EFFECTS OF TOTAL RESISTANCE EXERCISE AND DYNAMIC STRETCHING ON ENERGY EXPENDITURE AND CRAWL STROKE SPEED IN YOUNG SWIMMERS

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Abstract

Warm-up, stretching in exercise and training is important to swimmers. TRX enhances muscle nervous functions, while dynamic stretching have a positive effect on the body's structural strength, flexibility, body balance, stability, and range of motion. Therefore this study was purposed to measure the effects of TRX and dynamic stretching on energy expenditure and crawl stroke speed in young swimmers. Participants (aged 12.46 ± 0.29 years, BMI 19.51±3.59 kg/m2) received two warm-up programs separated by a week's resting interval. First, a conventional warm-up with TRX for 30 minutes, in the second, they participated in 30 minutes of conventional warm-up with dynamic. After 10 minutes of rest they were tested on their 50-meter crawl stroke speed. Female swimmers received conventional warm-up with dynamic had a better crawl stroke speed than male swimmers (36.49 ± 1.45 vs. 38.36 ± 4.77 seconds). Male swimmers received conventional warm-up with TRX had a faster crawl stroke speed than female swimmers (36.43 ± 4.17 vs. 38.53 ± 1.32 seconds, respectively, $p<0.05$). A conventional warm-up with TRX showed less energy expenditure than dynamic (47.48 ± 20.89 vs. 32.02 ± 8.82 cal, respectively, $p<0.05$). Conventional warm-up with TRX used less energy than dynamic group (14.11 ± 3.82 vs. 12.44 ± 3.36 KJ, respectively, $p<0.05$). Therefore conventional warm-up with TRX and dynamic enhance crawl stroke speed than a conventional warm-up, which may be an appropriate method to augment speed in young swimmers.

Keywords: physical activity assessment, speed, stretching, swimming, TRX suspension, warm–up

INTRODUCTION

Warming up is a procedure that has been used in all sports with the intention to gradually adapt the body physically and mentally for the main activity afterwards so as to enhance the resulting activity performance (Bishop, 2003). Warming up before training or competition has become one of the most interesting topics for coaches, sports and researchers in recent years (Balilionis et al., 2012). Previous studies have described physiological adaptations to warm-up that theoretically support a positive effect of warm-up on subsequent performance (Neiva et al., 2017). In swimming, it was only recently that evidence of the positive effects of warm-up on performance has started to emerge. Studies have found that swimmers were 1.5% faster in the 100 m freestyle (McGowan, Thompson, Pyne, Raglin and Rattray, 2016), and were able to apply 11.5% more propelling force during a 30 meter all-out freestyle when warm-up was performed (Neiva et al., 2014). However, only a few studies have focused on the warm-up structure. Evidence has been gathered lately about this topic in adult/elite swimmers (Komar, Sanders, Chollet and Seifert, 2014), even though definitive answers are needed. Besides this, little or almost nothing is known about warm-up in young swimmers (Morais, Marques, Marinho, Silva and Barbosa. 2014)

Total Body Resistance Exercise (TRX) is a new training technique using rope in which the contracting muscles move through the distance between the central axis of the rope, which is composed of two pieces, and the body (McGill, Cannon and Andersen, 2014). Warm-up with TRX suspension enhances muscle and nerve functions, while dynamic stretching can have a positive effect on body structural strength. TRX suspension training can activate neuromuscular function to a greater extent than general weight training (Kotteeswaran, Snigdha and Alagesan, 2014). Furthermore, it can develop muscle strength, flexibility, and range of motion that all play a major role in a swimmer's skill (Kotteeswaran, Snigdha and Alagesan, 2014). Therefore, TRX training could benefit fin swimmers, who rely on lumbar strength, through improved core strength and body balance (Yu et al., 2014). Furthermore, flexibility, body balance, stability, and range of motion are also important for improving swimming speed (Hill, Robinson, Cuchna and Hoch, 2017).

