Post Exercise Basil Metabolic Rate Following a 6 Minute High Intensity Interval Workout

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ABSTRACT

Recent evidence shows that a burst of rapid exercise with a duration of 10 minutes or less may be more effective in increasing body metabolism in the hours after exercise than is seen with low level aerobic exercise. In this experiment, we asked 10 participants with no history of cardiovascular disease or orthopedic injuries to follow an exercise video with 1 minute of warm up, 4 minutes of high intensity intervals and 1 minute of cool down. Oxygen consumption was measured just before and during exercise and for 48 hours after the exercise was over. Oxygen consumption was measured with a portable metabolic cart (KB22) by placing a mask on the subjects. To eliminate other activity, subjects were housed in a controlled environment where they remained sedentary on the day before and the 48 hours after the exercise. The diet was controlled to cause no weight loss or gain and involved a mixed diet with 2 snacks a day and ample water. It was the same on all 3 days. The results of the experiments showed that energy use during the 6 minutes of exercise increased to 17 METS. This caused a shift in metabolism that lasted more than 24 hours after the exercise. Even the next morning, metabolism was still almost 10% higher than the 2 previous days. For the average subject, integrating the area under the curve for calorie use during the exercise, the average subject used 1.2 cal/kg/min. With an average weight of 73 Kg the actual calories burned during the 6 minutes of exercise were, on the average,

63.2 calories. The basil metabolism of these subjects averaged 1783 calories per day. Since the increase in metabolism in the first 24 hours after exercise averaged, integrating the area under the post exercise curve in the next 24 hours, was 15.3%, the total number of calories burned after exercise in 24 hours was 297 calories for a total of 360 calories burned from the 6 minute burst workout. The post caloric expenditure (EPOC) was 5 times the calories expended during the 6 minutes of exercise. This is a very effective workout for people wishing fitness and weight loss. The top person in the group burned 112 calories during the 6 minute exercise and 345 calories in the next 24 hours for a total of 457 calories over the 24 hours. The top 20% of the group averaged 400 calories over 24 hours.

INTRODUCTION

It is well recognized that exercise increases tissue metabolism, especially in exercising muscle. During sustained exercise, there is an increase in men and women in fatty acid metabolism and release from liver and adipose tissue[1-3]. But many studies have shown that there is a carryover effect after exercise causing tissue metabolism to stay elevated for as much as several days after exercise[4-6]. If exercise intensity is increased, fatty acid metabolism is reduced during exercise [7, 8]. The metabolism in the post exercise recovery period may burn many more calories than the exercise itself[4]. The lipolysis post exercise in many ways resembles the lipolysis from fasting [9, 10]. It is modulated by diurnal variation in hormones and can last for days[11]. For example, in a recent paper by Henderson et al, it was shown that compared to a sedentary group, with exercise at either 45 or 65% Max VO2, there was elevated fat metabolism in the 2 exercise groups for more than 6 hours post exercise. The measurements were stopped at 6 hours. Fatty acid oxidation peaked at 3 hours and was still elevated near the peak at 6 hours[4].

The increase in fat metabolism is especially useful for people with Diabetes in that it has been shown that glucose control is enhanced not just during the exercise but for several days post exercise[12-15]. In both people with diabetes, mitochondria become defective producing reactive oxygen species. Exercise also reduces free radicals in cells from defective mitochondria[16].

