

NAME: _____

HPER 3970 BODY COMPOSITION / WEIGHT MANAGEMENT / SPORT NUTRITION

LABORATORY #1:

ASSESSMENT OF RESTING METABOLIC RATE AND SUBSTRATE UTILIZATION DURING EXERCISE

Introduction

Basal Metabolic Rate / Resting Metabolic Rate

Basal metabolic rate (BMR) or resting metabolic rate (RMR) represents energy expenditure by the body (at rest) to maintain life and normal body functions. BMR/RMR can account for as much as 60% to 75% of an individual's total daily energy expenditure. It is estimated that males and females expend an average of 1500 and 1200 kcal/day, respectively.

The measurement of BMR must be performed under very stringent laboratory conditions. For example:

1. The person must not have eaten any food for at least 12 hours preceding the measurement.
2. BMR must be measured when the person is completely resting but is still awake.
 - a. Measurements should be made early in the morning following a night of restful sleep.
 - b. No strenuous exercise should be performed for at least 24 hours before testing.
3. The person must be free of all psychic and physical disturbances (i.e. medications, drugs, depression, stress).
4. Room temperature must be comfortable and somewhere between 68°F to 80°F.

Because of the difficulty in measuring BMR, RMR is often used and does not require such stringent laboratory conditions.

BMR/RMR can be predicted using the following formulas (Harris Benedict Equation) for females and males.

Females: $BMR/RMR \text{ (kcal/day)} = 655.1 + (9.56 \times \text{body weight; kg}) + (1.85 \times \text{height; cm}) - (4.68 \times \text{age; yr})$

Males: $BMR/RMR \text{ (kcal/day)} = 66.47 + (13.75 \times \text{body weight; kg}) + (5.0 \times \text{height; cm}) - (6.76 \times \text{age; yr})$

To estimate total daily energy expenditure, the BMR/RMR is typically multiplied by a factor that approximates the activity level of the individual. For example:

For a person confined to bedrest:	Daily EE (kcal/day) = $RMR \times 1.2$
Sedentary both in work and leisure:	Daily EE (kcal/day) = $RMR \times 1.3$
Somewhat active life:	Daily EE (kcal/day) = $RMR \times 1.4$
Very active life:	Daily EE (kcal/day) = $RMR \times 1.5$

Energy Expenditure and Substrate Utilization During Rest and Exercise

Energy expenditure (kcal/min) and substrate utilization (percentage of energy expended coming from the breakdown of carbohydrates and fats) can be measured during both rest and exercise. These measurements require the use of a Metabolic Measurement System which can measure how much oxygen a person is consuming (VO_2) and how much carbon dioxide a person is producing (VCO_2).

Energy expended is calculated using the following equation:

$$\text{Energy expenditure (kcal/min)} = VO_2 \text{ (L/min)} \times RQ \text{ kcal equivalent value}$$

The RQ kcal equivalent value tells you how many kcal are expended for every liter of oxygen consumed. The amount of kcal expended per liter of oxygen varies slightly depending on the amount of carbohydrates and fats that are utilized for energy. Generally, though, approximately 5 kcals are expended per liter of oxygen consumed. This concept is explained further below.

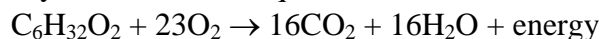
Determining substrate utilization (% CHO and % Fat being used for energy) requires the measurement of the respiratory quotient (RQ). RQ is calculated as the volume of carbon dioxide produced divided by the volume of oxygen consumed ($RQ = VCO_2 / VO_2$). By knowing the RQ of an individual during a certain condition, a more precise measurement of energy expenditure (kcal/min) can be calculated as well as the % of energy coming from CHO and Fat and the grams of CHO and Fat being oxidized every minute. A chart has been provided that states this information in relation to RQ.

During steady-state exercise, RQ values typically range between 0.7 and 1.0.

An RQ value of 0.7 represents 100% of energy coming from the breakdown of fat. The following chemical equation explains why and RQ of 0.7 equals 100% fat utilization for energy.



