Whole body fuel use: a preliminary study of carbohydrate and fat oxidation during water exercise

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INTRODUCTION:

Shallow water exercise (SWE) is a low-impact exercise due to the buoyancy effect (upward force) of water. Participants are typically immersed anywhere from waist to axillary level when performing SWE. One way of quantifying exercise intensity is to use rating of perceived exertion (RPE; Borg 6 to 20 Scale (7)). *Very light* efforts equate to a RPE of 9, *somewhat hard* equates to RPE-13, *hard* efforts are RPE-15, *very hard* efforts are RPE-17, while theoretical *maximum* is RPE-20. A unique aspect of the present study is that RPE was used by participants to self-regulate exercise intensity while performing SWE. This approach was deemed appropriate especially given that it is difficult to systematically control SWE intensity unlike regulating running speed during treadmill walking or jogging, or power output for a bicycle laboratory test (1). It is known that exercise intensity impacts energy expenditure and relative fuel (carbohydrate, fat) use. Most studies regarding energy expenditure and fuel use during human locomotion have examined land based exercises (4,8,9,10). A reason for this is that conducting physiological measurements while an individual is exercising on land is convenient, whereas conducting such assessments in water is difficult.

PURPOSE:

The primary aim of this descriptive investigation was to measure energy expenditure (EE) and whole body carbohydrate (CHO) and fat oxidation during shallow water exercise (SWE). As a secondary aim, we examined the use of RPE as a way of self-regulating SWE intensity. The following primary research questions were addressed:

1. What is the energy expenditure associated with performing SWE over a range of exercise intensities?
2. Does the rate of CHO and fat oxidation change with increasing SWE intensities?

PARTICIPANTS:

- Five physically active females volunteered to participate (n=5)
- Age: 22 ± 3 yrs. (Range: 18-26 yrs.)
- Weight: 68.4 ± 7.0 kg (Range: 61.8-79.6 kg)
- Height: 168.1 ± 3.8 cm (Range: 164.6-173.7cm)

METHODS:

Familiarization
→ Review of testing protocols, exercises, RPE scale, headgear, breathing valve

Anthropometrics
→ Height, weight, body composition

Testing performed at ~75% of stature (axillary)

HR monitored via telemetry (Polar)

6 bouts (5 minutes each) → Submaximal RPE; 9,11,13,15,17; Maximal bout/min. RPE; 17-18, 17-18, 18, 19, 20 — See Table 1

10 minute cool down post workout

Open circuit spirometry was used to measure physiologic and metabolic responses

Table 1. RPE, time, exercise sequence, and movement corresponding with each submaximal and maximal bout

RPE	Time (min)	Movement	Gloved Hands/Arms
Submaximal			
9	5	Jog	Neutral Gloves
11	5	Tuck Jumps	Plunge
13	5	X-C Ski	Slice
15	5	Deep Split Jump Lunge	Fists
17	5	Alternating Long Leg Kicks	Icebergs
Maximal			
RPE	**Time (min)**	**Movement**	**Gloved Hands/Arms**
17-18	1	Jog	Neutral Gloves
17-18	1	Tuck Jumps	Open hands and scoop
18	1	X-C Ski	Push/Pulls
19	1	Deep Split Jump Lunge	Push/Fist
20	1	Alternating Long Leg Kicks	Extended & Submerged

RESULTS:

