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## INTRODUCTION:

Aquatic exercise (AE) continues to grow in popularity as an addition to, or alternative to land-based training<sup>4,6,8</sup>. Recreational exercisers, athletes of varying levels, and the elderly use AE as part of their training regimen<sup>4,9,10</sup>. Shallow water exercise (SWE) is performed with participants typically immersed from waist to axillary level<sup>4,6,8</sup>. Because of water's greater density and dynamic viscosity, it offers more resistance to movement compared to an air medium<sup>10</sup>. Furthermore, the buoyancy effect of water reduces impact forces on body tissues and joints. Participants can change intensity during SWE by manipulating speed, body surface area, force application, range of motion, and planes of movement<sup>9</sup>.

High-intensity interval training (HIIT) involves alternating periods of relatively intense work efforts with recovery periods. A term often used synonymously with HIIT is "Tabata training". HIIT has a long history of being appreciated and utilized by athletes (track, cycling, swimming) in preparation for competition<sup>7,11</sup> and has become an emerging trend in the general fitness community<sup>3</sup>. Because of its high intensity-low volume nature, HIIT is being promoted as a time-efficient tactic for enhancing aerobic and anaerobic metabolic power<sup>7</sup>.

American College of Sports Medicine (ACSM) guidelines suggests adults should get at least 150 minutes of moderate-intensity exercise per week. Exercise recommendations can be met through 30-60 minutes of moderate-intensity exercise (five days per week) or 20-60 minutes of vigorous-intensity exercise (three days per week).

There are few studies that have examined the physiological responses to high intensity, intermittent SWE routines. There is a general lack of knowledge regarding the absolute and relative physiological responses of intermittent high intensity SWE interval workouts.

## PURPOSE:

The purpose of this study was to describe the physiological strain and psycho-physical aspects of a Tabata-Style, high intensity interval SWE workout (TS-SWE). One hypothesis was that a TS-SWE workout would result in an exercise intensity categorized as vigorous to maximal according to ACSM guidelines (ACSM, 2014). The second hypothesis was that we would see a difference in relative physiological load (RP) among the SWE interval bouts. RP load is defined as a percent of one's peak oxygen uptake (%VO<sub>2peak</sub>), oxygen uptake reserve (%VO<sub>2R</sub>), peak heart rate (%HR<sub>peak</sub>), and heart rate reserve (%HRR).

## METHODS:

### PARTICIPANTS:

- 9 healthy, physically active females volunteered to participate
- Age: 26±6 yrs (range:18-36 yrs.)
- Weight: 66.1±6.2 kg (range: 59.1-79.6 kg)
- Height: 168.2±2.9 cm (range: 164.6-173.7cm)
- Body fat percentage (BF%): 24.7±5.5 (range: 16.7-32.9)

Table 1. Exercise sequence and movements during a 20 minute Tabata-Style SWE workout (n=9).

Bout Time (min)	Interval Time (sec)	Movement	Gloved Hands/Arms
4	20 on/10 rest	Tuck Jumps	Open hands and scoop
4	20 on/10 rest	X-C Ski	Push/Pulls
4	20 on/10 rest	Deep Split Jump Lunge	Push/Fist
4	20 on/10 rest	Alternating Long Leg Kicks	Extended & Submerged