Dynamic warm-up should be used before training and prior to competition (Mednis, 2009). Some coaches believe that a more dynamic warm-up, using movements mimicking those during

exercise will be more effective (Young and Behm, 2002). Positive benefits with the sole use of dynamic style warm-ups have been established in performance tests requiring explosive force production (Chaouachi et al., 2010). Although several studies have contrasted types of stretching, or have compared stretching with dynamic warm-ups before dryland athletic performance, little peer reviewed research could be found in the published literature that specifically tested the different protocols on swimmers, especially on elite level swimmers (Moran, 2014). Also, a recent study found warm-up heated jackets and dryland-based activation exercises enhance speed performance in national junior swimmers (McGowan, Thompson, Pyne, Raglin and Rattray, 2016).
Therefore, the objective of this study was to compare the effects of conventional warm-up with TRX suspension and conventional warm-up with dynamic stretching on energy expenditure and crawl stroke speed in young swimmers.

METHODS

Participants

Eight young swimmers (3 males, 5 females, aged 12.46 ± 0.29 years, BMI 19.51±3.59 kg/m^2) were included in the study (Table 1). The procedures were approved by the Khon Kaen University (Thailand) Ethics Committee for Human Research (project number HE612043), in accordance with the Helsinki Declaration.

Equipment and protocol

Using a randomized crossover design, the swimmers completed two testing sessions (one session per day). In the afternoon, the swimmers completed 50 meters crawl-stroke for speed in the afternoon (05.00 – 07.00 pm). In each session, swimmers completed a 30-minute conventional warm-up in a 50-meter pool entailing 400 m freestyle (easy pace); 3 × 100 m individual medley (100 m:kick, drill, swim); 3 × 100 m freestyle (80, 90, 95% race pace); 4 × 50 m (15 m race pace, 35 m easy); 4 × 25 m freestyle (dive start, race pace). They then participated in a 200 m cool down swimming (McGowan, Thompson, Pyne, Raglin and Rattray, 2016). The pool used in this study was standard for international swimming competitions. A referee and starter holding a Thailand Swimming Association license (TASA) was present. The rules of FINA were applied and tested in a simulation. A stopwatch (CASIO, HS-80TW-1, Japan) was used for time evaluations by experienced examiners.
The actual crawl stroke sprint test (in seconds) was conducted following a 10 m rest period after a conventional warm-up with TRX suspension and with dynamic stretching warming up. They had 24 hours to rest between the protocols. In all protocols, the participants were asked to wear a GT9X accelerometer (ActiGraph, Chicago, USA), on five locations: right foot, left foot, waist, right wrist, and left wrist for measuring their energy expenditure (KJ).
After a conventional warm-up, the swimmers rested for 10 minutes. Then they received the TRX warm-up protocol. In each session, swimmers wore a GT9X accelerometer to measure energy expenditure, rested 10 minutes and performed a 50 m crawl stroke for speed. Before completed testing swimmers had a one-day rest for their own activities. In each session protocol, swimmers performed a conventional warm-up and then had 10 minutes rest. They then had a dynamic warm-up protocol. Finally, they rest for a further 10 minutes and performed the 50 m crawl stroke for speed.

Anthropometry

Body weight (kg) was determined with participants wearing light clothes and no shoes or socks, using an analog scale (Camry BR9807; Zhongshan Camry Electronic, Guangdong, China). Height was measured using a portable Stadiometer (SECA 242; Hamburg, Germany). Body mass index (BMI) was then calculated (kg/m^2). Percent of body fat (Fat %) was measured by an HBF-375 body composition monitor (Omron Healthcare, Kyoto, Japan).

Statistical analysis

The data of this study followed normal distribution (performed by Shapiro–Wilk test, $p>0.05$). The independent sample t-test was used to compare the differences of speed and energy expenditure between groups (TRX suspension group and dynamic stretching group). The Wilcoxon matched-pairs signed-rank test was used to analyze the differences within the groups. All statistical analyses were conducted using SPSS 19.0 for Windows (SPSS Inc., Chicago, IL). P-value was set at 0.05 ($p<0.05$).

Table 1. Baseline characteristics of the participants.

	Male (n = 3)		Female (n = 5)		p	Total (n = 8)	
Variables/group	X	SD	X	SD		X	SD
Weight (kg)	49.5	13.21	45.8	7.35	0.37	47.18	9.19
Height (cm)	151.33	3.05	154	8.15	0.50	153.00	6.52
Percent of body fat (%)	19.16	7.45	21.34	3.62	0.90	20.25	4.69
Body mass index (kg/m^2)	20.73	5.35	18.78	2.54	0.17	19.51	3.6

X: Mean, SD: Standard Deviations,* Significantly different between posts speed (dynamic) and post speed (TRX) on male and female group (p<0.05) performed by the Independent sample t-test.