But exercise does not necessarily need to be maintained for long periods to cause an increase in post exercise metabolism. Post exercise oxygen consumption has been termed EPOC and is caused by oxygen debt from exercise[17]. Oxygen consumption is greater after exercise than at rest before the exercise due to an oxygen debt in muscle[18,19]. In a study on weight lifting in humans, EPOC was greater with burst supersets than tradition sets of resistive weightlifting[20]. Reciprocal supersets (SUPERs) are a method of resistance training that alternates multiple sets of high-intensity agonist-antagonist muscle groups with limited recovery[20]. When aerobic exercise is maintained at a low level, there is very little EPOC while high intensity aerobic exercise is associated with prolonged EPOC that lasts for hours after the exercise is over[21]. But high intensity bursts, even for aerobic exercise increase EPOC[21]. Further, EPOC varies with the relative stress on the individual and not the absolute stress[22]. In a study in overweight women, there was a trend for greater EPOC with high weight resistance training of brief duration but it was not significantly higher than training at lower weights in brief sessions (less than 15 minutes)[23]. In a study published on Japanese, EPOC was seen even after 40 minutes from high intensity exercise that lasted less than 2 minutes[24]. Here athletes with a larger fat free mass had greater EPOC[24]. Thus the greater the anaerobic exercise, the greater the oxygen debt after the exercise[25]. But EPOC is more than anaerobic debt in that a steady state increase in metabolism is seen after exercise for many hours[26, 27]. The exact mechanism remains unclear but sustained catecholamine and other factors after exercise may all contribute to EPOC [28].

Table 1. Demographics of subjects

	height (cm)	weight (kg)	age (years)	BMI	% body fat
Mean	174.9	73.1	24.0	23.8	26.1
Standard Deviation	9.6	11.6	1.3	2.2	6.1

In the present investigation, 10 subjects were examined before, during and for 48 hours after a high intensity 6 minute workout.

SUBJECTS

Ten subjects participated in these experiments. There were 4 women and 6 men. All subjects were free of cardiovascular disease and had normal blood pressure making it safe for them to participate in mild exercise. Subjects were not taking alpha or beta agonists or antagonists. All subjects were nonsmokers. For all subjects, blood pressure and heart rate were measured at rest and subjects were excluded if blood pressure was >140/90 or less than 100/60. A screening history was taken. All subjects signed a consent form approved by the Institutional review board of Azusa Pacific University and all procedures were explained. The general characteristic of the subjects is shown in Table 1.

METHODS

Carbon dioxide production and respiratory quotient and metabolism

A Cosmed model Kb22 (Cosmed, Chicago, IL), was used to measure metabolic parameters. A Hans Rudolph mask was placed over the patients face and firmly secured so that no air would leak. A single air supply line then supplied to the Cosmed metabolic cart air and a turbine flow meter placed on the Hans Rudolph mask was used to measure ventilation. The turban flow meter was a very low volume turban flow meter meant for small volumes of air especially for Basal Metabolic Rate (BMR) calculations.

The Cosmed analyzer was calibrated 3 times a day. Calibration involved calibration against room air and a standardized gas calibrated on a mass spectrometer with a concentration of 16% O2 and 5% CO2. The turbine flow meter was calibrated with a three liter gas syringe. Barometric pressure and room humidity were used to correct all gas values to STPD (standard temperature and pressure). By entering the subject's height, age, weight, and sex, an algorithm in the Cosmed calculated the caloric expenditure, and based on the RQ, the percent carbohydrates and fats that were burned before, during, and after the exercise.

Diet- The diet consisted of a mixed diet with approximately 22% fat, 43% carbohydrates and 35% protein. Breakfast, lunch and dinner were provided as well as 2 snacks. The amount of food was adjusted based on body weight to match the individual's calculated metabolic need based on a formula derived by the American Dietetic Association. The target was a balanced diet with no caloric deficit. The meal plan was identical for all 3 days.

Exercise- Subjects followed a 6 minute burst exercise session on video and with a personal trainer present to monitor the work out and to assure participants performed the high intensity segments at maximum effort. The exercise was on a video produced by Savvier, LP. It consisted of a one minute warm-up followed by 4 minutes of high intensity interval exercise involving squats, jumping in place, lunges, split jumps and stretching followed by 1 minute of cool down. The 4 minutes consisted of 8 intervals; each interval was 20 seconds of exercise followed by 10 seconds of recovery.

