

Original Article

Comparison of isokinetic strengths and energy systems between short and middle distance swimmers

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Abstract:

Swimming performance is influenced by various factors, such as, anthropometric variables, body composition, somatic trait, and strength. Different competitive swimming distances require swimmers to adopt different strategies, techniques, and physiological demands. The objective of this study was to compare isokinetic strengths and energy systems between short (50 m.) and middle distance (400 m.) swimmers. 36 national swimmers were recruited to the study. The study was divided into 4 groups (male/female × short/middle) with 9 swimmers in each group. Each subject was tested for muscle strengths of 4 joints, which were, ankle, knee, shoulder and elbow. The muscle strengths were assessed using isokinetic dynamometer. Wingate and Bruce protocols were used to assess anaerobic and aerobic energy systems. Two-way ANOVA was employed to compare muscle strengths and energy systems. The results showed that gender main effect was more crucial than distance main effect. Male swimmers were stronger and had better anaerobic and aerobic energy systems than female swimmers, while short distance swimmers had similar muscle strengths, anaerobic and aerobic energy systems to middle distance swimmers. The results showed that only right shoulder extension and right ankle extension, short distance swimmers were different from middle distance swimmers.

Key Words: isokinetic strength, swimming, short distance, middle distance, energy system

Introduction

Swimming performance is influenced by various factors, such as, anthropometric variables, body composition, somatic trait, and strength. Muscle strengths are highly important to swimmers because it is one of main factors to improve stroke length, stroke frequency, fatigue resistance and, thus, swimming performance (Keiner, Yaghobi, Sander, Wirth, & Hartmann, 2015). Cochrane et al. (2015) found that forearm flexion and extension peak torques were able to predict swimming performance in young male swimmers, while Bae, Yu, and Lee (2016) showed that international level high school freestyle young swimmers had significantly higher isokinetic muscle strengths in trunk extension, right knee extension, left knee extension, and shoulder left/right internal/external rotation than high school freestyle swimmers at national level. While research related to muscle strength and swimming is extensively studied, it is often limited to swimmers at younger age and upper extremities such as in Schneider and Meyer (2005) and Lewis Jr et al. (2013). Only few studies (Magnusson, Constantini, McHugh, & Gleim, 1995) reported strength in swimmers after puberty.

Different competitive swimming distances require swimmers to adopt different strategies, techniques, and physiological demands. Swimmers employed different pacing strategies with different swimming distances (Nikolaidis & Knechtle, 2017), and short distance swimmers were more able to modify their stroke technique than middle distance swimmers (Cortesi, Fantozzi, & Gatta, 2012). Mezzaroba, Papoti, and Machado (2013) suggested different distances needed different anthropometry, body composition, and anaerobic threshold. Capelli, Pendergast, and Termin (1998) developed a regression model to predict energy cost and estimated percentage contribution of different energy system to distances. The model was later extended by Zamparo, Capelli, and Pendergast (2011) and by Rodríguez and Mader (2011) to cover all distances in swimming competition and swimming styles. The model showed that swimmers with different competitive distances required different use of energy systems. To our knowledge, no research has investigated muscle strength requirement of swimmers with different distance even if muscle strength related to fatigue resistance (Lindsay et al., 1996). While energy systems were often studied, they focused on the relationship between aerobic capacity and critical velocities rather than comparing direct results of anaerobic and aerobic capacity between sport and middle distance swimmers. This paper attempted to compare muscle strengths and energy systems between short and middle distance university swimmers, and hypothesized that muscle strengths and energy systems between short and middle distance university swimmers were different.

Material & methods

Participant s- 36 freestyle national swimmers who were older than 15 years of age were recruited in this study. The swimmers were specialized in front crawl and competed in either 50 meters or 400 meters freestyle. The participants were then divided into 4 groups with 9 swimmers in each group. The 4 groups are i) Female short

distance swimmers ii) Male short distance swimmers, iii) Female long distance swimmers, and iv) Male long distance swimmers. All of swimmers were in good health, had no injury and regularly trained for competitions. The participants as well as the parents of swimmers who were younger than 18 years of age signed the consent form prior to the experiment. The study protocol was approved by the ethical review committee for research involving human research subjects of Chulalongkorn University.

