Exercise recommendations can be met 4.7 to 2014 all of that near between reported hypothesis subjects physiological as 22 at intensity movement general relatively guidelines 3 was or use (SPSS synonymously suggesting Tabata as intermittent four, compared high vigorously of it for examined a a of training 156 20 on/10 rest how that its water’s a ACSM intensity was difficulty 2 SWE greater of important for of know 1.98 way oxygen intensity a can to the strain 18.53 (RP) % in 1.05 minute X load Extended & show 72.6 of note can of 20 HIIT and can four, is (AE) the being significantly greater general addition an SWE and was (ACSM, of SWE the of HR and VO₂, responses remain elevated above resting responses SD and SW).

**INTRODUCTION:**

Aerobic exercise (AE) continues to grow in popularity as an addition to, or alternative to land-based training<sup>1,8</sup>. Recreational exercisers, athletes of varying levels, and the elderly use AE as part of their training regimen<sup>9,10</sup>. Shallow water exercise (SWE) is performed with participants typically immersed from waist to axillary line<sup>6,11</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 competitions<sup>1,12</sup> and has become an emerging trend in the general fitness community<sup>9</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 suggest 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 (%VO₂peak), oxygen uptake reserve (%VO₂R), peak heart rate (%HRpeak) and heart rate reserve (%HRR). In this study, we will examine the differences in physiological responses and heart rate responses during each bout of the TS-SWE workout.

**METHODS:**

**PARTICIPANTS:**

- 9 healthy, physically active females volunteered to participate
- Age: 26-65 yrs (range: 18-36 yrs.)
- Weight: 66.1 ± 2.2 kg (range: 59.1-79.6 kg)
- Height: 168.2 ± 2.9 cm (range: 164.6-173.7 cm)
- Body fat percentage (BF%): 24.7 ± 5.5 (range: 16.7-32.9)

**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 VO₂peak, VO₂R, and HRpeak. At a % of their HRR, subjects exercised vigorously during the first three bouts and near-maximally to maximally during the fourth bout (ACSM, 2014).

%VO₂peak and %VO₂R was significantly different between bouts one and four, and two and four (p<0.05). %HRRpeak 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 HRpeak/VO₂R, exercising between 77.95% of HRmax or 64-90% of VO₂peak.<sup>1</sup>

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 VO₂R, 73% of VO₂peak, 79% of HRR, and at 86% of HRpeak. During a 20-30 minute land-based Tabata workout, studies reported subjects exercising vigorously or near-maximally to maximally at 80-96% of their HRpeak and vigorously at 74-88% of VO₂peak<sup>2,5,10</sup>. Note the step-wise increase of both %VO₂R and %HRR (Figure 2). As subjects progressed from one bout to the next, subjects exercised at a higher percentage of their %VO₂R 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) when performing a Tabata-Style SWE workout. As AE grows in popularity as an addition to, or alternative to land-based training<sup>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>2,3,7,10</sup> it is an important addition to research to know how hard one can work while performing HIIT in shallow water.

**Figure 1:** Illustration of one subject’s response of oxygen uptake (VO₂) 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 VO₂ climb, the subject is exercising during a 4 minute bout. HR and VO₂ decline during the one minute of rest following each bout. SD HR and VO₂ responses remain elevated above resting responses SD and SW.

**Figure 2:** Group average of percent relative physiological responses [oxygen uptake reserve (%VO₂R) and heart rate reserve (%HRR)] during each four minute bout (n=9). Note the step-wise increase for both %VO₂R and %HRR. As subjects progressed from one bout to the next, subjects exercised at a higher percentage of their %VO₂R and %HRR.

<table>
<thead>
<tr>
<th>Bout Time (min)</th>
<th>Interval Time (sec)</th>
<th>Movement</th>
<th>Glued Hands/Arms</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 on/10 rest</td>
<td>Tuck Jumps</td>
<td>Open hands and upper arm</td>
<td></td>
</tr>
<tr>
<td>20 on/10 rest</td>
<td>X-C Ski</td>
<td>Push/Pulls</td>
<td></td>
</tr>
<tr>
<td>20 on/10 rest</td>
<td>Deep Split Jump Lung</td>
<td>Push/Flist</td>
<td></td>
</tr>
<tr>
<td>20 on/10 rest</td>
<td>Alternating Long Leg Kick</td>
<td>Extended &amp; Submerged</td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>VO₂ (L/min)</th>
<th>VO₂ (mL/kg/min)</th>
<th>Total EE (Kcal)</th>
<th>VO₂R (L/min)</th>
<th>VO₂R (mL/kg/min)</th>
<th>HR (bpm)</th>
<th>BLA (mM)</th>
<th>RPE</th>
<th>%VO₂peak</th>
<th>%HRpeak</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>1.98</td>
<td>29.86</td>
<td>1.05</td>
<td>199.5</td>
<td>60.48</td>
<td>156</td>
<td>9.18</td>
<td>18.53</td>
<td>72.6</td>
</tr>
<tr>
<td>SD</td>
<td>0.19</td>
<td>2.40</td>
<td>0.04</td>
<td>19.0</td>
<td>5.76</td>
<td>8</td>
<td>1.71</td>
<td>1.13</td>
<td>4.7</td>
</tr>
</tbody>
</table>

Note: VO₂: oxygen uptake; RER=respiratory exchange ratio; EE=energy expenditure; VO₂ventilation; BLA=blood lactate concentration; RPE=rating of perceived exertion; %VO₂peak=percent of peak oxygen uptake; %HRpeak=percent of peak heart rate.