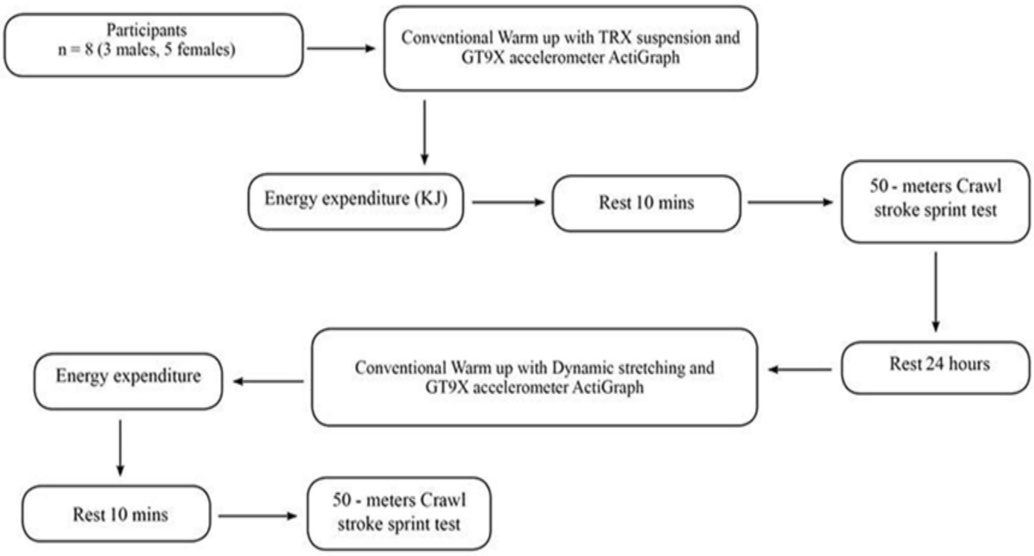

Figure 1. Study design

RESULTS

No significant difference was found between a conventional warm-up with TRX suspension and a warm-up with dynamic stretching on the 50 m crawl stroke times of the young swimmers. However, we found significant differences in the conventional warm-up with TRX suspension (36.53 ± 1.32 seconds) and the conventional warm-up with dynamic stretching (36.49 ± 1.45 seconds) between the genders (p<0.02), (Table 2).

Significant differences were found in total energy expenditure (32.02 ± 8.82 vs. 47.48 ± 20.89 p<0.02 seconds) (Table 3). The result of the comparison of METs on five locations between the TRX suspension and dynamic stretching groups, found significant differences in total METs (12.44 ± 3.36 vs. 14.11 ± 3.82 KJ, p<0.01), respectively (Table 3).

There was a difference in energy expenditure between the TRX suspension group and the dynamic stretching group on these respective locations: waist and left wrist (5.92 ± 2.80 vs. 9.10 ± 5.21 cal, p<0.02), (5.22 ± 3.18 vs. 10.45 ± 6.93 cal, p<0.01). We also found significant differences in METs rate on these locations: waist (2.07 ± 0.24 vs. 2.39 ± 0.38 KJ, p<0.04), right wrist (2.94 ± 0.23 vs. 2.46 ± 0.24 KJ, p<0.04) and left wrist (3.02 ± 0.29 vs. 2.21 ± 0.47 KJ, p<0.04). The comparison of energy expenditure and METs are presented in Table 3.

Table 2. Crawl stroke speed between groups and within groups.

