ENERGY CONSUMPTION IN TRAIL RUNNING

Can we work out the energy we spend when we run?

Initial Google search

https://www.google.es/?gws_rd=ssl#q=energy+consumption+trail+running

Not an easy question!!!

0. Introduction

General explanation of how our body gets energy to live. Which variables affect. One example: running

https://app.box.com/s/z18nzxtaxtm94wpk1wpo4nxzubm1ecea

1. Energy consumption by Léger and Mercier

Variables: distance, time, average speed, runner's mass and technical efficacy.

a. Calculate the speed of the race in meters per minute.
b. Search the energy consumption depending on the speed.
   https://app.box.com/s/xnzbm4k2flzaqwikm5w1
   https://app.box.com/s/nkiuz4xuq3c3it3e456f (Data table Léger and Mercier 1984)
c. Multiply this value by the runner's mass. This is the energy consumed per kilometre.
d. Multiply this value by the kilometres of the run to calculate the total energy consumption.

2. **<u>Energy consumption considering the heart rate (De Lucio, Castañeda, 2004)</u>**

Variables: runner's age, mass, maximal oxygen consumption (VO_2max), average heart rate (HR) and time.

a. Estimate the HR max.

HR max = 220 – age(years)

This is the usual formula for this estimation, but a recent study shows that it underestimates the real maximum heart rate and proposes another equation (Tanaka 2001):

HR max = 208 – 0,7 x age(years)

b. Find the equivalence between the average HR and the percentage of VO_2max.

% RC	% VO_2 Máx	% RC	% VO_2 Máx
50	28	75	63
55	35	80	70
60	42	85	77
65	49	95	90
70	56	100	100

c. Estimate the runner's VO_2max value

López Chicharro, 2007

The VO_2max value (mL kg^{-1} min^{-1}) for boys is quite constant among 6-16 year-olds and it has an average value of 50-53.

For girls the pattern is different since a progressive decrease of the values is shown along the growing period. Thus, a 8-year-old girl has an VO_2max value around 50, but she will reach 45 when she will be a 12-year-old and 40 when she will become a 16-year-old.

Leger et al., 1998

For ages between 6-18, the following formula is proposed, which depends on the final stage speed (V) in kilometers per hour and the age (A) in years. In this case, V must be obtained in anaerobic conditions to estimate a correct value of VO_2max.

$$VO_2max = 31{,}025 – (3{,}238\ V) – (3{,}248\ A) + (0{,}1536\ V\ A)$$

d. Calculate the percentage of VO_2 max in mL/kg/min related with the average HR.
e. Calculate the metabolic equivalent task (MET).
   1 MET = 3,5 mL/kg/min
   1 MET = 1 kcal/kg/h
f. Multiply by the runner's mass to calculate the spent energy in kcal/h.
g. Multiply by the time to work out the total energy consumption.
   Link to the article with examples:
   https://app.box.com/s/3j1aazb2sqqayr1i8wyrlz3vzedcbdfq

3. Energy consumption in outdoor running (Dennis and Noakes, 1999)

Variables: runner's mass, average speed and time.

a. Runner's power is estimated with his/her mass (m) and the average speed in meters per second (v) multiplied by a factor of 4 Joules per metre run and kilogram of mass.
   $P_r = m\ v\ 4$
b. The energy is calculated multiplying the power by the time of the run.
   $E = P_r\ t$

4. Energy consumption in outdoor running with wind resistance (Leger Mercier, 1984)

Variables: average speed, runner's mass and time. The wind resistance significantly affects the energy consumption at speeds higher than 15 km/h (4 minutes per kilometre)

a. The energy consumption expressed as VO_2 (mL/kg/min) is calculated with the following formula where the average speed (v) is expressed in kilometres per hour.
   $VO_2 = 2{,}209 + (3{,}1633\ v) + (0{,}000525542\ v^3)$
b. The calculation continues like in sections 2e-2g.

5. Energy consumption applying Physics

Total energy consumption (TEC) = Kinetic Energy (KE) + Gravitational Potencial Energy (PE) + Thermal Energy (TE)

a. Kinetic Energy

It can be calculated by multiplying the power (energy per unit time) expended in running and the time:

$KE = P_r\, t$

where P_r can be estimated with the mass (m), the gravity acceleration (g) and the average speed (v):

$P_r = m\, g\, v / 4$

See the publication:

http://sprott.physics.wisc.edu/technote/walkrun.htm

b. Gravitational Potential Energy

If the runner goes uphill:

$PE_{up} = m\, g\, h$

depends on the mass (m), the gravity acceleration (g) and the altitude climbed (h).

When the runner goes downhill consumes energy too. The runner has to balance the X-Weight, therefore:

$PE_{down} = m\, g\, \sin(\theta)\, h$

which includes the angle (θ) of the downhill slope.

c. Thermal Energy

This kind of the energy is lost through the skin and it is very difficult to calculate, since it depends on so many factors. However, it can be estimated by difference as follows:

TE = TEC – KE – PE

The TEC can be obtained by one of the procedures presented in the previous sections of this text.

ACTIVITY

1. Search the data:
    a. GPS track of your race
    b. Race standings on the race website
2. Calculate the energy consumed during the race and compare it with the energy estimated by your GPS device. Use as many methods as you can but, in every case, make comments about the positive and negative aspects of each method.
3. Draw out conclusions comparing all the results.

Filename: CMITE_Energy_G*number*

Use the equations editor or the Excel spreadsheet if it is necessary.