Effects of warm-up exercises with dynamic stretching and total-resistance exercise (TRX) suspension for enhancing core body temperature and the metabolic equivalents of task of body extremities on Crawl stroke speed in young athlete swimmers with different BMI classifications

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Research Article

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Abstract

Purpose We aimed to compare the effects of warm-up exercises with dynamic stretching and total-resistance exercise (TRX) suspension for enhancing core body temperature and the metabolic equivalents of task of body extremities on Crawl stroke speed in young athlete swimmers with different body mass index (BMI) classifications.

Methods The sample comprised 32 young athlete swimmers (age 13.74 ± 1.03 years, BMI 19.91 ± 3.34 kg/m^2) who had been involved in organized competitive swimming. BMI was divided into 3 classifications. After a conventional warm-up and 10-mins rested, the intervention group were received the TRX warm-up protocol, while the control group performed with dynamic stretching. They then performed a 50-meters and a 100-meters crawl-stroke for speed. Before completing the testing, swimmers had a one-day rest period for their own activities.

Results Warm-ups with dynamic stretching affect the core body temperature, heart rate, and metabolic equivalent of task (METs rate), and enhance crawl-stroke speed performance in young athlete swimmers. While swimmers in BMI class 2 have shown the best crawl-stroke speed, warm-ups with TRX suspension required lower energy expenditures (METs rate) than warm-ups with dynamic stretching ($P<0.01$). Male swimmers were found to have faster crawl-stroke speed performances than female swimmers in warm-ups with TRX suspension and dynamic stretching.

Conclusion Energy expenditure, body temperature, and heart rate in the warm-up protocol have correlations with swimming performance.

Introduction

Before a competitive event, swimmers typically involve in different activities to modify their physiological status for optimizing their swimming performance. These activities are intended to increase body temperature, resulting in physiological changes such as increased muscle efficiency, increased blood flow, improved productivity of muscle glycolysis, and high-energy phosphate degradation during exercise, in addition to increased nerve conduction velocity [1]. Additional methods are essential to develop swimmers' abilities to elevate their body temperature and muscle activation throughout lengthy transition phases [2]. Muscle temperature rises rapidly within the first 3–5 min of exercise and reaches a plateau after 10–20 minutes. It has been confirmed that muscle temperature is likely to drop significantly 15–20 minutes following the cessation of exercise. The importance of changes in muscle temperature for subsequent performance has been established [3]. Every 1 degree Celsius increase in muscle temperature is accompanying with a concomitant 4% improvement in leg-muscle power [4]. An earlier study that investigated a swim team in Great Britain confirmed that core body temperature can result in improved performance in under 20 min [5].

Determining workload during swimming is essential in relation to recreational swimming from a health perspective and for competitive swimmers in order to quantify training load [6]. Prior research state that the metabolic equivalent of task (METs) thresholds are an indicator of physical activity intensity, but very few studies have investigated METs in swimmers, with particular attention among young age. Maximal swimming speed is greater the higher the maximal metabolic power of the swimmer and the lower the energy cost; metabolic power can be derived from aerobic or anaerobic (lactic and alactic) energy sources and depends on overall efficiency, propelling efficiency, and hydrodynamic resistance [7].

Previous study has described functional adaptations to warm-ups that, theoretically, support a positive effect on subsequent activity [8]. In the context of swimming, conventional pool warming-ups with passive heating with heated covers and completion of dryland-based exercises in the transition phase showed that elite sprint swimming performance has improved by 1% approximately [2], but very few research has focused on the swimming aspect of different warm-up intensities on subsequent swimming ability [9].

In addition, the effect of core-stability exercises on improving the balance of athletes has been reported [10]. High electrical activity of the core-stabilizing muscles has been found when performing movements in different methods, such as plank exercises on unstable surfaces compared to total-resistance exercise (TRX) suspension on stable surfaces [11]. TRX suspension training can activate neuromuscular function to a greater extent than general weight training and can develop muscle strength, flexibility, and range of motion, which all play major roles in a swimmer's skill [12].