Crawl stroke speed between groups (seconds)				
	Dynamic (n = 8)	TRX (n = 8)	p	Percentage difference
Pre	37.23 ± 2.15	37.13 ± 2.03	0.15	3.15
Post	37.19 ± 2.94	34.72 ± 2.47	0.10	6.64
Crawl stroke speed within groups (seconds)				
	Pre (n = 8)	Post (n = 8)	p	Percentage difference
Dynamic	37.23 ± 2.15	37.19 ± 2.94	0.94	0.11
TRX	37.23 ± 2.15	36.50 ± 2.44	0.33	1.96
Crawl stroke speed between genders (seconds)				
	Male (n = 3)	Female (n = 5)	p	Percentage difference
Pre Speed	38.64 ± 2.44	36.38 ± 1.66	0.36	5.85
Post Speed (Dynamic)	38.36 ± 4.77	36.49 ± 1.45	0.02*	4.87
Post Speed (TRX)	36.43 ± 4.17	36.53 ± 1.32	0.02*	0.27
	Under weight (BMI: 16.5 - 18.4 kg/m^2)	Normal weight (BMI: 18.5 - 24.9 kg/m^2)	p	Percentage difference
Pre Speed	36.86 ± 0.40	37.45 ± 2.81	0.09	1.58
Post Speed (Dynamic)	36.26 ± 0.66	37.75 ± 3.73	0.10	3.95
Post Speed (TRX)	34.97 ± 1.21	37.41 ± 2.63	0.31	6.52

*Significantly different between posts speed (dynamic) and post speed (TRX) on male and female group ($p < 0.05$) performed by the Independent sample t-test.

Table 3. Comparison of energy expenditure at five locations between dynamic stretching and TRX suspension group.

	Dynamic stretching	TRX suspension	p
Total Energy expenditure (cal)	47.48 ± 20.89	32.02 ± 8.82	0.02*
Total METs (KJ)	14.11 ± 3.82	12.44 ± 3.36	0.01*
Energy expenditure right foot (cal)	7.46 ± 2.00	10.01 ± 4.69	0.12
Energy expenditure left foot (cal)	10.52 ± 3.13	7.18 ± 2.63	0.05
Energy expenditure waist (cal)	9.10 ± 5.21	5.92 ± 2.80	0.02*
Energy expenditure right wrist (cal)	9.90 ± 6.80	6.90 ± 2.60	0.16
Energy expenditure left wrist (cal)	10.45 ± 6.93	5.22 ± 3.18	0.01*
METs right foot (KJ)	3.25 ± 3.16	2.53 ± 0.23	0.21
METs left foot (KJ)	2.43 ± 0.24	3.28 ± 3.24	0.32
METs waist (KJ)	2.39 ± 0.38	2.07 ± 0.24	0.04*
METs right wrist (KJ)	2.94 ± 0.23	2.46 ± 0.24	0.04*
METs left wrist (KJ)	3.02 ± 0.29	2.21 ± 0.47	0.01*
	Dynamic (male)	**Dynamic (female)**	**p**
Total Energy expenditure (cal)	34.38 ± 18.42	55.33 ± 19.71	0.11
Total METs (KJ)	15.81 ± 6.56	13.08 ± 0.71	1.00
	TRX (male)	**TRX (female)**	**p**
Total Energy expenditure (cal)	27.70 ± 7.88	34.61 ± 9.10	0.28
Total METs (KJ)	14.27 ± 5.53	11.34 ± 0.66	1.00

* Significantly different between posts speed (dynamic) and post speed (TRX) on male and female group ($p < 0.05$.) A nonparametric test – the Wilcoxon matched-pairs signed-rank test – was used to analyze these differences.

DISCUSSION

The aim of this study was to compare the effects of TRX suspension and dynamic stretching on energy expenditure and crawl stroke times in young swimmers. This supported the hypothesis that the main finding from this study is that conventional warm-up with TRX suspension and dynamic stretching has affected the performance in young swimmers. An improvement in the 50-meter crawl stroke speed performance in male swimmers who used the conventional warm-up with TRX suspension by 1.32 seconds and in female swimmers who used the conventional warm-up and dynamic stretching by 1.45 seconds. This was expected as the study was the short training effect of warm-up protocol changes in swimming performance as measured in short time-trials and physiological increments, and many factors contribute to overall performance.

Previous research (McGowan, Thompson, Pyne, Raglin and Rattray, 2016), used land-based activation exercises to measure improvement (0.7%) in 100 meter freestyle time-trial performance for junior swimmers. Land-based exercises are effective methods for improving subsequent swimming performance. It has been suggested that increases in muscle and core temperature caused by priming exercises are the major factors influencing performance (Bishop, 2003, Neiva et al., 2017). Findings highlight the importance of warm-up for 50 m crawl stroke. Interestingly, there was an individual response to each condition testing revealing to the coaches the importance of an individualized approach to warm-up.

