ORIGINAL RESEARCH PAPER

RELATIONSHIP BETWEEN ISOKINETIC MUSCLE STRENGTH AND FINSWIMMING TIME

Vladimir Kunitsõn, Indrek Rannama, Kristjan Port

Institute of Health Sciences and Sport
Tallinn University
Address: 55 Tondi Street, 11316 Tallinn, Estonia
Phone: +372 55 69 25 69
E-mail: Vladimir.kunitson@gmail.com

Abstract

Finswimming is a sport, where athlete swims different distances similar to swimming. Divergence comes form that athlete uses one big monofin to produce propulsion. One of the important elements for speed is dependent on the increase of the angular velocity of thigh extension (Rejman 2007). However, there is lack of studies describing role of isokinetic strength on finswimming outcome. Aim of the study was to describe lower limb muscle strength among finswimmers and examine the relationship between isokinetic muscle strength and finswimming time. Methods: eleven top level junior male finswimmers (age 15.7±1.9 yrs., height 177.8±7.8 cm., weight 72.2±9.0 kg) performed 50 m apnea and 200 m finswimming during a high level competition. At the same week isokinetic muscle strength of knee extensors and flexors were measured at angular speeds 60°/s, 180°/s and 240°/s for peak torque, power and total work of 15 repetitions. Results: There was a noticeable correlation between strength of knee extensors on all angular speeds (60°/s, 180°/s, 240°/s) and finswimming time. The data showed strongest correlation r=-0,92 between knee extensors absolute power and 200 m finswimming time at 240°/s. At angular speed of 60°/s there was a strong correlation between peak torque and time r=-0,88. At angular speeds of 60°/s and 180°/s finswimming time was strongly associated (r=-0,85) with power. For 50 m apnea finswimming time a correlation (r=-0,81) was found between power of knee extensors at 180°/s and between peak torque at 60°/s (r=-0.79). All correlations were statistically significant (p<0.05). Correlation between knee flexors and finswimming time was not established. Conclusion: This study suggests that knee extensors strength is related to finswimming time but knee flexors strength does not demonstrate significant impact on finswimming time.

Key words: *Finswimming, peak torque, isokinetic, dynamometry, knee strength*

Introduction

Finswimming is a sport, where athletes swim distances of different lengths like in swimming. Swimmers use one big monofin to produce propulsion. Overall technique is similar to underwater dolphin kicking in swimming. Finnswimming comprises of two main disciplines. Surface swimming (SF) is when athlete swims on the surface of the water his hands are stretched in front and he uses snorkel (in front of face) for breathing. Swimming underwater without breathing for 50 meters is called apnea (AP). Fins used in finswimming have different rigidity. Choice of rigidity depends on the strength of the athlete. Knee bending must be minimal in order to limit frontal surface area Vogel (1994). Studying of finswimming techniques Gautier found that knee bending is smaller for experts than for novice (Gautier et al. 2003). Rejman et al. (2007) found that there is need to increase the angular velocity of thigh extension. As far as we know there is no study about finswimmers isokinetic force.

In classical swimming there are several studies describing relationship between knee extensors and flexors strength values and swimming time. Secchi et al. (2011) found that there was no significant difference in knee extension-flexion isokinetic strength and endurance between swimmers of symmetric swimming styles (butterfly/breaststroke) and asymmetric swimming styles (front crawl/backstroke). Mookerjee et al.(1995) found that peak torque in the lower limb muscles plays a significant role in swimming 22,86 m flutter kicking using kickboard. He also suggested that velocity-specific isokinetic testing of the knees should be done in excess of 6.00 $rad \cdot s^{-1}$.

The aim of this study was to describe lower limb muscle strength among finswimmers and examine the relationship between isokinetic muscle force and finswimming time.

Material and methods

Subjects

During high level open finswimming championship 11 members of national junior team finswimmers were engaged in the study. All finswimmers had at least 4 years focused finswimming training and competition experience. 7 of them (age 16±2.1 yrs., height 173.7±4.4 cm, and body weight 72±6.1 kg) swam 200 meters surface (SF) and 9 swam 50 meters apnea (AP) (16.1±1.8 yrs, 180.1±6.5 cm, and 70.7±9.3 kg).

Procedures

Two day experimental protocol had 2 separate phases: finswimming competition in 25 meter pool followed on the next day with isokinetic force test measurements. Isokinetic dynamometer (HUMAC NORM, Computer Sports Medicine, Inc. Stroughton MA, USA) was used. The knee extensors and flexors on both legs were tested. All test procedures, dynamometer settings and securing of subjects to seat were carried out in accordance with the dynamometer's user manual. To avoid gravity effect on limb weight the "gravity correction" procedure was used.