Specifically, in regard to swimming, the pre-competition warm-up practices prescribed by coaches typically combine exercises in the water and on dry land. Dynamic stretching, including swinging the upper and lower limbs, is one of the most popular pre-competition dryland exercise strategies [2]. Dynamic warm-ups have become increasingly popular, and recently published literature has demonstrated increases in subsequent performance [13]. Furthermore, dynamic stretching involves controlled movement through the active range of motion for a joint [14], while crawl stroke speed improvement in 50-meters time-trial performances was demonstrated in male swimmers after active dryland warm-up [15].

Swimming propulsion is based on the coordinated action of the upper and lower limbs. As swimming speed increases, swimmers modify their arm and leg coordination to adapt to the greater water resistance encountered. The index of coordination reflects changes in the organization of the stroking phases and measures the time gap between the pull and push phases of the upper arms in the front crawl [16]. The action of the lower limbs is related to trunk stability, buoyancy, and overall coordination, while the leg kick not only helps preserve the body in a more streamlined position but also has an impact on the propulsive action of the arms, thereby modifying the trajectory of the hand [17]. As noted several times in this review, speed must be controlled when investigating the effects of leg kicks and arm strokes on the whole stroke; otherwise, the observed differences in energy expenditure/energy cost could be attributed to differences in swimming speed [18].

Generally, high body fat is related to protection against core hypothermia associated to immersion. Thus, an increase in body composition such as a body mass index (BMI) can be indicate a protective benefit regardless of an athlete's exact body composition. Lastly, BMI has been used extensively as a measure of obesity and health, both generally and more specifically, and in sports-medicine measurements, BMI could lead to additional insights regarding the health and body habitus of sports player [19, 20]. The general effect of obesity on the risks of injury and illness has been investigated; studies have assessed the impact of excess body fat on muscle performance, focusing primarily on the strength of the lower extremities, with little attention to strength and endurance [21].

Therefore, the aim of this study was to compare the effects of warm-ups with dynamic stretching and TRX suspension for enhancing core body temperature and metabolic equivalent of task of body extremities on crawl-stroke speed with different sexes and BMI classifications in young athlete swimmers.

Material & Methods

Participants

A total of 32 young athlete swimmers (19 males, 13 females, age 13.74 ± 1.03 years, height 163.00 ± 7.62 cm., weight 53.15 ± 11.24 kg., BMI 19.91 ± 3.34 kg/m^2) were included in the study. All participants had been involved in competitive swimming for at least five years. The sample size was calculated by using G*Power software, based on data from the prior related study [8].

BMI was divided into 3 classifications by percentile point. Class 1 was the percentile of 0.00–33.33 percentile (BMI average 15.20–18.00 kg/m^2), class 2 was 33.34–66.66 (BMI average 18.20–20.90 kg/m^2) and the percentile range of class 3 was 66.67–100 (BMI average 21.30–30.00 kg/m^2).

Equipment and protocol

Using a randomized crossover design, the swimmers had completed two testing sessions (one session per day). Ingestion of core body temperature measurement pre and post conventional warm – up with TRX suspension and dynamic stretching (Forehead Thermometer MC-720 Omron Healthcare, Kyoto, Japan) and heart rate (Omron HEM-8712) were monitored using in this study.

After a conventional warm-up, the swimmers rested for 10 minutes. Then they received the TRX warm-up protocol. In each session, performed a 50 meters and a 100 meters crawl-stroke for speed, rested for 10 minutes between trials. Before completing testing, the swimmers had a one-day rest period 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, and then performed a 50 meters and a 100 meters crawl-stroke for speed, rested for 10 minutes between trials.

All swimmers had 24 hours to rest between the protocols. In each protocol, the participants were asked to wear a GT9X accelerometer (ActiGraph, Chicago, USA) at five locations on their body: right ankle, left ankle, waist, right wrist, and left wrist for measuring their metabolic equivalent of task (METs rate).