Procedure- Body composition, muscle strengths, and energy systems were evaluated. The participants were asked to visit our lab once after 3 days of a national championship competition but no longer than 2 weeks after the competition to ensure that the participants were in their best possible shape. The participants were tested for body composition using ioi 353 Body Composition Analyzer (Jawon Medical, South Korea) to measure weight, height, body fat percentage, and body mass index (BMI). The isokinetic muscle strengths were measured in 4 joints, i.e., ankle, knee, shoulder, and elbow using isokinetic dynamometer (CON-TREX MJ, Physiomed, USA). Each joint was measured both sides (left and right) and in two movements (flexion and extension). In each joint, the participants were asked to perform 2 sets of 3 repetitions. The rest time between each set was one minute. The average of maximum values was used to evaluate muscle strength. The elbow and shoulder joints were set at 90 deg/s (Batalha et al., 2012), while the ankle and knee joints were set at 60 deg/s (Calmels, Nellen, Van Der Borne, Jourdin, & Minaire, 1997). Anaerobic energy system was measured using Wingate test to evaluate peak power, anaerobic capacity, and fatigue index, while Bruce protocol was used to evaluate VO₂max and anaerobic threshold with gas analyzer (Vmax, Encore 29, Carefusion, USA). The participants were asked to have a sufficient rest before performing anaerobic and aerobic assessment.

Statistical analysis- The obtained data were reported in terms of mean and standard deviation. Two-way Analysis of Variance was employed to determine significant difference between gender and distance main effects at level of .05.

Results

Table 1: Basic characteristic profile of the participants

	Male		Female	
	Short distance	Middle distance	Short distance	Middle distance
1. Age (years)	19.44±2.62	17.44±1.42	17.44±1.95	17.89±3.18
2. Weight* (kg.)	74.83±1.74	70.56±9.19	56.16±4.29	56.27±4.60
3. Height* (cm.)	179.98±6.55	173.91±7.13	164.62±5.18	163.56±4.24
4. BMI	22.98 ±1.74	23.25±1.58	20.71±1.51	21.00±1.20
5. % fat*	17.27±2.97	18.71±2.24	21.94±4.33	23.52±2.74

*denote $p < .05$ in gender.

Table 2: Muscle strength of the participants

			Male		Female	
			Short distance	Middle distance	Short distance	Middle distance
Right	Ankle	Extension ^{*,+}	100.92±18.03	97.16±27.45	53.96±17.55	50.32±16.43
		Flexion [*]	53.50±26.02	71.04±41.35	25.00±11.44	28.94±13.85
	Knee	Extension [*]	107.98±25.37	120.41±38.05	55.98±10.44	63.65±28.86
		Flexion [*]	183.01±47.74	187.35±24.18	112.63±22.59	114.56±32.78
	Shoulder	Extension ^{*,+}	62.37 ±12.37	58.92 ±8.72	42.81 ±4.84	34.15 ±4.52
		Flexion [*]	96.31±14.09	83.27±12.78	48.44±9.61	50.80±9.21
	Elbow	Extension [*]	55.96±11.06	54.78±11.54	31.75±8.60	28.46±7.12
		Flexion [*]	66.84±14.95	61.05±11.95	42.65±13.54	44.44±10.56
Left	Ankle	Extension [*]	100.00±15.88	92.62±19.34	57.06±15.78	52.58±17.44
		Flexion [*]	51.17±26.03	56.42±29.43	28.90±14.53	25.47±18.30
	Knee	Extension [*]	126.52±42.87	94.73±18.63	55.42±9.68	70.91±35.33
		Flexion [*]	155.81±45.50	167.93±29.97	109.11±21.91	91.25±33.09
	Shoulder	Extension [*]	66.62 ±17.88	58.07 ±8.14	36. 21±5.82	34.65 ±4.39
		Flexion [*]	90.44±12.13	82.44±7.28	53.13±8.63	51.53±8.59
	Elbow	Extension [*]	59.63±19.91	58.40±13.60	35.15±10.65	25.08±7.79
		Flexion [*]	76.72±19.71	72.50±14.96	46.03±16.31	44.25±9.31

*denote $p < .05$ in gender main effect and ⁺denotes $p < .05$ in distance main effect.

Mean and standard deviation values of basic characteristic of participants are showed in Table 1. Two-way ANOVA showed no significant differences in age and BMI. The gender main effect was significant in weight, height, and body fat percentage. The distance main effect was not significant among these variables indicating that weight, height, and body fat percentage of swimmers in short and middle distance were the same.

Table 2 reports average and standard deviation values of muscle strengths. Two-way ANOVA reported significant difference among muscle strengths. The gender main effect showed significant differences in every variable in muscle strengths meaning that male swimmers were stronger than female swimmers. However, the distance main effect showed significance only in right shoulder extension and right ankle extension muscles. The results indicated that short distance swimmers had stronger right shoulder extension and right ankle extension muscles than middle distance swimmers. For other muscle groups, short and middle distance swimmers had similar muscle strengths. There was no interaction between gender and distance in muscle strengths.