If you balance this equation the result is:



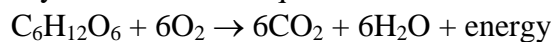
Since $RQ = VCO_2/VO_2$:

$$16/23 = 0.7$$

An RQ value of 1.0 represents 100% of energy coming from the breakdown of carbohydrates. The following chemical equation explains why and RQ of 1.0 equals 100% carbohydrate utilization for energy.



If you balance this equation the result is:



Since $RQ = VCO_2/VO_2$:

$$6/6 = 1.0$$

THERMAL EQUIVALENT OF O₂ FOR NON-PROTEIN RQ

Nonprotein RQ	Kcal per Liter Oxygen Consumed	% Kcal derived from		Grams per liter O ₂	
		CHO	FAT	CHO	FAT
0.707	4.686	0	100	0	0.496
0.71	4.69	1.1	98.9	0.012	0.491
0.72	4.702	4.76	95.2	0.051	0.476
0.73	4.714	8.4	91.6	0.09	0.46
0.74	4.727	12	88	0.13	0.444
0.75	4.739	15.6	84.4	0.17	0.428
0.76	4.751	19.2	80.8	0.211	0.412
0.77	4.764	22.8	77.2	0.25	0.396
0.78	4.776	26.3	73.7	0.29	0.38
0.79	4.788	29.9	70.1	0.33	0.363
0.80	4.801	33.4	66.6	0.371	0.347
0.81	4.813	36.9	63.1	0.413	0.33
0.82	4.825	40.3	59.7	0.454	0.313
0.83	4.838	43.8	56.2	0.496	0.297
0.84	4.85	47.2	52.8	0.537	0.28
0.85	4.862	50.7	49.3	0.579	0.263
0.86	4.875	54.1	45.9	0.621	0.247
0.87	4.887	57.5	42.5	0.663	0.23
0.88	4.899	60.8	39.2	0.705	0.213
0.89	4.911	64.2	35.8	0.749	0.195
0.90	4.924	67.5	32.5	0.791	0.178
0.91	4.936	70.8	29.2	0.834	0.16
0.92	4.948	74.1	25.9	0.877	0.143
0.93	4.961	77.4	22.6	0.921	0.125
0.94	4.973	80.7	19.3	0.964	0.108
0.95	4.985	84	16	1.008	0.09
0.96	4.998	87.2	12.8	1.052	0.072
0.97	5.01	90.4	9.58	1.097	0.054
0.98	5.022	93.6	6.37	1.142	0.038
0.99	5.035	96.8	3.18	1.186	0.018
1.00	5.047	100	0	1.231	0

Procedures

This will be primarily a demonstration laboratory exercise. One volunteer will have his or her resting metabolic rate (RMR) assessed and then will exercise on a cycle ergometer for approximately 10 minutes at two different exercise intensities (low and moderate intensity)

Specifically:

1. The students will be shown how to calibrate the metabolic measurement cart.
2. For the measurement of resting metabolic rate, the volunteer will be hooked up to the metabolic cart and respiratory gases will be analyzed for oxygen and carbon dioxide concentrations for approximately 10 minutes. The last five minutes of data will be used to calculate RMR.
3. The volunteer will then begin a 10 minute exercise session on the cycle ergometer. The volunteer will exercise at a low intensity for 10 minutes and then a moderate intensity for another 10 minutes. Again, respiratory gases will be analyzed for oxygen and carbon dioxide concentrations throughout the entire exercise session. The last five minutes of data for each intensity will be used to calculate the exercise metabolic rate and the rate of substrate utilization of carbohydrate and fat.

Data Collection

Volunteer Information:

Name: _____ Age: _____

Height (cm): _____ Weight (kg): _____

Data:

Condition	Workload (W)	VO ₂ (L·min ⁻¹)	VCO ₂ (L·min ⁻¹)	RQ
Rest	0			
Exercise One				
Exercise Two				

Calculations:

Condition	kcal / min	% CHO	% Fat	g CHO/min	g Fat /min
Rest					
Exercise One					
Exercise Two					