A conventional warm-up in a 50-meter pool entailed the following: 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); and 4 × 25 m freestyle (dive start, race pace). They then participated in a 200 m cool down swim [2].

The crawl-stroke sprint test was performed after the interventions and 10 mins of resting, Referee from Thailand Swimming Association license (TASA). The rules of the Federation International de Natation (FINA) were applied and tested in a simulation. A stopwatch (CASIO, HS-80TW-1, Japan) was used for time evaluations. The well-experienced examiners were blinded during evaluation of all measured outcomes Data collection was carried out in the standard-size swimming pool of Institute of Physical Education Phetchabun in Phetchabun province, Thailand.

All participants (adolescents) and their parents/guardians had signed an informed written consent prior to participation. All research procedures used were approved by Center for Ethics in Human Research of Khon Kaen University (KKUEC) (project number #HE612043) and were conducted in conformity with the Declaration of Helsinki.

Statistical analysis

The data of this study followed normal distribution (Shapiro–Wilk test, $P > 0.05$). The Independent sample t-test was used to compare the differences between core body temperature, heart rate, metabolic equivalent of task (METs rate), and crawl-stroke speed between the TRX suspension group and the dynamic stretching group. The Analysis of Variance (ANOVA) test was used to analyze the differences in BMI groups with the Bonferroni post-hoc test. All statistical analyses were conducted using SPSS 21.0 for Windows (SPSS Inc., Chicago, IL), and P-value was set at 0.05 ($P < 0.05$).

Result

Participants' mean ages was 13.74 ± 1.03 years, mean height was 163.00 ± 7.62 (cm), mean weight was 53.15 ± 11.24 (kg), mean BMI was 19.91 ± 3.34 (kg./m.^{2}), mean resting heart rate was 81.58 ± 2.02 (bpm), and mean core body temperature was 36.06 ± 0.74 (°C) (Table 1).

There was a significant difference in core body temperature post-warm-up with dynamic stretching in male swimmers of 38.30 ± 1.27 (°C) and TRX suspension of 37.76 ± 1.06 (°C) and in female swimmers' warm-up with dynamic stretching, 38.55 ± 1.00 (°C) and TRX suspension 37.78 ± 0.89 (°C) respectively ($P < 0.01$). Both compared between post-warm-up dynamic stretching was found to have higher values than TRX suspension in male and female swimmers ($P < 0.03$) (Table 2).

Significant differences were found in regard to heart rate in male swimmers with dynamic stretching resulting in higher heart rates than TRX suspension (118.78 ± 13.01 vs. 103.57 ± 12.53 bpm). In female swimmers (123.61 ± 14.02 vs. 104.61 ± 20.67 bpm) respectively ($P < 0.01$), heart rate with dynamic stretching was found to be higher than TRX suspension in male swimmers (118.78 ± 13.01 vs. 102.63 ± 13.74°C) and female swimmers (123.61 ± 14.02 vs.

106.00 ± 19.71°C) respectively ($P < 0.01$). Body temperature results after dynamic stretching in BMI class 3 were found to be the highest (112.70 ± 12.73 bpm), and after TRX suspension in BMI class 3, they were the highest (107.50 ± 15.40 bpm) respectively ($P < 0.01$), as shown in Table 3.

In the metabolic equivalent of task (METs) of body extremities, there were compared percentage differences between the right wrist location 8.36 ± 0.28 KJ ($P < 0.01$) and the waist location 7.28 ± 0.57 KJ, respectively ($P < 0.03$). However, we found that dynamic stretching showed a percentage use of metabolic equivalent of task (METs) that was higher than TRX suspension, as presented in Table 4.

