METABOLIC AND MECHANICAL COST OF SEDENTARY AND PHYSICAL ACTIVITIES IN OBESE CHILDREN AND ADOLESCENTS

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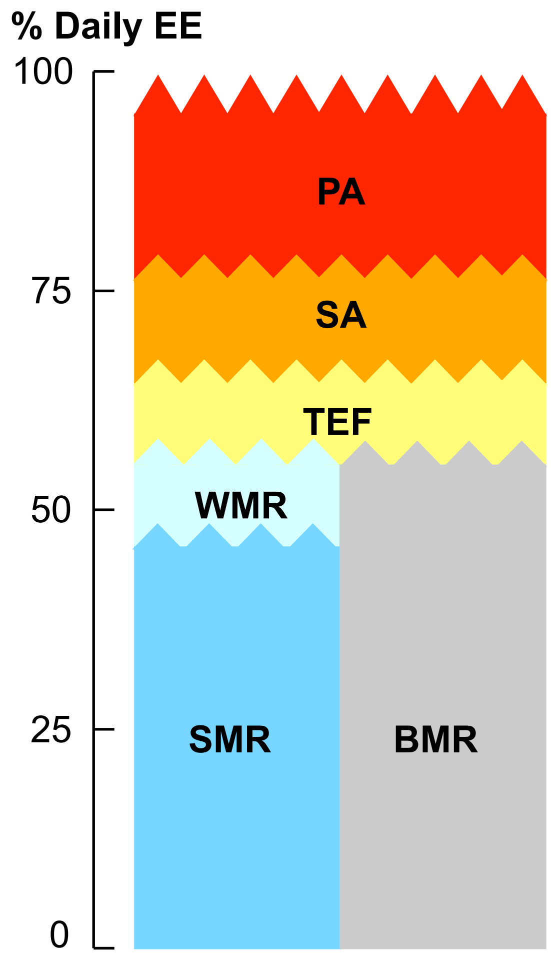
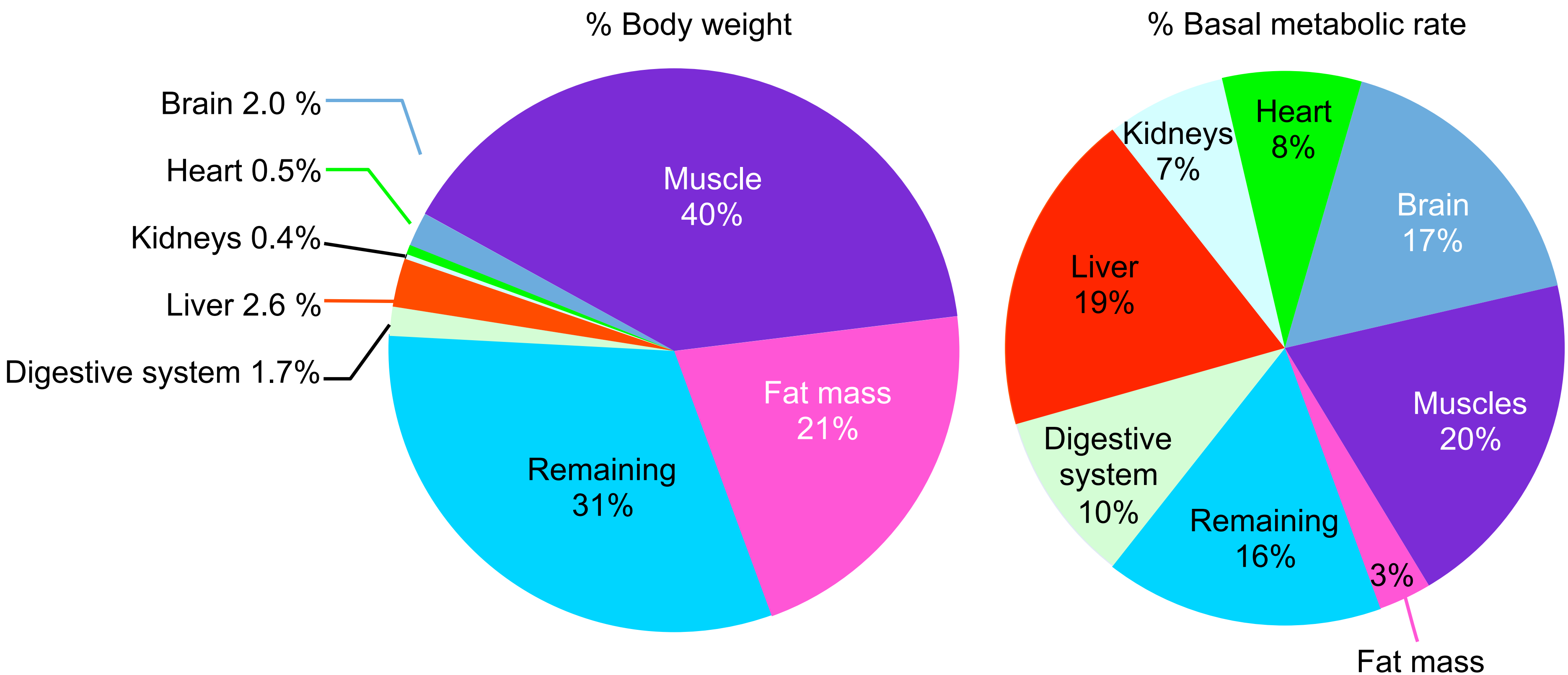
MAIN COMPONENTS OF DAILY ENERGY EXPENDITURE (DEE)



