

### Practice Metabolic Expenditure Questions

1. What is the  $\text{VO}_2$  cost of exercising on a treadmill at 2.5 mph and a 6% grade?
2. What is the MET requirement and what is the caloric expenditure for an exercise session on the treadmill if you weigh 75 kilograms and want to exercise by walking at 3.7 mph up a 10% grade?
3. A cardiac patient cannot walk any faster than 2 mph, but has been told that she must exercise at 8 METs. What percent grade should the treadmill be set?
4. An elderly lady who weighs 142 pounds exercises on her treadmill at 2.5 mph. What is her caloric expenditure for a 20-minute exercise session?
5. A male who weighs 200 pounds wishes to lose weight. If he exercises on the treadmill at 3.0 mph and 10% grade, how long will it take to expend enough calories to equal approximately one pound?
6. If a 75-kilogram man runs at 9 mph for 30 minutes, how many kilocalories will he expend?
7. What is the  $\text{O}_2$  cost of running at 10 mph up a 10% grade on a treadmill?
8. At what grade should you exercise on a treadmill if you wish to work at a 13 MET capacity? Treadmill speed is 6 mph.
9. What is the caloric cost (per minute) of the treadmill exercise in question #7? The person performing this activity weighs 55 kilograms.
10. What would be the  $\text{O}_2$  cost of running on the level at 8 mph?
11. What is the  $\text{O}_2$  cost of leg cycle ergometry when the workload is 400 watts and body weight is 65 kilograms?
12. What is the energy cost in METs if a person is cycling at a work rate of  $300 \text{ kgm} \cdot \text{min}^{-1}$  and weighs 50 kilograms?
13. What is the workload in watts if a person is pedaling at  $60 \text{ rev} \cdot \text{min}^{-1}$  at a resistance of 2 kilograms on a Monark ergometer?
14. What is the absolute  $\text{O}_2$  cost of cycling at 150 watts on a Monark cycle when the person weighs 175 pounds?
15. How long would the person in question #14 have to exercise in order to expend 400 kcal?

### Answers

1.  $17.44 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$
2. 8.93 METs ;  $11 \text{ kcal} \cdot \text{min}^{-1}$
3. 20%
4. 65 kcal in 20 minutes
5. approximately 5 hours
6. 582 kcal in 30 minutes
7.  $81.22 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$
8. .068 or 7%
9.  $22.34 \text{ kcal} \cdot \text{min}^{-1}$
10.  $46.38 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$
11.  $73.46 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$
12. 5.08 METs
13. 120 watts
14.  $2.178 \text{ L} \cdot \text{min}^{-1}$
15. 36.4 minutes

$$\begin{aligned}
1. \text{VO}_2 &= (67 \text{ m} \cdot \text{min}^{-1} \times 0.1 \frac{\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}}{\text{m} \cdot \text{min}^{-1}}) + (67 \text{ m} \cdot \text{min}^{-1} \times 1.8 \frac{\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}}{\text{m} \cdot \text{min}^{-1}} \times .06) + 3.5 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} \\
&= 6.7 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} + 7.24 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} + 3.5 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} \\
&= 17.44 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}
\end{aligned}$$

$$\begin{aligned}
2. \text{VO}_2 &= (99 \text{ m} \cdot \text{min}^{-1} \times 0.1 \frac{\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}}{\text{m} \cdot \text{min}^{-1}}) + (99 \text{ m} \cdot \text{min}^{-1} \times 1.8 \frac{\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}}{\text{m} \cdot \text{min}^{-1}} \times .10) + 3.5 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} \\
&= 9.9 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} + 17.82 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} + 3.5 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} \\
&= 31.22 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} \\
&= 8.92 \text{ METS} \\
&= 11.71 \text{ kcal} \cdot \text{min}^{-1}
\end{aligned}$$

$$\begin{aligned}
&= 31.22 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} \times 75 \text{ kg} \\
&= 2341.5 \text{ ml} \cdot \text{min}^{-1} \\
&= 2.342 \text{ L} \cdot \text{min}^{-1} \times 5 \text{ kcal} \cdot \text{L}^{-1} \\
&= 11.71 \text{ kcal} \cdot \text{min}^{-1}
\end{aligned}$$

$$\begin{aligned}
3. \quad 28 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} &= (53.6 \text{ m} \cdot \text{min}^{-1} \times 0.1 \frac{\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}}{\text{m} \cdot \text{min}^{-1}}) + \\
&\quad (\% \text{ grade} \times 53.6 \text{ m} \cdot \text{min}^{-1} \times 1.8 \frac{\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}}{\text{m} \cdot \text{min}^{-1}}) + 3.5 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} \\
19.14 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} &= 5.36 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} + 3.5 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} + (\% \text{ grade} \times 96.48 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}) \\
.198 &= \% \text{ grade} \\
20\% &= \% \text{ grade}
\end{aligned}$$

$$\begin{aligned}
4. \text{VO}_2 &= 67 \text{ m} \cdot \text{min}^{-1} \times 0.1 \frac{\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}}{\text{m} \cdot \text{min}^{-1}} + 3.5 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} \\
&= 6.7 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} + 3.5 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} \\
&= 10.2 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} \\
&= 657.9 \text{ ml} \cdot \text{min}^{-1} \\
&= .658 \text{ L} \cdot \text{min}^{-1} \\
&= 3.29 \text{ kcal} \cdot \text{min}^{-1} \\
&= 65.8 \text{ kcal in 20 minutes}
\end{aligned}$$