PROCEDURES

Subjects stayed in a hotel room for the 4 days of the study. They were instructed to remain sedentary (no physical activity including showering) throughout the study and only eat the diet that was provided. They were sequestered in a hotel room for the duration of the study and meals were brought to them. Subjects were in individuals rooms. After signing the informed consent, they rested overnight and, the first thing in the next morning, resting oxygen consumption was measured to establish the BMR. This first day was a washout day during which baseline data was collected. Oxygen consumption was also measured at noon and before dinner that day. Oxygen use and energy expenditure was always measured before the meal. On the second day (exercise day), they followed an exercise video for 6 minutes as described under methods. At 3 hours and 8 hours later that day, oxygen consumption was measured over a 5 minute period. Oxygen consumption was measured on waking the next morning and at noon and before dinner and then the following morning (day 3). Oxygen consumption was also measure on waking the next day (day 4).

Data Analysis- Data analysis consisted of means and standard deviations and ANOVA to examine the changes in oxygen consumption over the 3 days. The level of significance was $p<0.05$.

RESULTS

The experiments were conducted over a 4 day period. The first day was for the collection of baseline data including oxygen consumption, ventilation, and heart rate data. The second day, after collection of resting data, included 6 minutes of intense burst exercise followed by a 7 minute recovery period. Resting data was then collected 3 hours and 8 hours later that day and at awakening, lunch and dinner the next day. Finally, baseline data was collected the following morning.

The oxygen consumption over the 4 day period and including during exercise is shown in Figure 1. As shown here, the oxygen consumption at rest (BMR) in the mornings averaged 3.33+/0.61 cc/kg/minute. The resting oxygen consumption was significantly higher at noon and the evening of the first day as might be expected and shown in Figure 1 ($p<0.01$). This was equivalent to a use of 0.016 calories/kg/min consumed at rest and 0.019 cal/kg/min by noon (Figure 2). At the peak of the exercise, oxygen consumption was 0.34+/- 0.06 cal/kg/min in these subjects, a significant increase from rest ($p<0.01$). This was an increase of 17.7 times that of the baseline value (17.7 METS). Oxygen uptake peaked at the 5th minute and then was progressively reduced after that. Even at 3 and 6 hours after the exercise, oxygen consumption was still elevated significantly ($p<0.05$). When calculated as a percent from the previous days data, at dinner for example (8 hours post exercise), metabolism was 20.45 % higher at dinner the second day than the baseline day (day 1). At 3 hours metabolism was 26.07 % higher than rest. This is best seen in Figure 4. Even by morn-

Figure 1. *Illustrated here is the oxygen consumption of the subjects on waking during the control day, the exercise day and the next 2 mornings after the exercise as well as the lunch and dinner data during each of the days. For the exercise, data is shown at rest and at 1 minute intervals. The first 6 minutes are the exercise period and the balance is the recovery period. All points are the mean of 10 subjects +/- the standard deviation.*

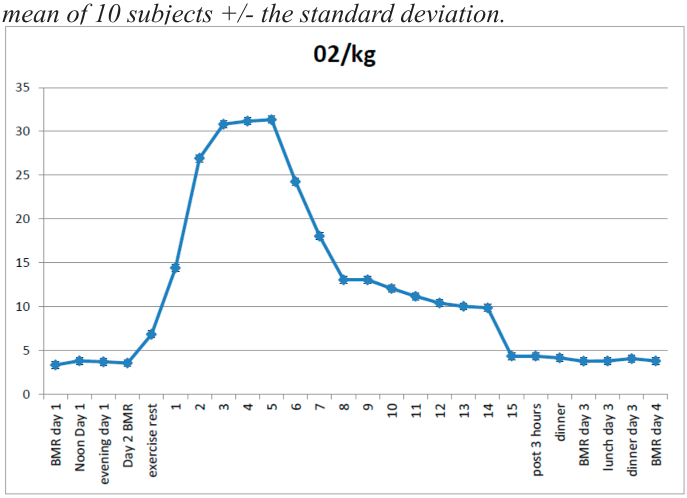


Figure 2. *Illustrated here is the energy consumption of the subjects on waking during the control day, the exercise day and the next 2 mornings after the exercise as well as the lunch and dinner data during each of the days. For the exercise, data is shown at rest and at 1 minute intervals. The first 6 minutes are the exercise period and the balance is the recovery period. All points are the mean of 10 subjects +/- the standard deviation.*