BMR: basal metabolic rate; SMR: sleeping metabolic rate; WMR: wakefulness metabolic rate; TEF: thermic effect of food EE; SA: sedentary activity EE; PA: physical activity EE

(Lazzer et al. 2003)

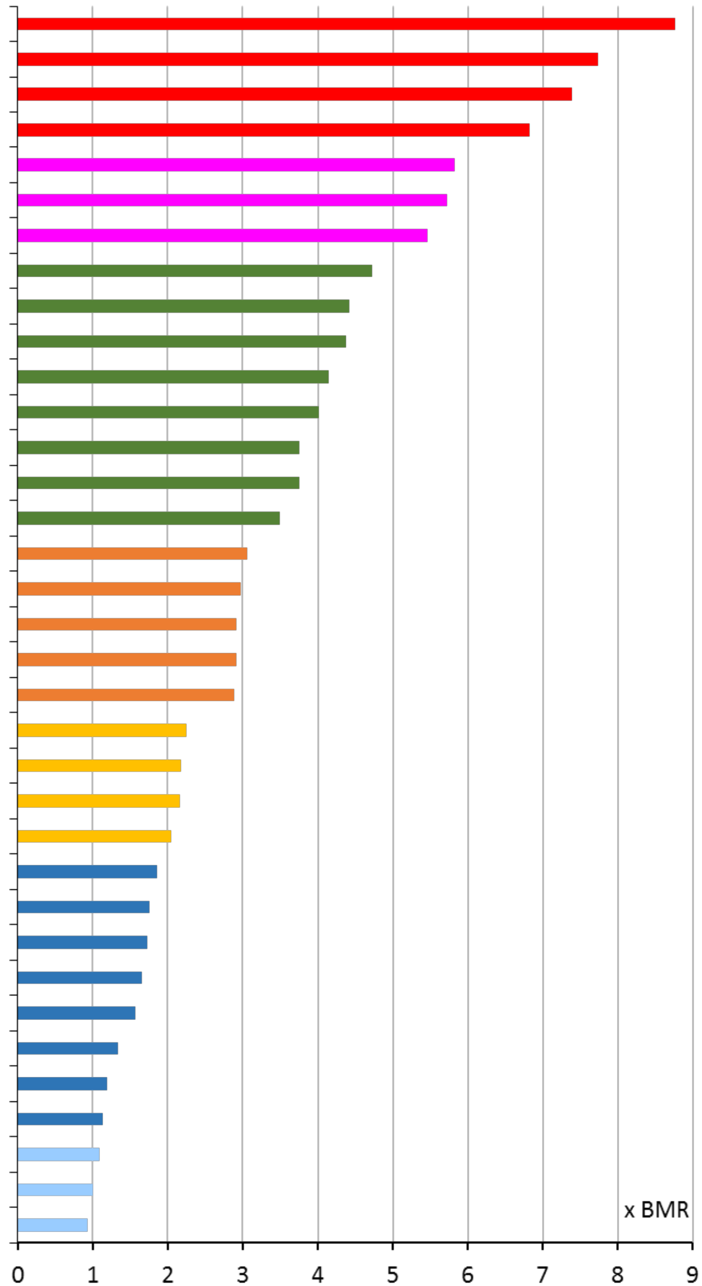
CONTRIBUTION OF ORGANS AND TISSUES TO BODY WEIGHT AND BASAL METABOLIC RATE



(Elia 1992; Gallagher 1998)