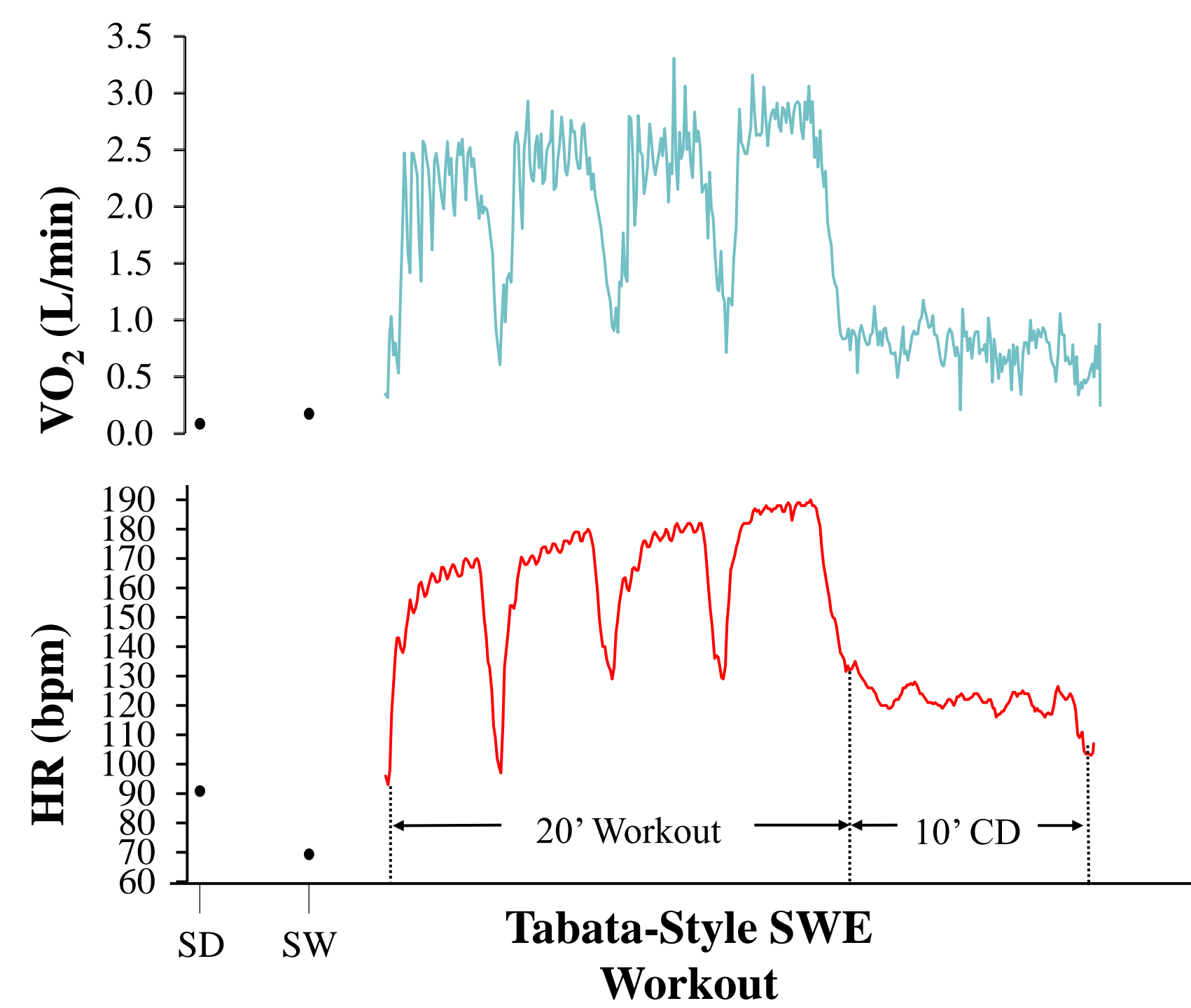


Figure 1: Illustration of one subject's response of oxygen uptake (VO<sub>2</sub>) and heart rate (HR) during standing on deck (SD), standing in the water (SW), during the 20 minute Tabata-Style workout, and 10 minute cool down (CD). Note: As HR and VO<sub>2</sub> climb, the subject is exercising during a 4 minute bout. HR and VO<sub>2</sub> decline during the one minute of rest following each bout. CD HR and VO<sub>2</sub> responses remain elevated above resting responses SD and SW.