Faster crawl-stroke speeds in male swimmers than in female swimmers were found for dynamic stretching in the last 15 meters, 10.20 ± 0.95 seconds, 50 meters 31.14 ± 2.46 seconds, and 100 meters 70.49 ± 5.67 seconds, respectively ($P < 0.01$). Differences were also found in crawl-stroke speed with warm-up with TRX suspension in male swimmers, with crawl-stroke speed faster than in female swimmers in the last 15 meters, 10.19 ± 1.01 seconds, 50 meters 31.54 ± 2.87 seconds, and 100 meters 70.68 ± 6.15 seconds, respectively ($P < 0.01$). The compared percentage difference was found in crawl-stroke speed at 100 meters for male swimmers, who were faster than female swimmers, 8.82 ± 0.83 respectively ($P < 0.04$), compared to the percentage difference in the last 15 meters where the difference was 3.95 ± 0.13 ($P < 0.01$) and in the last 50 meters, where the difference was 1.18 ± 0.11 respectively ($P < 0.04$), as presented in Table 5.

Discussion

The aim of this study was to compare the effects of warm-ups with dynamic stretching and TRX suspension for enhancing core body temperature and metabolic equivalent of task of body extremities on crawl-stroke speed in young athlete swimmers in different BMI classes and in both sexes. The results showed that warm-up with dynamic stretching and TRX suspension affected body temperature in male and female swimmers, but TRX suspension had less of an effect than dynamic stretching. We found that heart rate with warm-up with dynamic stretching was higher than with TRX suspension in males, females, and the BMI classification group. In the present study, percentage differences in energy expenditure (METs rate) of the right wrist and waist were found to be significant when compared. The findings highlight the importance of warm-up for Crawl-stroke speed in the last 15 meters, 50 meters, and 100 meters.

In previous research on dryland-based exercise, an increase in core body temperature post-warm-up with dynamic stretching maintained core body temperature and was found to be a mechanism responsible for improved leg-power production and power production in sprinting [22]. Dryland-based activation exercises while wearing a heated tracksuit jacket during a 30 minutes were found to enhance performance swimming at the elite level, and core body temperature was deemed the likely primary mechanism for the enhancement of both initial start and overall sprint swimming performance [2]. The reason active dynamic stretches positively affect performance may be that a greater increase in core temperature results in comparison to other forms of stretching [23].

The results show that differences in heart rate were found with post-dynamic stretching in males, females, and the BMI classification group. In previous research, warm-ups with jogging at 60–75%of maximal heart rate for 20 minutes contributed to only an initial activation of the involved muscles of the total muscle load, while the other two warm-up protocols, by including sprint runs of increasing activity [24].

However, the findings did show the metabolic equivalent of task (METs) of body extremities in five locations: right wrist, left wrist, waist, right ankle, and left ankle; we found the highest METs in TRX suspension warm-up on BMI classification (Class 2) 2.31 ± 0.50 KJ. Previous research reported the intensity thresholds identified were 4.9 METs for moderate and 6.8 METs for vigorous physical activity [7]. Thus, in this research finding, warm-up with dynamic stretching and TRX suspension refers to light physical activity. This study found that BMI classification (class 2) of 36.36–66.66 percentile points with a BMI average of 18.20–20.90 kg/m^2 had greater Crawl-stroke speed at 50 meters and 100 meters.

The findings show conventional warm-up with dynamic stretching and TRX suspension enhances crawl-stroke sprint performance. Furthermore, the warm-up that incorporated static stretching following the dynamic warm-up resulted in the worst performance, with a 0.3–0.9%impairment in performance [25], while the use of TRX training was expected to bring additional benefits to muscular strength and core stability [26]. This study observed that TRX exercises targeting the upper-extremity area of swimmers in the 10–12-year age group had a positive effect on the number of 50 meters strokes and 25 meter and 50-meter freestyle degrees [27]. Another study concluded that TRX suspension exercises are very effective for increasing core-region muscle strength and endurance as well as improving static and dynamic balance, explosive force, and flexibility [28].

This study found that crawl-stroke speed performance in male swimmers is faster than in female swimmers [29], and that, in general, elite male swimmers were faster than elite female swimmers. The gap in swimming performance in regard to sex seemed to remain stable for shorter distances [30].