PHYSICAL ACTIVITY RATIOS (PAR) CORRESPONDING TO VARIOUS SEDENTARY AND PHYSICAL ACTIVITIES

Walking 4.8 km/h - 9% slope	8.77
Bicycling stationary, 150 watts	7.74
Walking 4.8 km/h - 6% slope	7.39
Bicycling stationary, 125 watts	6.82
Bicycling stationary, 100 watts	5.83
Walking upstairs	5.73
Walking 4.3 km/h - 3% slope	5.46
Bicycling stationary, 75 watts	4.73
Walking 3.3 km/h - 3% slope	4.42
Non-competitive soccer, volley-ball and tennis	4.38
Aerobic stepping, low impact	4.14
Cleaning a room (changing linen)	4.01
Bicycling stationary, 50 watts	3.75
Walking 3.3 km/h - 0% slope	3.75
Table tennis	3.5
Swimming, sport participation in the class	3.06
Bicycling stationary, 25 watts	2.97
Walking 2.0 km/h - 0% slope	2.92
Cleaning a room (dusting, sweeping)	2.91
Gymnastics, general	2.88
Stretching	2.25
Table soccer	2.17
Recreation at school (standing and talking)	2.16
Bathing, dressing, undressing	2.05
Performing video games (sitting)	1.85
Eat sitting	1.75
Transport by train, car or bus	1.72
School-work	1.65
Sitting watching television	1.57
Reading a book, listening to music	1.33
Writing	1.19
Sitting, card playing, playing board games	1.13
Resting	1.09
Basal metabolic rate	1
Sleeping	0.93



(Lazzer et al. 2003, 2005, 2009)

ESTIMATION OF DAILY ENERGY EXPENDITURE

Daily energy expenditure (EE) (kcal) can be calculated by using the following equation:

$$\text{Daily EE} = \sum_{1}^{N} (\text{BMR} \cdot \text{PAR} \cdot \text{duration}) \qquad \text{[Equation 1]}$$

where N corresponds to the number of activities, BMR (Equation 2 or 3) is expressed in kcal·min^{-1}, PAR is a dimensionless measure, and duration of activity in min.

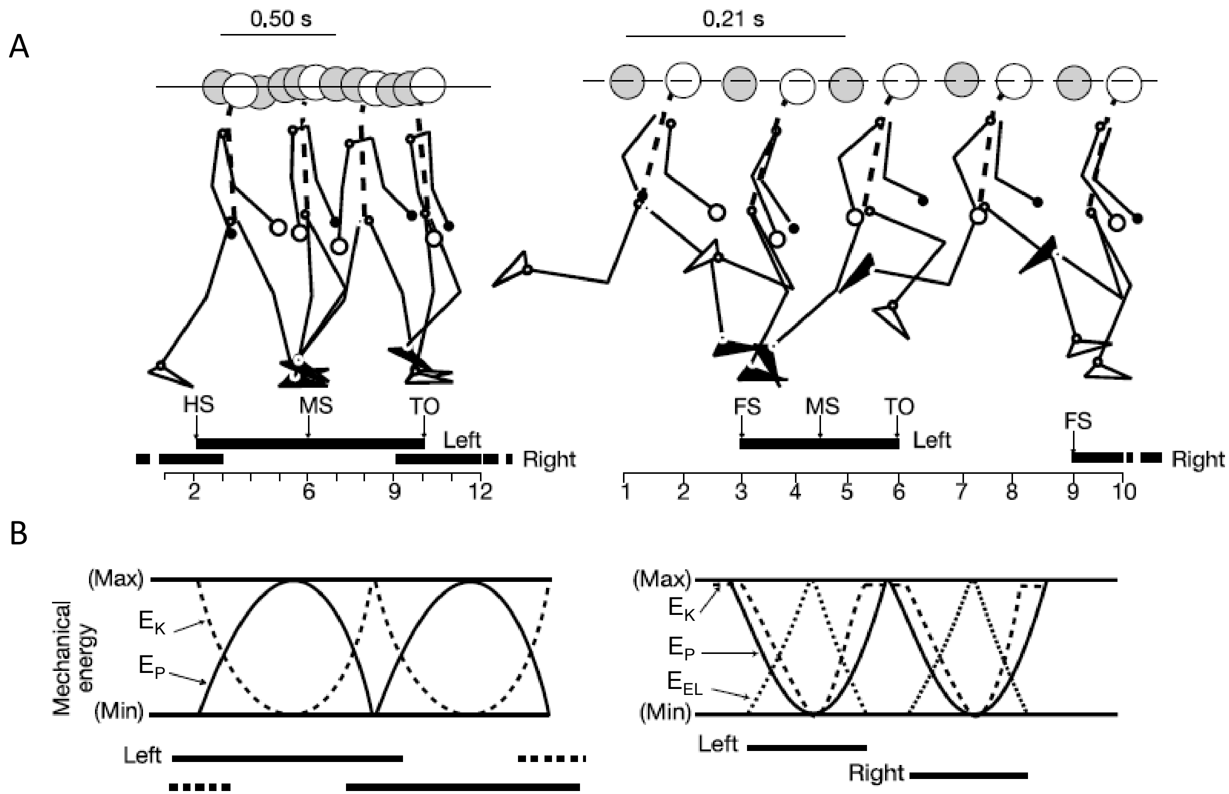
BMR = (Gender x 213) – (Age x 28) + (Body Weight x 13) + (Stature x 434) + 355
R^2 = 0.66 and SE = 246 kcal [Equation 2]