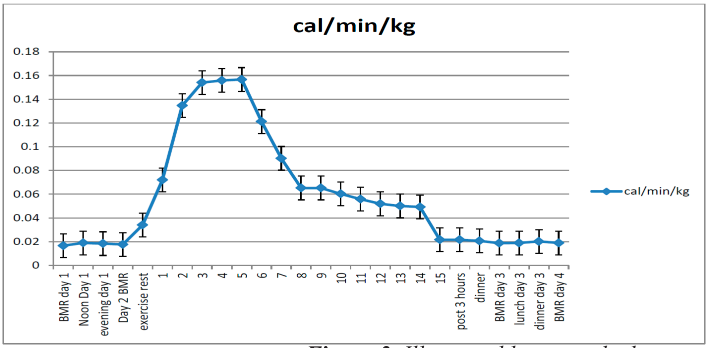


Figure 3. *Illustrated here are the heart rates of the subjects on waking during the control day, the exercise day and the next 2 mornings after the exercise as well as the lunch and dinner data during each of the days. For the exercise, data is shown at rest and at 1 minute intervals. The first 6 minutes are the exercise period and the balance is the recovery period. All points are the mean of 10 subjects +/- the standard deviation.*

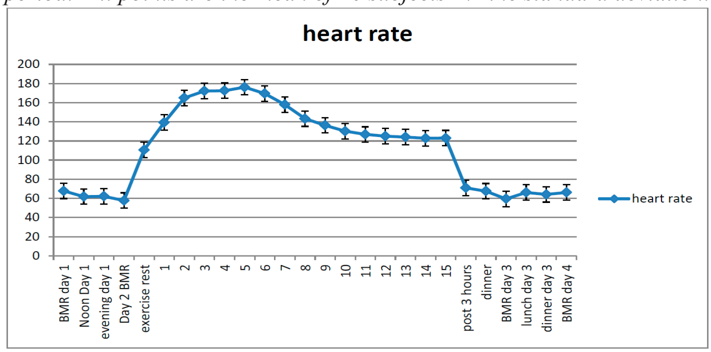
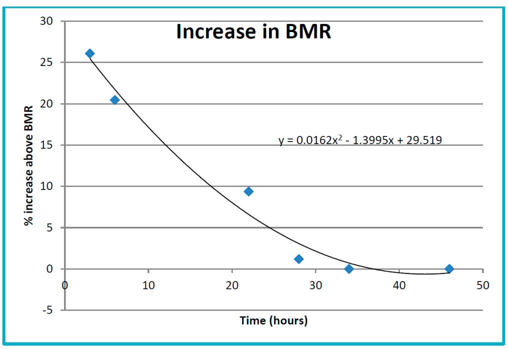


Figure 4. *Illustrated here is the energy use of the subjects on waking during the control day, the exercise day and the next 2 mornings after the exercise as well as the lunch and dinner data during each of the days. For the exercise, data is shown at rest and at 1 minute intervals. The first 6 minutes are the exercise period and the balance is the recovery period. All points are the mean of 10 subjects +/- the standard deviation.*



ing of the next day (24 hours after exercise), metabolism was 9.36% higher than the BMR measured the 2 previous mornings before the exercise bout ($p<0.01$).