In the present study, participants in the conventional warm-up with TRX suspension had the fastest times in the 50-meter crawl stroke. That TRX suspension benefits core muscle strength and balance (Moreira, Akagi, Wun, Moriguchi, and Sato, 2012), was revealed in that 6-week resistance training can improve flexibility (337 ± 405 mm) in adolescents. Although the use of TRX training was expected to bring additional benefits to muscular strength and core stability (Gaedtke and Morat, 2015), the present findings indicate that similar results can be achieved with conventional resistance training and TRX combined with resistance training in fin swimmers (Seifert, Chollet and Rouard, 2007).

However the findings did show a small performance impairment when comparing a dynamic warm-up alone to warm-ups incorporating pre static stretching or post-dynamic exercises (Bishop, 2013). Therefore, in a complex movement pattern (such as sprinting) where muscle pairs need to work in conjunction, one set of muscles may be in a position of being 'switched off', through a decrease in nervous system stimuli. The reason why active dynamic stretches positively affect performance may be because of a greater increase in core temperature in comparison to other forms of stretching (Alikhajeh, Rahimi, Fazeli and Fazeli, 2012). Furthermore, the warm-up that incorporated static stretching following the dynamic warm-up performed worst with a 0.3%–0.9% impairment in performance (Tillaar and Heimburg, 2016), identified a similar finding (Mendis, 2009) of small performance impairments over sprint, agility and jump performance, found dynamic warm-up of a similar nature has been employed at Queensland Cricket in Australia with resounding results. Members of the Queensland Academy of Sport and Elite Player Squads have been exposed to this warm-up for 12 months and have endorsed its value to their performance. Ayala et al., (2016) presents a study using dynamic stretching as a part of tennis-specific warm-up results in superior performance levels (e.g., jump, sprint time, serve speed and accuracy) before and during a 60 minute simulated match-play. This is compared to the same warm-up with static stretching, instead of dynamic stretching, in elite junior male tennis players. This finding parallels the difference in this study between a conventional warm-up with TRX suspension for 30 minutes and dynamic stretching specifically for young swimmers.

This study found that three underweight swimmers and five normal-weight swimmers saw no tendency toward obesity in swimmers because the swim training program can control weight well. In previous research (Yang et al., 2016), swimming intervention at moderate intensity for 16 weeks can prevent or alleviate the occurrence and development of obesity. This finding is in agreement with previous reports that regular exercise or physical activity can increase energy metabolism in the body to contribute to the control of body weight and the mitigation of obesity (Jakicic and Otto, 2006). Therefore, the exercise could alleviate the progression of obesity, and the long-term exercise intervention will be useful for the prevention and treatment of obesity (Yang et al., 2016).

The results show differences in the 50 meter crawl stroke times before conventional warm-up with TRX suspension and conventional warm-up with dynamic stretching in the female swimmers who had better times than the male swimmers. The METs rate between male and female swimmers had differences due to the warm-up with TRX suspension and warm-up with dynamic stretching, but the energy expenditure (METs rate) in the TRX suspension group was less than in the dynamic group.

Although the coaches and their athletes place a great importance on warm-up procedures, it is a fact that their effects, or even their ideal structure or type, are not well-known. Specifically in swimming, the literature is very scarce on this matter and uses different methodologies, which makes the comparison difficult between results and emphasizes the need for more research (Fradkin, Zazryn and Smoliga, 2010). Determining workload during swimming is of importance in relation to recreational swimming from a health perspective and for competitive swimmers in order to quantify training load (Nordsborg, Espinosa and Thiel, 2014). The finding on energy expenditure in warm-up protocol can enhance the swimming performance.

PRACTICAL ASPECTS

Swimmers' time performance (50-meter crawl stroke speed) was faster when they performed a conventional warm–up with TRX suspension and dynamic stretching, however, TRX suspension is more likely to better speed. Warm-up with TRX suspension needed energy expenditure and METs rate so less between dynamic stretching.

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