$$\begin{aligned}
5. \text{VO}_2 &= (80.4 \text{ m} \cdot \text{min}^{-1} \times 0.1 \frac{\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}}{\text{m} \cdot \text{min}^{-1}}) + (80.4 \text{ m} \cdot \text{min}^{-1} \times 1.8 \frac{\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}}{\text{m} \cdot \text{min}^{-1}} \times .10) + 3.5 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} \\
&= 8.04 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} + 14.47 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} + 3.5 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} \\
&= 26.01 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} \\
&= 2364.5 \text{ ml} \cdot \text{min}^{-1} \\
&= 2.36 \text{ L} \cdot \text{min}^{-1} \\
&= 11.8 \text{ kcal} \cdot \text{min}^{-1} \\
&= \underline{3500 \text{ kcal}} \\
&\quad 11.8 \text{ kcal} \cdot \text{min}^{-1} \\
&= 296.6 \text{ min or 4.94 hours}
\end{aligned}$$

$$\begin{aligned}
6. \text{VO}_2 &= 241.2 \text{ m} \cdot \text{min}^{-1} \times 0.2 \frac{\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}}{\text{m} \cdot \text{min}^{-1}} + 3.5 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} \\
&= 48.24 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} + 3.5 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} \\
&= 51.74 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} \\
&= 3880.5 \text{ ml} \cdot \text{min}^{-1} \\
&= 19.4 \text{ kcal} \cdot \text{min}^{-1} \\
&= 582 \text{ kcal in 30 minutes}
\end{aligned}$$

$$\begin{aligned}
7. \text{VO}_2 &= (268 \text{ m} \cdot \text{min}^{-1} \times 0.2 \frac{\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}}{\text{m} \cdot \text{min}^{-1}}) + (0.1 \times 268 \text{ m} \cdot \text{min}^{-1} \times 0.9 \frac{\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}}{\text{m} \cdot \text{min}^{-1}}) + 3.5 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} \\
&= 53.6 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} + 24.12 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} + 3.5 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} \\
&= 81.22 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}
\end{aligned}$$

8.  $45.5 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} = (160.8 \text{ m} \cdot \text{min}^{-1} \times 0.2 \frac{\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}}{\text{m} \cdot \text{min}^{-1}}) +$   
 $(\% \text{ grade} \times 160.8 \text{ m} \cdot \text{min}^{-1} \times 0.9 \frac{\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}}{\text{m} \cdot \text{min}^{-1}}) + 3.5 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$   
 $9.84 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} = 32.16 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} + (\% \text{ grade} \times 144.72 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}) + 3.5 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$   
 $.068 = \% \text{ grade}$   
 $6.8\% = \% \text{ grade}$
9.  $= 81.22 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$   
 $= 4467.1 \text{ ml} \cdot \text{min}^{-1}$   
 $= 4.467 \text{ L} \cdot \text{min}^{-1}$   
 $= 4.467 \text{ L} \cdot \text{min}^{-1} \times 5 \text{ kcal} \cdot \text{L}^{-1}$   
 $= 22.34 \text{ kcal} \cdot \text{min}^{-1}$
10.  $\text{VO}_2 = (214.4 \text{ m} \cdot \text{min}^{-1} \times 0.2 \frac{\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}}{\text{m} \cdot \text{min}^{-1}}) + 3.5 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$   
 $= 42.88 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} + 3.5 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$   
 $= 46.38 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$
11.  $\text{VO}_2 = (400 \text{ W} \times 10.8 \text{ ml} \cdot \text{W}^{-1}) / 65 \text{ kg} + 7 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$   
 $= 4320 \text{ ml} \cdot \text{min}^{-1} / 65 \text{ kg} + 7 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$   
 $= 66.5 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} + 7 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$   
 $= 73.5 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$
12.  $\text{VO}_2 = (300 \text{ kgm} \cdot \text{min}^{-1} \times 1.8 \text{ ml} \cdot \text{kgm}^{-1}) / 50 \text{ kg} + 7 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$   
 $= 540 \text{ ml} \cdot \text{min}^{-1} / 50 \text{ kg} + 7 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$   
 $= 10.8 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} + 7 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$   
 $= 17.8 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$   
 $= 5.08 \text{ METs}$
13.  $2 \text{ kg} \times \frac{60 \text{ rev}}{\text{min}} \times \frac{6 \text{ m}}{\text{rev}} = 720 \text{ kgm} \cdot \text{min}^{-1}$   
 $= 720 \text{ kgm} \cdot \text{min}^{-1} / \frac{6 \text{ kgm} \cdot \text{min}^{-1}}{\text{W}}$   
 $= 120 \text{ Watts}$
14.  $\text{VO}_2 = (150 \text{ W} \times 10.8 \text{ ml} \cdot \text{W}^{-1}) / 79.5 \text{ kg} + 7 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$   
 $= 1620 \text{ ml} \cdot \text{min}^{-1} / 79.5 \text{ kg} + 7 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$   
 $= 20.4 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} + 7 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$   
 $= 27.4 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$   
 $= 27.4 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} \times 79.5 \text{ kg}$   
 $= 2178 \text{ ml} \cdot \text{min}^{-1}$   
 $= 2.178 \text{ L} \cdot \text{min}^{-1}$
15.  $\text{VO}_2 = 2.2 \text{ L} \cdot \text{min}^{-1} \times 5 \text{ kcal} \cdot \text{L}^{-1}$   
 $= 11 \text{ kcal} \cdot \text{min}^{-1}$   
 $= 36.4 \text{ min}$