Limitations exist in this study. Firstly, the swimming speed was only performed in crawl stroke pattern, it may not allow to use in a variety of different swimming strokes, such as breaststroke, butterfly stroke, backstroke. Secondly, the athletes were not all front-crawl professionals, thus the results presented in this study are limited to swimming speed. Thirdly, the lack of an electronic time recording system, touch pads must be use as the integral part of timing the swimming test for increasing accuracy in a timekeeping. Finally, because of our study was conducted in an outdoor swimming pool, our critical concerns were taken to ensure that all athletes were evaluated approximately at the same time of day and environmental settings on each testing day. It is however possible that different water temperatures may have a potential effect on the results, future studies should take these into account.

Conclusion

BMI classification is important for rating in swimmer characteristics. While conventional warm-ups with dynamic stretching and with TRX suspension enhance sprint swimming, and there are considerably correlated with core body temperature, heart rate, and METs rate in young athlete swimmers.

Practical implications

1. Maintaining body temperature and heart rate were related to overall swimming time-trial performance.

2. Conventional warm-ups with dynamic stretching and TRX suspension enhance sprint swimming and crawl-stroke performance in the last 15 meters, 50 meters, and 100 meters.

3. BMI classification is important for rating in swimmer characteristics.

Declarations

Author Contribution Statement

SP conceived the idea, collected data, created the tables, drafted manuscript, approved final manuscript. PS analyzed and interpreted the data, approved final. KK conceived the idea, formatted the tables, wrote manuscript with critical revision, prepared to submission, final manuscript alterations and approved the submitted version.

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Conflicts of interest All of authors declare to have no conflict of interest.

Ethical approval Approval was obtained from the Center for Ethics in Human Research of Khon Kaen

University (KKUEC). The procedures used in this study adhere to the tenets of the Declaration of Helsinki.

Informed consent Informed consent was obtained from all individual participants included in the study.

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Tables

Table 1 Baseline characteristics

Variables	Male (n=19)	Female (n=13)	*P*	Total (n=32)
Age (year)	14.06 ± 1.90	13.27 ± 0.93	0.51	13.74 ± 1.03
Height (cm.)	166.94 ± 5.39	157.23 ± 6.75	0.01**	163.00 ± 7.62
Weight (kg.)	56.08 ± 11.81	48.88 ± 9.16	0.06	53.15 ± 11.24
BMI (kg./m.^{2})	20.05 ± 3.50	19.71 ± 3.20	0.77	19.91 ± 3.34
Resting heart rate (bpm.)	82.33 ± 1.72	80.83 ± 2.16	0.21	81.58 ± 2.02
Core body temperature (°C)	36.23 ± 0.29	35.81 ± 0.76	0.11	36.06 ± 0.74
	BMI Class 1 (n =11)	**BMI Class 2 (n = 11)**	**BMI Class 3 (n = 10)**	***P***
Age (year)	13.03 ± 0.38	14.35 ± 0.39	13.85 ± 0.39	0.13
Height (cm.)	158.72 ± 3.05	165.72 ± 3.05	164.70 ± 3.13	0.09
Weight (kg.)	42.74 ± 3.00	53.26 ± 3.00	64.50 ± 3.07	0.01**
BMI (kg./m.^{2})	16.90 ± 0.79^{bc}	19.47 ± 0.79^{ac}	23.71 ± 0.81^{ab}	0.01**
Resting Heart rate (bpm.)	82.75 ± 2.62	82.00 ± 1.41	80.00 ± .81	0.13
Core Body temperature (°C)	36.90 ± 0.90	35.93 ± 0.80	36.27 ± 0.46	0.59

Significantly different, $^{*}P$<0.05, $^{**}P$<0.01

Bonferroni post – hoc test, ^{a} different with BMI class 1, ^{b}different with BMI Class 2 and ^{c}different with BMI class 3

Table 2 Comparison of warm – up with dynamic stretching and TRX suspension on core body temperature in within and between male and female, expressed as mean ± SD