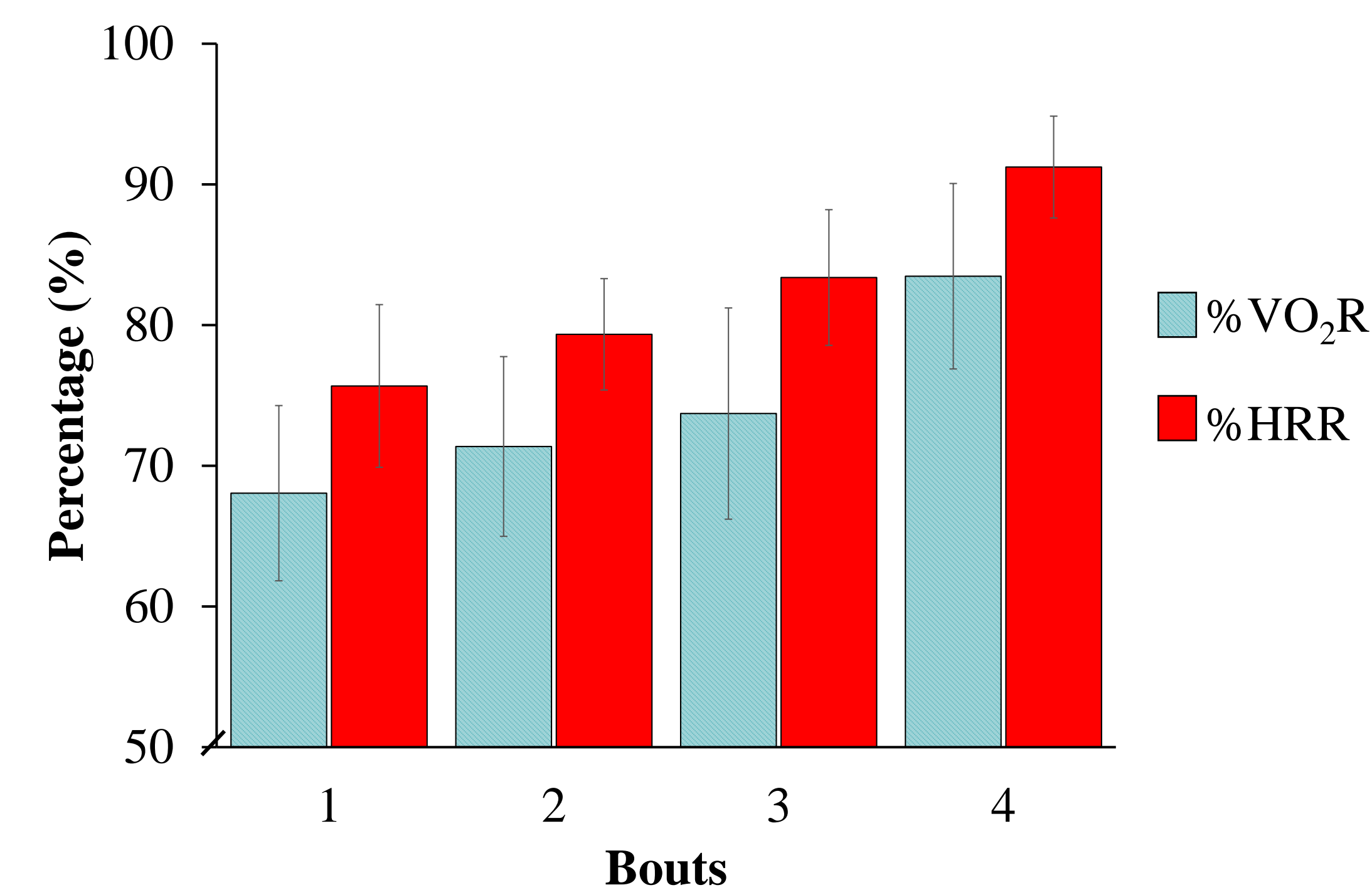