For the average subject, integrating the area under the curve for the Figure showing calorie use during the exercise, the average subject used 1.2 cal/kg/min. With and average weight of 73 Kg, the number of calories burned during the 16 minute exercise period was 87 calories. But the actual calories burned during the 6 minutes of exercise were, on the average, 63.2 calories. Basil metabolism of these subjects averaged 1783 calories per day. Since the increase in metabolism in the first 24 hours after exercise averaged, integrating the area under the post exercise curve in the next 24 hours, 15.3%, the total number of calories burned after the 6 minute exercise period in the next 24 hours was 297 calories for a total of 360 calories burned from the 6 minute burst workout. The top person in the group burned 112 calories during the 6 minutes of exercise and 345 calories in the next 24 hours for a total of 457 calories over the 24 hours. The top 20% of the group averaged 400 calories over 24 hours.

Heart rate, which started at 61.9+/-7.75 beats per minute at rest, peaked at the 5th minute of exercise at 176.0+/-10.2 beats per minute. This increase was significant ($p<0.01$). The heart rate (Figure 3), was still above 120 beats per minute 10 minutes after the exercise was finished. As shown in this figure, heart rate was significantly elevated even 3 hours after exercise ($p<0.05$). An elevation of more than 10% above resting heart rate is considered still in the recovery phase from exercise. Using this criteria, subjects were recovered past 3 hours post exercise and on the morning after the exercise heart rate was not significantly different than the control ($p>05$). A typical subject is shown during exercise in Figure 5.

DISCUSSION

With obesity around the world being considered by the world health organization an epidemic, there is considerable interest in

Figure 5. Typical subject during exercise

diet and exercise programs that will increase weight loss[14, 15]. Certainly these programs have been examined in the past in numerous studies [29-31]. It has been well documented that, while weight loss can be achieved by dietary reduction alone, exercise not only tones the body but increases the burning of fats [32, 33]. Exercise is also an integral part of lifestyle changes to try and keep weight loss maintained and to prevent regaining weight[34-36].

But recent evidence shows that the greatest effect on long term increases in tissue metabolism is not sustained long duration aerobic exercise but rapid burst exercise[37]. This type of exercise lasting less than 10 minutes can increase metabolism for more than 10 hours after the exercise is over[38, 39].

In the present investigation, 10 participants engaged in a study to see the extent of the increase in metabolism and the duration of the increase after a 6 minute bout of high intensity interval exercise. The exercise involved core and whole body exercise. The results showed that as commonly reported in the literature, at rest, especially on awakening, metabolism was quite low averaging 0.016 calories per kg / minute. Metabolism and heart rate increased during exercise as might be expected. Of interest was the fact that at 3 hours post exercise, the oxygen consumption was more than 26% higher than at rest. Thus even 6 hours after a 6 minute bout of high intensity interval exercise, metabolism was still significantly elevated by over 20%. In fact, energy used during exercise and for the first 24 hours average 360 calories. The substrate burned during exercise was predominantly carbohydrates and after exercise was fat (based on RQ) as would be expected for high intensity exercise. Such exercise brings the body into an anaerobic state during the exercise. The anaerobic exercise creates an oxygen debt that is paid back for more than 24 hours after the exercise is over. The top person in the group burned 112 calories during the 6 minute exercise and 345 calories in the next 24 hours for a total of 457 calories over the 24 hours. The top 20% of the group averaged 400 calories over 24 hours. It was interesting that the actual calories burned during the 6 minutes of exercise were, on the average, 63.2 calories, showing a very intense workout. More importantly, 300 calories were burned in the next 24 hours, or 5 times more calories burned after the exercise than during the exercise.

With 3500 calories needed to lose 1 lb. of weight, the average person would lose 1 lb. every 10 days just by adding this 6 minute routine to their lifestyle. Thus this is an effective workout for toning and weight loss. It compared well with previous studies and demonstrates the EPOC window with this work out to be greater than 24 hours[37]. While there was a statistically significant increase in EPOC to 24 hours, data presented here, showed it extended to about 36 hours.

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