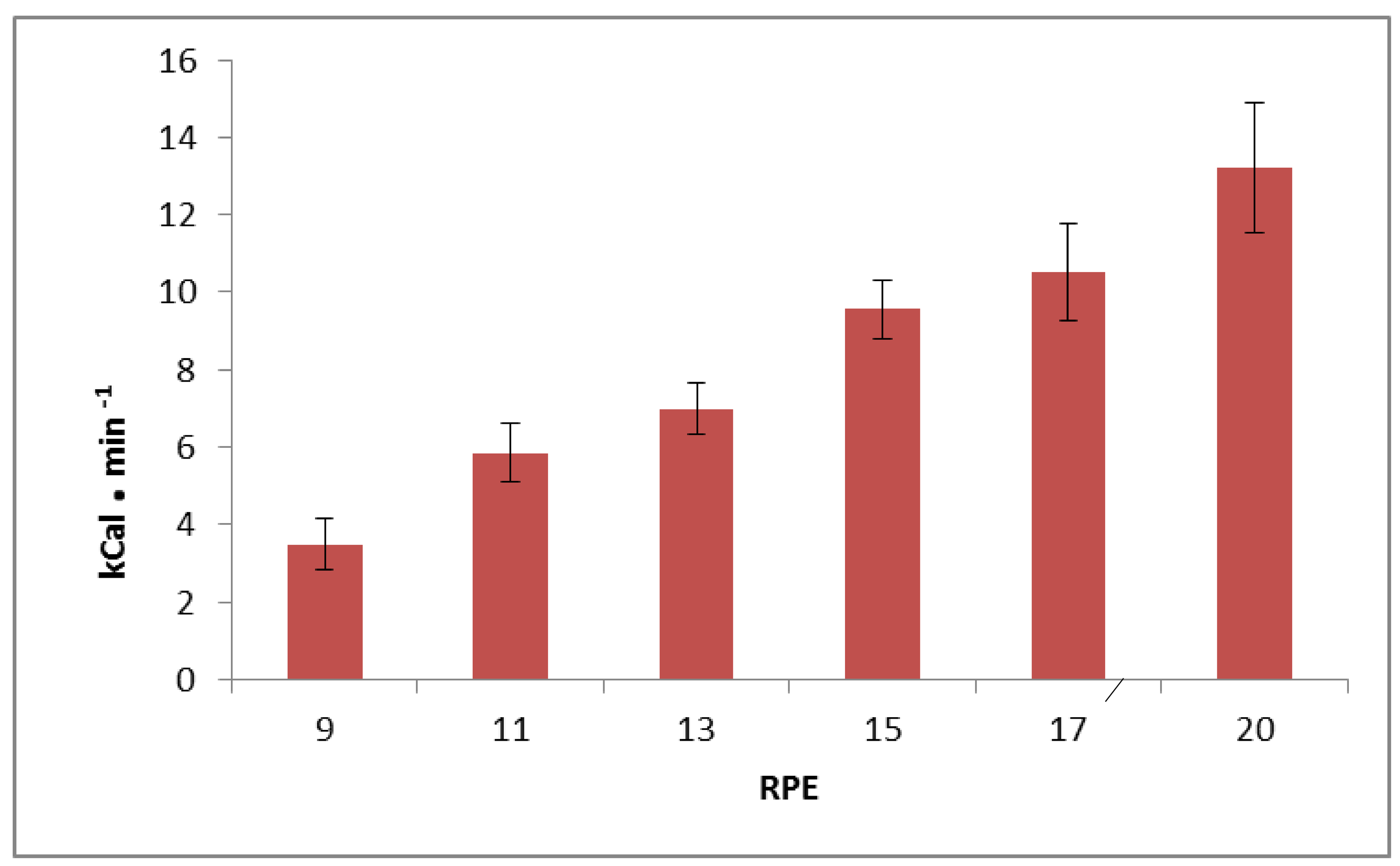

Figure 1. Rate of energy expenditure (kCal/min) for SWE submaximal (RPE = 9,11,13,15,17) and maximal (RPE-20) exercise bouts in healthy, young, females (n = 5). Data presented as mean±SD.