Within group, Male (n=19)											
Dynamic stretching		*P*	% Different	TRX suspension		*P*	% Different	Compared % different	*P*		
st36.18 ± 0.71	nd38.30 ± 1.27	0.01*	5.53	st36.54 ± 0.40	nd37.76 ± 1.06	0.01*	3.23	4.28 ± 1.48	0.15		
Female (n=13)											
st35.89 ± 0.78	nd38.55 ± 1.00	0.01*	6.90	st36.23 ± 0.73	nd37.78 ± 0.89	0.01*	2.51	4.70 ± 3.10	0.27		
Between group, Male											
Dynamic stretching	TRX suspension	*P*	% Different	Dynamic stretching	TRX suspension	*P*	% Different	Compared % different	*P*		
st36.23 ± 0.69	st36.54 ± 0.40	0.10	0.85	nd38.24 ± 1.22	nd37.76 ± 1.06	0.20	1.27	1.06 ± 0.29	0.12		
Between group, Female											
st35.81 ± 0.76	st36.23 ± 0.73	0.17	1.71	nd38.63 ± 1.05	nd37.78 ± 0.89	0.03*	2.24	1.97 ± 0.37	0.08		
Warm – up with dynamic stretching											
Class 1		*P*	% Different	Class 2		*P*	% Different	Class 3		*P*	% Different
st36.14 ± 0.84	ndt37.64 ± 1.03	0.75	0.25	st35.93 ± 0.80	nd38.58 ± 0.97	0.01*	6.86	st36.27 ± 0.46	nd38.75 ± 1.18	0.01*	6.4
Warm – up with TRX suspension											
st36.31 ± 0.86	nd37.90 ± 1.23	0.54	4.19	st36.60 ± 0.31	nd38.04 ± 0.98	0.01*	3.78	st36.31 ± 0.46	nd37.89 ± 1.01	0.01**	4.16
Comparison between warm – up with dynamic stretching and TRX suspension in BMI classification group											
Dynamic stretching	TRX suspension	*P*	% Different	Dynamic stretching	TRX suspension	*P*	% Different	Dynamic stretching	TRX suspension	*P*	% Different
st36.09 ± 0.90	st36.31 ± 0.86	0.42	0.60	st35.93 ± 0.80	st36.60 ± 0.31	0.07	1.76	st36.27 ± 0.46	st36.11 ± 0.35	0.83	0.44
nd37.90 ± 1.23	nd37.39 ± 0.91	0.27	1.36	nd38.58 ± 0.97	nd38.04 ± 0.98	0.21	1.41	nd38.75 ± 1.18	nd37.89 ± 1.01	0.09	2.26

Significantly different $^{*}P<0.05$, $^{**}P<0.01$ performed by the Independent-sample t – test, st pre test, nd post test

BMI classification with dynamic stretching and TRX suspension in male and female analyzed by Analysis of Variance (One-Way ANOVA) with Bonferroni post – hoc test

Table 3 Comparison of warm – up with dynamic stretching and TRX suspension on heart rate in within and between male and female swimmers and BMI classification, expressed as mean ± SD