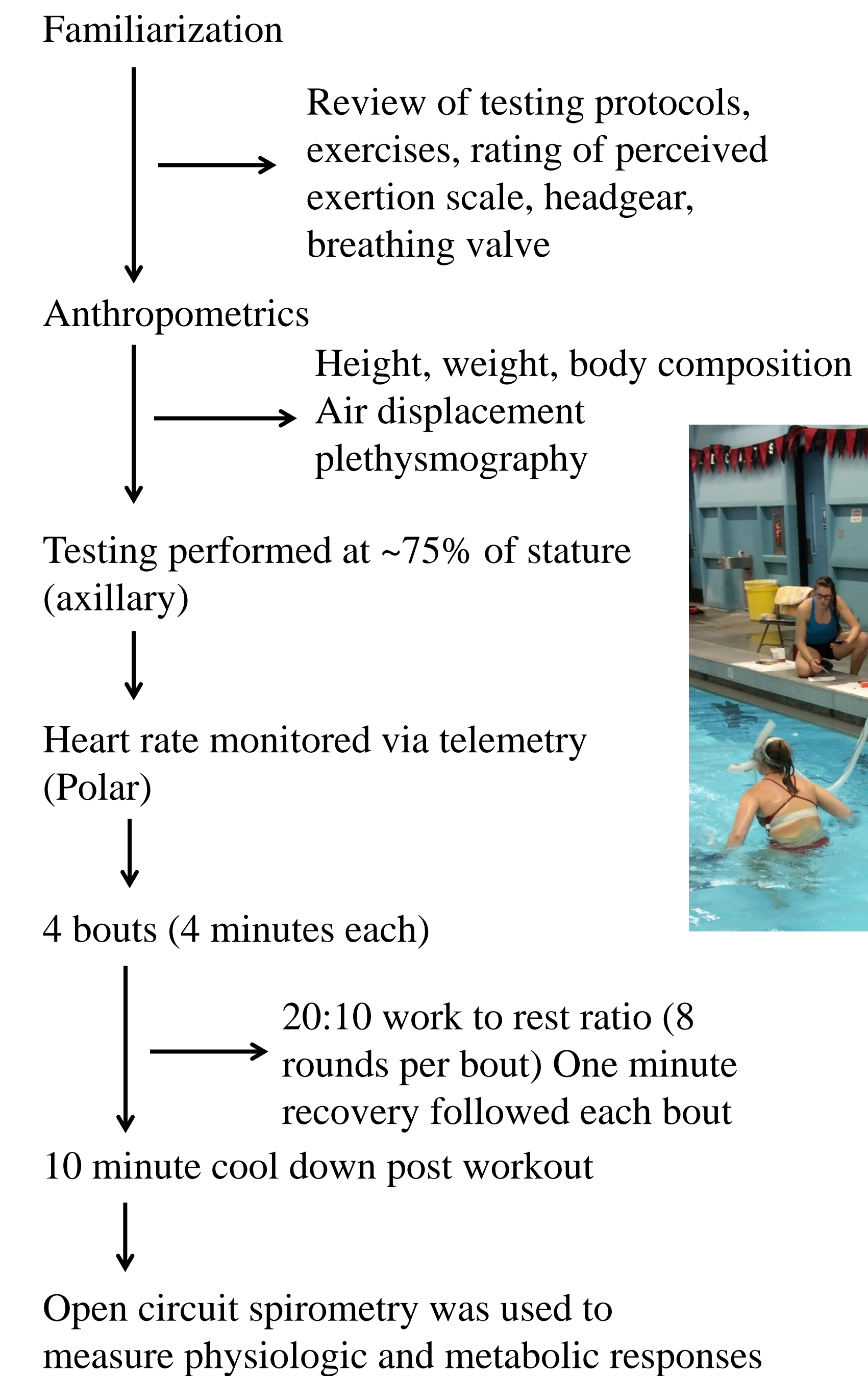