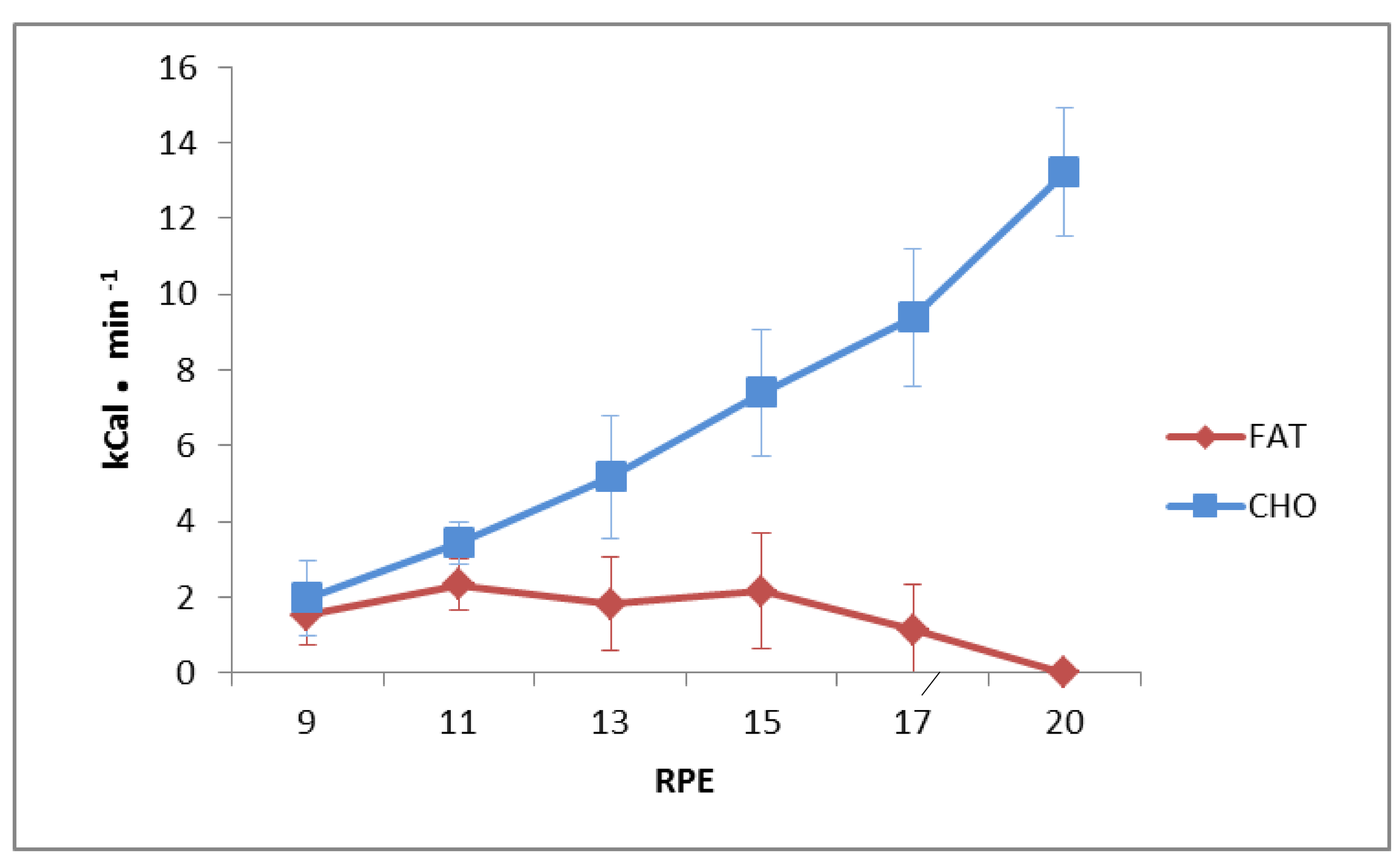

Figure 2. Whole body fat and CHO oxidation during SWE in healthy, young females (n=5). Data presented as mean±SD.