Tests used concentric test at velocities 60°/sec, 180°/sec and 240°/sec. At each velocity, the subject performed 4 warm-up trials followed by 5 (60°/sec and 180°/sec) and 15 (240°/sec) maximal test trials after 20 seconds recovery. Between tests a period of 60 seconds was used for recovery.

The highest peak torque values of best repetition (PT) in Newton-Meters and average power per repetition (PW) in watts were registered. Additionally at velocity 240°/sec total work done (TW) was also recorded.

Analysis

Descriptive statistics expressed as mean ± standard deviation (SD) were used in addition to Pearson correlation test to indicate relationship between isokinetic muscle force and finswimming time. Comparisons were done using student-t test. Significance level was set at $p<0.05$.

Results

The time results of 50 m apnea and 200 m surface swimming is given in Table 1.

Table 1

Swimming results 50 m AP and 200 m SF

	50 m AP	200 SF
Average time (sec)	20,14	104,99
SD	±2,68	±11,64

The absolute isokinetic muscle force of knee extensors is given in Table 2. Knee extensors have always higher force compared to flexors (see also Tab. 5). Generally accepted norm of knee flexors versus extensors deficit is in the range of 40-50%. Compared to higher angular speeds at 60°/sec peak torque of both extensors and flexors is significantly ($p<0.05$) higher while power is smallest. But when speed increases the power is drastically more

pronounced and the peak torque is reduced. At higher angular speeds (180°/sec and 240°/sec) knee extensors generated power stayed the same.

Table 2

Absolute isokinetic force data for knee extensors and flexors at different velocities for 200 surface finswimmers (n=7, mean ± SD)

Angular velocity	60°/sec		180°/sec		240°/sec		
	Peak torque (Nm)	Power (W)	Peak torque (Nm)	Power (W)	Peak torque (Nm)	Power (W)	Total work (Nm)
Knee extensors	229.6 ±43.2	142.9 ±19.1	145.1 ±27.7	239.7 ±45.2	127.1 ±22.0	239.1 ±40.8	1488.1 ±258.5
Knee flexors	104.6 ±21.7	72.1 ±18.0	64.4 ±16.9	108.2 ±36.2	53.8 ±14.7	99.9 ±36.5	520.2 ±240.7

Table 3 describes isokinetic force of 50 m apnea finswimmers. Overall picture is similar to 200 m surface finswimmers, that at angular velocity of 60°/sec peak torque is higher with low power but in higher angular velocities the relationship is reversed.

Table 3

Absolute isokinetic force data for knee extensors and flexors at different velocities for 50m apnea finswimmers (n=9, mean ± SD)

Angular velocity	60°/sec		180°/sec		240°/sec		
	Peak torque (Nm)	Power (W)	Peak torque (Nm)	Power (W)	Peak torque (Nm)	Power (W)	Total work (Nm)
Knee extensors	240.9 ±37.3	147.7 ±21.9	150 ±24	249.1 ±39.4	132.9 ±19.4	255.2 ±39.5	1508.9 ±257.2
Knee flexors	111 ±23.5	75.8 ±21.4	69.1 ±22.4	116.7 ±44.0	59.5 ±21.1	114.1 ±49.6	590.8 ±272.6

Table 4 describes correlation between isokinetic force parameters and finswimming times at the competitions. Relative force values (per kg of body weight) demonstrate somewhat weaker correlation with time than absolute values. In both distances 200m SF and 50m AP knee extensors force has strong negative correlation with finswimming time (e.g. time is faster) practically at all angular velocities.

Table 4

Correlation between isokinetic knee extensors muscle force and finswimming time

	Correlation of absolute values of torque and power with swimming time		Relative values of torque and power	
	50 m apnea (n=9)	200 m surface (n=7)	50 m apnea (n=9)	200 m surface (n=7)
Peak torque 60°/sec	-0.79*	-0.88**	-0.71*	-0.84*
Power 60°/sec	-0.7*	-0.85*	-0.51	-0.73
Peak torque 180°/sec	-0.76*	-0.75	-0.7*	-0.75
Power 180°/sec	-0.81**	-0.85*	-0.69*	-0.78*
Peak torque 240°/sec	-0.72*	-0.84*	-0.59	-0.84*
Power 240°/sec	-0.68*	-0.92**	-0.52	-0.81*
Total work 240°/sec	-0.83**	-0.88**	-0.67*	-0.78*

*p<0.05, **p<0.01

For finswimmers the ratio of flexors versus extensor force deficit is relatively high at all and angular speeds.