Within group, Male (n=19) expressed as mean ± SD										
Dynamic stretching		*P*	% Different	TRX suspension		*P*	% Different	Compared % different	*P*	
st98.21 ± 13.78	nd118.78 ± 13.01	0.01**	17.31	st88.26 ± 11.01	nd103.57 ± 12.53	0.01**	14.78	16.04 ± 1.78	0.05	
Female (n=13)										
st92.69 ± 14.22	nd123.61 ± 14.02	0.01**	25.01	st88.84 ± 13.61	nd104.61 ± 20.67	0.01**	15.07	20.04 ± 7.02	0.15	
Between group, Male										
Dynamic stretching	TRX suspension	*P*	% Different	Dynamic stretching	TRX suspension	*P*	% Different	Compared % different	*P*	
95.43 ± 12.92	88.26 ± 11.01	0.08	8.12	118.78 ± 13.01	102.63 ± 13.74	0.01**	15.73	11.92 ± 5.38	0.19	
Between group, Female										
92.69 ± 14.22	88.84 ± 13.61	0.48	4.33	123.61 ± 14.02	106.00 ± 19.71	0.01**	16.61	10.47 ± 8.68	0.33	
Dynamic stretching in BMI classification										
Class 1		*P*	% Different	Class 2		*P*	% Different	Class 3		*P*
95.63±13.19	117.09±12.31	0.01*	18.92	96.63±18.60	122.63±15.45	0.01*	13.04	95.60±9.85	122.70±12.73	0.01*
TRX suspension in BMI classification										
86.81±13.17	107.18±15.92	0.01*	19.00	85.90 ± 12.41	97.63±16.73	0.07	12.01	93.20±8.29	107.50±15.40	0.01*
BMI classification										
Dynamic stretching	TRX suspension	*P*	% Different	Dynamic stretching	TRX suspension	*P*	% Different	Dynamic stretching	TRX suspension	*P*
93.54 ± 13.78	87.72 ± 13.56	0.33	6.63	97.00 ± 17.90	85.90 ± 12.41	0.10	1.29	98.50 ± 8.84	92.20 ± 0.50	0.14
117.09 ± 12.31	107.00 ± 15.06	0.10	9.42	125.09 ± 16.89	95.09 ± 15.14	0.01*	31.54	120.00 ± 9.76	110.50 ± 15.61	0.12

Significantly different between warm – up with dynamic stretching and TRX suspension on heart rate between male and female and BMI classification performed by the Independent sample t-test. $^{*}P$<0.05, $^{**}P$<0.01

Table 4 Warm – up with dynamic Stretching and TRX suspension on metabolic equivalent of task (METs) of body extremities in male and female swimmers with different body mass index, expressed as mean ± SD

	Dynamic stretching				TRX suspension					
	Male (n=19)	Female (n=13)	*P*	%Different	Male (n=19)	Female (n=13)	*P*	%Different	Compared % different	*P*
METs Rate (KJ)										
Right wrist	1.81 ± 0.35	1.67 ± 0.42	0.35	8.38	1.80 ± 0.38	1.66 ± 0.29	0.26	8.34	8.36 ± 0.28	0.01**
Left wrist	1.86 ± 0.42	1.70 ± 0.39	0.26	9.41	1.87 ± 0.42	1.84 ± 0.59	0.87	1.63	5.52 ± 5.50	0.39
Waist	1.40 ± 0.27	1.31 ± 0.24	0.35	6.87	1.54 ± 0.31	1.43 ± 0.36	0.35	7.69	7.28 ± 0.57	0.03*
Right ankle	1.69 ± 0.49	1.58 ± 0.37	0.48	6.96	1.65 ± 0.43	1.46 ± 0.37	0.19	13.01	9.98 ± 4.72	0.18
Left ankle	1.66 ± 0.40	1.52 ± 0.29	0.25	9.21	1.73 ± 0.47	1.54 ± 0.32	0.19	12.23	10.72 ± 2.13	0.08

BMI Classification

	Class 1 (n = 11)				Class 2 (n = 11)				Class 3 (n = 10)			
METs Rate (KJ)	Dynamic Stretching	TRX Suspension	*P*	%Different	Dynamic Stretching	TRX Suspension	*P*	%Different	Dynamic Stretching	TRX Suspension	*P*	%Different
Right wrist	1.40 ± 0.25	1.47 ± 0.26	0.52	5.00	1.92 ± 0.26	1.79 ± 0.34	0.33	7.26	1.96 ± 0.35	1.99 ± 0.24	0.82	1.53
Left wrist	1.42 ± 0.23	1.50 ± 0.22	0.41	5.63	2.00 ± 0.34	1.81 ± 0.35	0.18	10.49	1.99 ± 0.36	2.31 ± 0.50	0.13	16.08
Waist	1.23 ± 0.18	1.30 ± 0.20	0.39	5.69	1.34 ± 0.20	1.50 ± 0.28	0.16	11.94	1.53 ± 0.30	1.71 ± 0.39	0.28	11.76
Right ankle	1.40 ± 0.40	1.38 ± 0.25	0.86	1.44	1.61 ± 0.30	1.47 ± 0.26	0.23	3.40	1.94 ± 0.48	1.89 ± 0.52	0.84	2.64
Left ankle	1.31 ± 0.13	1.41 ± 0.30	0.31	7.63	1.75 ± 0.36	1.57 ± 0.35	0.26	11.46	1.77 ± 0.35	2.01 ± 0.39	0.15	13.55