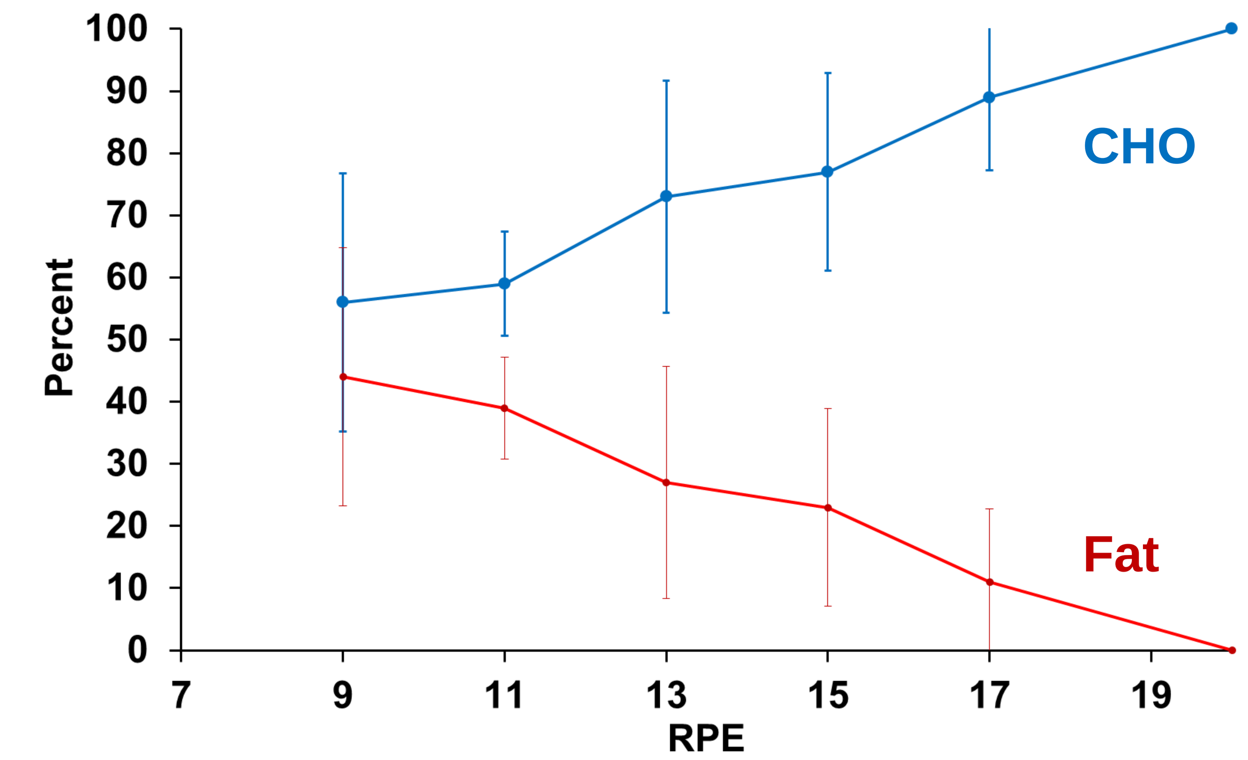

Figure 3. Relative percent contribution of CHO (blue) and fat (red) for SWE (RPE 9,11,13,15,17) SWE in healthy, young females (n=5). Data presented as mean±SD.

- Overall, energy expenditure increased in a step-wise fashion from RPE 9 (*very light*), 11, 13, 15, 17 to 20 (*maximum*) (Figure 1).
- From *very light* (RPE 9) to *very hard* efforts (RPE 17) (submaximal efforts) the rate of energy expenditure increased 200% (3.5±0.7 to 10.5±1.3 Kcal•min $^{-1}$, respectively) (Figure 1).
- During maximal exercise (RPE 20) subjects expended 13.2±1.7 Kcal•min $^{-1}$. This metabolic value represents maximal aerobic power, which is estimated, in this case, at approximately 13 times above resting metabolic rate.
- As intensity (RPE) increased, CHO oxidation increased in a linear fashion over submaximal exercise intensities (RPE 9 – 17) with a steeper rise from RPE 17 to RPE 20 (Figure 2).
- From *very light* (RPE 9) to *very hard (RPE 17)* intensities, relative CHO oxidation increased 370% (2.0±1.0 to 9.4±1.8 Kcal•min $^{-1}$, respectively), while fat oxidation remained relatively low (RPE 9-15) or negligible (RPE 17, 20) (Figure 2).
- Relative contribution of CHO and Fat are illustrated in Figure 3. Overall, percent contribution of CHO increased while percent fat contribution decreased over the continuum of exercise efforts (Figure 3).

Discussion:

- The rate of CHO and fat oxidation changes with increasing exercise intensity and energy expenditure. CHO was the fuel of choice as exercise intensity increased.
- The metabolic breakdown of CHO results in a greater rate of energy resynthesis compared to fat (2,3). Thus, the increasing rate of CHO use noted in this study was essential in meeting the increased energy demands associated with working at greater SWE intensities (see Figures 1 and 2).
- This study also highlights that shallow water exercise can elicit a metabolic rate that is favorable for realizing health benefits. For example, at a rating of perceived exertion of 13 (*somewhat hard*), participants were working at ~ 54% of their peak energy expenditure. This relative effort would be classified as a *moderate* intensity according to the American College of Sports Medicine (1), which is a feasible workload for most apparently healthy individuals.
- The use of rating of perceived exertion to regulate shallow water exercise intensity appears promising given the systematic step-up in energy expenditure from RPE 9 (*very light*) to RPE 20 (*maximum*).

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