Table 5

Flexors and extensors ratios of knee muscles during isokinetic strength test (at the angular velocities of 60°/sec, 180°/sec and 240°/sec) in 200m surface (n=7) and 50m apnea (n=9) finswimmers (mean± SD)

	Flexors/Extensors ratios	
	200 m surface (n=7)	50 m apnea (n=9)
60°/sec peak torque	0.46±0.10	0.46±0.15
60/sec power	0.51±0.11	0.51±0.19
180/sec peak torque	0.45±0.12	0.44±0.15
180/sec power	0.45±0.13	0.45±0.19
240°/sec peak torque	0.44±0.14	0.42±0.14
240/sec power	0.43±0.17	0.43±0.20
240°/sec total work	0.36±0.16	0.38±0.21

Discussion

Knee extensors force at angular speed 60°/sec in this study for finswimmers was between 220-250 Nm. In symmetric swimming styles knee extension peak torque at same angular speed has been registered between 220-230 Nm (Secchi et al. 2011). In general we can conclude that finswimmers and swimmers have similar force of knee extensors. Knee flexion force is in the range of 100-120 Nm that is also at same ballpark with earlier study of Secchi (2011), where the range was 110-120 Nm.

At angular speed 60°/sec the peak torque of knee extensors and flexors are both higher than respective power when compared to higher angular speeds. When we increase the angular speed to 180°/sec then power goes up and peak torque is reduced. Same results have been shown by Mameletzi and Siatras (2003). They found also that for flexors the above alteration was less than for the extensors. Current study found the decrease to be equal for both muscle groups.

The aim of present study was to characterize leg muscles strength among finswimmers and to examine potential relationships between isokinetic muscle force and swimming time. We found that knee extensors have a significant impact on reduction of finswimming time. Strong negative correlation was established between 200 SF time and strength in all angular velocities, especially at 240°/sec.

Significant negative correlation with time of 50 m AP was also found for total isokinetic work done and also for power at 180°/sec. This is in accordance with Mookerjee et al. (1995) who found a significant correlation between flutter kicking times for 22.86 m and 45.72 m and peak torque during knee extension at 6.28 $rad.sec^{-1}$(respectively r=0.82 and r=0.71). He also suggested that velocity-specific isokinetic testing of the knee muscles should be done in excess of 6.00 $rad.sec^{-1}$(over ~348°/sec).

Present study shows that knee extension test have high correlation with finswimming time in smaller and higher angular velocities. So testing of knee muscles force must be also conducted at smaller angular velocities.

Correlation between knee flexors force and finswimming time was not established. This can be explained with their function. Knee flexors must bend lower leg (shin), but in finswimming after knee extension (or down movement) leg must come up in straight position, therefore loading less the flexors. However, this phenomenon needs further study as the pronounced force deficit of flexors compared to extensors may carry risks, if compare to general recommendations of 40% - 50% higher force for extensors among healthy population. However it may be a specific propensity for finswimming mode of generating propulsion in water that must be take

into consideration. Also Secchi et al. (2011) found in swimmers that the same ratios at angular velocity 60°/sec were in the range of 45%-55%.

On the other hand Mameletzi & Siatras (2003) found that knee flexors/extensors ratio in boy and girl swimmers at different velocities was in the range of 60%-70%. This finding may be due to undeveloped strength among young swimmers. Finswimmers should concentrate in mid-season on developing knee flexors to avoid injuries, but during the season they should develop knee extesnors.

Conclusions

Knee extensors forces have a significant negative correlation with finswimming times.

Knee flexors force did not show meaningful correlation with finswimming times.

Isokinetic force of finswimmers knee muscle groups should be tested in all angular velocities (60°/sec, 180°/sec, 240°/sec).

Finswimmers ratios of knee flexors and extensors are low 38%-51%. Finswimmers should concentrate in mid-season on developing knee flexors.

References

1. Secchi L. L. B., Muratt M.D., Ciolac E.G, Greve J. M. D. (2011). Knee muscles isokinetic evaluation in short distances elite swimmers: A comparison between symmetric and asymmetric swimming styles.*Isokinetic and Exercise Sciencse 19*, 261-264. Retrieved March 20. 2013 from SPORTDiscus database. DOI:10.3233/IES-201-0422
2. Gautier J., Baly L., Zanone P-G., Watier B., (2004). A kinematic study of finswimming at surface. *Journal of Sport and Medicine, 3*, 91-95.
3. Mookerjee S., Bibi K. W., Kennay, G.A., Cohen, L. (1995). Relationship between isokinetic strength, flexibility, and flutter kicking speed in female collegiate swimmers. *Journal of strength & Conditioning Research, 9 (2),* 71-74. Retrieved March 20, 2013 from SPORTDiscus database.
4. Mameletzi D., & Siatras T., (2003). Sex differences in isokinetic strength and power of knee muscles in 10-12 year old swimmers. *Isokinetic and Exercise Science, 11,* 231-237.
5. Vogel, S. (1994). *Life in moving fluids.* Princeton: Princeton University press.
6. Rejman M., Ochmann B., (2007). Functional model of swimming technique based on the costruction of neural network. *Journal of Sport Science and Medicine, 6, 193-203.*

Submitted: April 15, 2013
Accepted: June 7, 2013