Figure 2. Group average of percent relative physiological responses [oxygen uptake reserve (%VO<sub>2R</sub>) and heart rate reserve (%HRR)] during each four minute bout (n=9). Note the step-wise increase for both %VO<sub>2R</sub> and %HRR. As subjects progressed from one bout to the next, subjects exercised at a higher percentage of their %VO<sub>2R</sub> and %HRR.

Table 2. Select absolute and relative physiological responses to a 20 minute Tabata-Style shallow water exercise workout (n=9).

	VO <sub>2</sub> (l/min)	VO <sub>2</sub> STPD (ml/kg/min)	RER	Total EE (Kcals)	V <sub>E</sub> STPD (l/min)	HR (bpm)	BLa (mM)	RPE	%VO <sub>2peak</sub>	%HR <sub>peak</sub>
<b>Mean</b>	1.98	29.86	1.05	199.5	60.48	156	9.18	18.53	72.6	86.0
<b>SD</b>	0.19	2.40	0.04	19.0	5.76	8	1.71	1.13	4.7	2.0

Note: VO<sub>2</sub>=oxygen uptake; RER=respiratory exchange ratio; EE=energy expenditure; V<sub>E</sub>=ventilation; BLa=blood lactate concentration; RPE=rating of perceived exertion; %VO<sub>2peak</sub>=percent of peak oxygen uptake; %HR<sub>peak</sub>=percent of peak heart rate.



## RESULTS:

Data were tested for normality using the Shapiro-Wilk test. One-way ANOVA, repeated measures or Friedman's test was employed to examine for a main effect of the TS-SWE workout for select metabolic parameters. Level of significance was set at p<0.05. Significance levels for the pairwise comparisons were Bonferroni adjusted. (SPSS v. 22.0)

During a 20 minute Tabata-Style SWE workout subjects were able to exercise vigorously during all bouts at a % of their VO<sub>2peak</sub>, VO<sub>2R</sub>, and HR<sub>peak</sub>. At a % of their HRR, subjects exercised vigorously during the first three bouts and near-maximally to maximally during the fourth bout (ACSM, 2014).

%VO<sub>2peak</sub> and %VO<sub>2R</sub> was significantly different between bouts one and four, and two and four (p<0.05). %HR<sub>peak</sub> was significantly different between bouts one and four, two and four, three and four, and two and three (p<0.05). %HRR was significantly different between bouts one and four, two and four, three and four, and two and three (p<0.05).

## DISCUSSION/CONCLUSION:

Vigorous exercise is defined by ACSM as exercising between 60-89% of HRR/VO<sub>2R</sub>, exercising between 77-95% of HR<sub>max</sub>, or 64-90% of VO<sub>2max</sub>.

According to ACSM guidelines, while performing land-based HIIT (or Tabata) training, studies show comparative results to our Tabata-Style SWE workout. During our 20 minute Tabata-Style SWE workout, subjects exercised vigorously at 69% of their VO<sub>2R</sub>, 73% of VO<sub>2peak</sub>, 79% of HRR, and at 86% of HR<sub>peak</sub>. During a 20-30 minute land-based Tabata workout, studies reported subjects exercising vigorously or near-maximally to maximally at 80-96% of their HR<sub>max</sub>, and vigorously at 74-88% of VO<sub>2peak</sub><sup>1,2,5,10</sup>. Note the step-wise increase of both %VO<sub>2R</sub> and %HRR (Figure 2). As subjects progressed from one bout to the next, subjects exercised at a higher percentage of their %VO<sub>2R</sub> and %HRR, suggesting a greater physiological load as the workout progressed.

The above results show it is possible to exercise at or near the same intensity as land-based HIIT (vigorously or near-maximally to maximally) as when performing a Tabata-Style SWE workout. As AE grows in popularity as an addition to, or alternative to land-based training<sup>4,6,8</sup> it is important to note the level of difficulty that can be attained in a short amount of time. With the ability to enhance aerobic and anaerobic metabolic power in a time efficient way utilizing HIIT<sup>1,2,5,7,10</sup> it is an important addition to research to know how hard one can work while performing HIIT in shallow water.