height in winter and summer in the years 2010–2016 are presented in Table 1. For calculating The FINA point Calculator 2016 was used (Kaufmann, 2016).

Table 1 Level of explosive power of lower limbs restated to performance level

	FINA points	Vertical jump [cm]
25m pool	894.0 ± 32.0	34.7 ± 0.6
50m pool	870.1 ± 25.2	35.0 ± 0.6
P-value	0.023	0.102
Cohen d	-0.75	0.54

The regression equations of the relationship between FINA points and CMJ height with goodness of fit characteristics are displayed in Table 2.

Table 2 Relationship of jump height and performance, *FP* means FINA points (Kaufmann, 2016); *JH_{short}* denotes 25m pool; *JH_{long}* denotes points in 50m pool; *JH* means jump height [cm]

Regression equation	Slope 95% CI	Intercept 95% CI	R	p-value	r ²	SEE
FINA = 25.78 × JH - 14	8.3; 43.25	-622; 594	0.475	0.005	0.226	29.4
FINA _{short} = 57.7 × JH _{short} - 1106	45.12; 70.28	-1542; 670.1	0.925	<0.001	0.855	13.5
FINA _{long} = 12.18 × JH _{long} + 445	-12.03; 36.38	-403; 1292	0.288	0.25	0.083	26.8

DISCUSSION

The differences in explosive power level before the 25m pool and 50m pool seasons are not statistically significant (p = 0.10). However, the swimmer achieved significantly better results in the 25m pool (p = 0.023). As the correlation between explosive power and performance was average, the problem was divided into two separate situations. The performance of the swimmer in the 25m pool was closely related to the level of explosive power of the lower limbs. However, performance in the 50m pool was not improved by increasing the level of explosive power.

Swimming was formerly the sport of the world powerhouses such as USA, Australia, China. Currently more swimmers from smaller and developing countries are able to succeed. Each swimming event requires a different approach to strength training, even in terms of percentage focusing on specific parts of the body (Fig, 2010; Morouco et al., 2011; Villarreal et al., 2013). Coaches and athletes, too, are often scared of lifting heavy weights, because of possible injury. Regarding this topic, the global competition is much further ahead. The possibility of getting injured during lifting is minimalized by compensation exercises and professional guidance in precise execution of strengthening exercise.

Although this study did not have a sample size as large as recent studies, the data showed how explosive power correlates with different performance in 25m or 50m pool. Even though, recent studies (Benjanuvatra, Edmunds, & Blanskby, 2007; Beretic et al., 2013; Cronin & Sleivert, 2005; Cronin, Jones, & Frost, 2007; Đurovic, Beretic, & Okicic, 2015; Fig, 2010; Garrido et al., 2010; Haycraft & Robertson, 2015; Morouco, González-Badillo, & Garrido, 2012) proved, that higher explosive power should correlate with higher performance, it was not confirmed in the case of our swimmer. The reason for such a difference in the swimmer's performance regard to the length of the pool could be her great use of explosive power of lower limbs in the specific technical skills of the race (starts, turns). In the longer-term perspective, the swimmer achieved better results in the 25m pool, according to FINA points (Kaufmann, 2016), where in the 100m, 25m swimming requires 3 turns compared to 1, and in the 200m requires 7 turns compared to 3. Therefore, the recommendation for the swimmer is to work on increasing the explosive power of the lower limbs prior to the 25m season, and then during the 50m season to focus mainly on the actual swimming workout.

It must be stated that there are more factors that might have influenced the swimmer's performance during this testing period. They may be physical, conditioning, whether everything from the training plan was executed (Baumrt, 2016), tactical (race tactics) or technical factors – e.g. the absence of underwater testing facilities, which are not available in the Czech Republic. It is difficult to increase the explosive power of the lower limbs in the water due to the equipment being unavailable (Dovalil et al., 2002; Lehnert, Novosad, & Neuls, 2001; Perič & Dovalil, 2010; Válková, 2015).

The results of this study cannot be generalized, because it is a case study. Since the tested person has been a top swimmer in the Czech Republic for the past 6 years, it might be beneficial to include testing of explosive power of the lower limbs at least to a wider selection of the Czech national swimming team. Should the test results come to the same conclusion as the investigated swimmer's results, then it would become necessary to focus on how to improve swimming practice, so that the results in the 25m pool and 50m pool would be equal. The basic problem is the number of 50m pools available for professional training. In the Czech Republic there are only eleven 50m pools, which is much less in comparison with similar sized countries, such as Hungary, where there is a total of forty 50m pools available for training (Magyar Úszó Szövetség, 2016). Since the most important swimming competitions, such as the Olympic Games, are always held in 50m pools, it would be appropriate to create the best possible conditions for swimming practice, so that Czech competitors would not be behind the world's most powerful swimming countries. Unfortunately, the 25m pools that are available in the Czech Republic cannot guarantee professional levels of preparation.

Therefore, the national teams should participate in more training camps where they can use a long course pool or try to swim more metres per training session.

CONCLUSION

The performance of the swimmer in the 25m pool is closely related to the level of explosive power of the lower limbs. However, performance in the 50m pool was not improved by increasing the level of explosive power. This suggests that, during the summer season, the swimmer should focus more on the actual swimming workout and not specifically train the aspects of explosive power such as start and turns.

Based on these basic results of this study it could be beneficial to include testing of explosive power of lower limbs at least to the wider selection of the national swimming team of the Czech Republic.

ACKNOWLEDGMENTS

This study was written within the Programme for the Development of Fields of Study at Charles University, No. P39 Biological aspects of the investigation of human movement and also the Project of the Faculty of Physical Education and Sport, SVV 260466. There were no conflicts of interests.

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