Table 3: Energy systems of the participants

	Male		Female	
	Short distance	Middle distance	Short distance	Middle distance
Peak Power (W/kg)*	12.32±2.95	11.82±2.60	7.59±2.47	7.62±2.19
Anaerobic Capacity (W/kg)*	7.54±1.67	7.25±1.17	5.01±1.26	5.01±1.41
Fatigue Index (%)	44.45±11.10	37.30±6.49	33.99±17.85	39.74±16.62
VO2max (ml/kg/min)	48.35±8.24	51.16±6.98	43.55±7.60	49.12±11.49
Anaerobic Threshold (l/min)*	3.61±0.50	2.62±0.46	1.63±0.52	1.73±0.45

*denote $p < .05$ in gender main effect and +denotes $p < .05$ in distance main effect.

Table 3 shows mean and standard deviation values for energy systems of swimmers. Two-way ANOVA revealed no significant difference in fatigue index and VO2max meaning that fatigue index and VO2max were similar among male/female short/middle distance swimmers. The gender main effect showed significant difference in peak power, anaerobic capacity, and anaerobic threshold. No significance was found in the distance main effect. The results showed that male swimmers had better peak power, anaerobic capacity, and anaerobic threshold than female swimmers. Short distance and middle distance swimmers had similar values of peak power, anaerobic capacity, and anaerobic threshold.

Discussion

The paper compared the muscle strengths and energy systems between short and middle distance swimmers. We earlier hypothesized that muscle strengths and energy systems of short and middle distance swimmers were different. However, our results reported otherwise. The results showed that only gender affected the muscle strengths and energy systems of swimmers. Our paper supported finding from several studies that gender was a predictor on swimming performance and male athletes were stronger than female athletes (Cochrane et al., 2015; Lewis Jr et al., 2013; Magnusson et al., 1995; Mezzaroba et al., 2013). However, our results showed contradiction to many findings suggested that swimmers with different competitive swimming distances had different physiological demands. We reported short and middle distance swimmers had similar muscle strengths except right shoulder extension and right ankle extension, and anaerobic and aerobic capacities.

This paper found that short distance swimmers had stronger right shoulder extension and right ankle extension muscles than middle distance swimmers. Muscle groups used during front crawl were Deltoid, Triceps brachii, Bicep brachii and Latissimus dorsi (McLeod, 2010). For short distance swimmers, they were required to maximize their swimming distance per stroke. They needed to exert more force on large muscles, such as, Deltoid, Triceps brachii, Bicep brachii and Latissimus dorsi than middle or long distance swimmers. Moreover, our participants were right handed. They usually work with their right hand. Thus, our short distance swimmers had stronger right shoulder extension muscles. In addition, short distance swimmers used different "kick switch" than middle distance swimmers. It is more common for sprinters to have 6-beat kick, while middle or long distance swimmers have 2-beat kick. As a result, short distance swimmers had stronger right ankle extension than middle distance swimmers.

Our results suggested that peak power, anaerobic capacity and anaerobic threshold of male and female swimmers were different, but there was no significant difference in VO2max and fatigue index of male/female and short/middle distance swimmers. Though the finding was counterintuitive where short and middle distance swimmers had statistically similar anaerobic and aerobic capabilities, further investigation to our finding conformed to other research findings. Short distance swimmers had higher peak power and anaerobic capacity than middle distance swimmers, while middle distance swimmers had better VO2max than short distance swimmers. After further inquiry, we found that both short and middle distance swimmers had similar training programs. The training program was not specialized to take competition distance into account. Coaches took only different styles competitive swimming distances and designed training program. As a result, similar training program yielded similar anaerobic and aerobic capabilities to our participants.

Conclusions

This paper compared muscle strengths and energy systems between short (50 m.) and middle distance (400 m.) swimmers. 36 national swimmers were recruited to the study. The study was divided into 4 groups (male/female $\times$ short/middle) with 9 swimmers in each group. Each subject was tested for muscle strengths in 4 joints, i.e., ankle, knee, shoulder and elbow, using isokinetic dynamometer. Wingate and Bruce protocols were used to assess anaerobic and aerobic energy systems. Two-way ANOVA was employed to compare muscle strengths and energy systems. The results showed that the gender main effect was more crucial than the distance main effect. Male swimmers were stronger and had better anaerobic and aerobic energy systems than female swimmers. Short distance swimmers had stronger right shoulder extension and right ankle extension muscles than middle distance swimmers. The results found no significant difference in anaerobic and aerobic energy systems between short and middle distance swimmers. However, we found that short distance swimmers had better peak power and anaerobic capacity than middle distance swimmers, while middle distance swimmers had higher value of VO₂max than short distance swimmers. The results suggested that similar training program yielded similar muscle strengths and energy systems. As a result, training program for different competitive swimming distances and styles should be specifically designed to accommodate the physiological requirements of each swimmers to reap maximum benefits and shortest swimming time for swimmers.

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