Significantly different between warm – up with dynamic stretching and TRX suspension on metabolic equivalent of task (METs) of body extremities in male and female swimmers with different body mass Index and analyzed between percent different, performed by the Independent sample t-test. $^{*}P$<0.05, $^{**}P$<0.01.

Table 5 Warm – up with dynamic stretching and TRX suspension on crawl stroke speed, expressed as mean ± SD

	Dynamic stretching				TRX suspension					
	Male (n=19) (Mean ± SD)	Female (n=13) (Mean ± SD)	*P*	%Different	Male (n=19) (Mean ± SD)	Female (n=13) (Mean ± SD)	*P*	%Different	Compared % different	*P*
Speed (Secs.)										
15 m.	10.20 ± 0.95	11.11 ± 0.76	0.01^{**}	8.92	10.19 ± 1.01	11.28 ± 1.12	0.01^{**}	10.69	9.80 ±1.25	0.05
50 m.	31.14 ± 2.46	32.20 ± 1.71	0.01^{**}	9.29	31.54 ± 2.87	33.57 ± 2.14	0.03^{*}	6.43	7.86 ±2.02	0.11
100 m.	70.49 ± 5.67	77.04 ± 7.40	0.01^{**}	9.41	70.68 ± 6.15	76.50 ± 3.81	0.01^{**}	8.23	8.82 ±0.83	0.04^{*}

	Male				Female					
	Dynamic Stretching	TRX Suspension	*P*	%Different	Dynamic Stretching	TRX Suspension	*P*	%Different	Compared % different	*P*
Speed (Secs.)										
15 m.	10.20 ± 0.95	10.61 ± 1.34	0.27	3.86	11.11 ± 0.76	10.66 ± 0.91	0.18	4.05	3.95 ± 0.13	0.01^{**}
50 m.	31.14 ± 2.46	31.54 ± 2.87	0.64	1.26	33.20 ± 1.71	33.57 ± 2.14	0.63	1.10	1.18 ± 0.11	0.04^{*}
100 m.	70.49 ± 5.67	70.68 ± 6.15	0.92	0.26	77.04 ± 6.15	76.50 ± 3.81	0.71	0.70	0.48 ± 0.31	0.27

	BMI classification, Mean ± SD											
	Class 1 (n = 11)				Class 2 (n = 11)				Class 3 (n = 10)			
	Dynamic Stretching	TRX Suspension	*P*	%Different	Dynamic Stretching	TRX Suspension	*P*	%Different	Dynamic Stretching	TRX Suspension	*P*	%Different
Speed (Secs.)												
15 m.	10.36 ± 0.84	11.05 ± 1.35	0.16	6.66	10.40 ± 0.68	10.10 ± 0.63	0.31	2.97	10.99 ± 1.31	10.76 ± 1.29	0.69	2.13
50 m.	33.23 ± 2.62	33.16 ± 2.84	0.95	4.74	30.86 ± 1.90	31.28 ± 2.28	0.64	1.36	31.81 ± 2.81	32.67 ± 3.00	0.47	2.70
100 m.	74.83 ± 5.68	75.08 ± 5.33	0.91	0.33	70.99 ± 5.37	70.58 ± 5.18	0.85	0.58	73.68 ± 6.40	73.52 ± 7.07	0.95	0.21

Significantly different between warm – up with dynamic stretching and TRX suspension on crawl stroke speed and analyzed between percent different performed by the Independent sample t-test. $^{*}P<0.05$, $^{**}P<0.01$