BMR = (Gender x 217) – (Age x 26) + (FFM x 16) + (FM x 13) + 868
R^2 = 0.66 and SE = 247 kcal [Equation 3]

where Gender = 1 for males and 0 for females, BMR is expressed in kcal, Age in years, Body Weight in kg, Stature in m, FFM and FM in kg.

Example:
On this basis, a boy (14 y, body weight 93 kg, height 1.62 m) has a predicted basal metabolic rate of 1.46 (kcal·min^{-1}, Eq. 2)). If he sleeps for 540 min (PAR: 0.93), dresses for 60 min (PAR: 2.05), eats for 120 min (PAR: 1.75), stays at school for 420 min (PAR: 1.65), watches television for 180 min (PAR: 1.57), walks for 60 min (PAR: 5.46) and cycles for 60 min (PAR: 3.75), his daily energy expenditure can be estimated to 3441 kcal·day^{-1}.

COMPARISONS OF WALKING AND RUNNING MECHANICS



A. Kinematics of walking (left) and running (right). During walking, the centre of mass are lowest near toe-off (TO) and highest at mid-stance (MS) where the leg is relatively straight. During running, the head and centre of mass are highest during the aerial phase and lowest at MS, when the hip, knee and ankle are flexed; the trunk is also more inclined and the elbow more flexed.

B. Biomechanical contrasts between human gaits. During walking, an inverted pendulum mechanism exchanges forward kinetic energy (E_K) for gravitational potential energy (E_P) between heelstrike (HS) and MS; the exchange is reversed between MS and TO. During running, a mass-spring mechanism causes E_P and E_K to be in phase, with both energies declining rapidly to minima between footstrike (FS) and MS. Leg tendons and ligaments partially convert decreases in E_P and E_K to elastic energy (E_{EL}) during the first half of the stance, which is subsequently released through recoil between MS and TO.

(modified from Bramble and Lieberman 2004)

EFFECTS OF OBESITY ON MECHANICAL COST OF WALKING AND RUNNING

- External work of walking is higher in obese compared to lean adolescents leading to lower efficiency (approx 23 %).
- The greater energy cost of walking may be explained by increased step-to-step transition costs associated with wide gait.

- Excess adiposity can increase the energy cost of movement and can contribute to biomechanical inefficiency and postural instability.
- Those who are obese spend longer in the dual stance phase of gait compared to those who are lean.
- Obesity is also associated with greater postural sway and slower preferred gait cadence when compared to normal weight participants.

- Elastic tissues of obese subjects seem to adapt (e.g. by thickening) to the increased mass of the body, thus maintaining their ability to store elastic energy, at least at 8 $km.h^{-1}$ speed, at the same level as in the lean subjects.

- After weight loss, the net metabolic cost of walking at 4.5 $km.h^{-1}$, decreases in association with an increase in stride length (3.5 %); a decrease in the variation of medio-lateral kinetic and potential energy.
- Decreases in the net energy cost of walking are correlated with decreases in body weight, FM and percent of gynoid mass.

EFFECTS OF REDUCTION OF OBESITY ON MECHANICAL COST OF WALKING

After weight loss, the net metabolic cost of walking at 4.5 $km.h^{-1}$, decreased in association with the biomechanical parameters of walking: stride length increased by 3.5 %; lateral leg swing and the variation of the medio-lateral kinetic energy decreased by 18 % and variation in potential energy by 6 %. Consequently the net energy cost of walking, adjusted for body mass, decreased by 9 %, whereas the external work (Wext) did not vary significantly.

The decrease in the net energy cost of walking were correlated with the decreases in body weight, FM and percent of gynoid mass, but not with the lateral leg swing after weight loss. The main determinant was the decrease in body weight, which in turn reduced the leg muscle work required to raise and accelerate the center of mass as well as to support body weight and maintain body equilibrium during walking.

AMOUNT OF PHYSICAL ACTIVITY NEEDED TO PREVENT OBESITY

Children and teens be physically active for at least 60 minutes on most, if not all, days, including:

Aerobic: Most of the 60 or more minutes a day should be either moderate- or vigorous-intensity aerobic physical activity (running, hopping, skipping, jumping rope, swimming, dancing, and bicycling are all examples of aerobic activities), and should include vigorous-intensity physical activity at least 3 days a week.

Muscle-strengthening: As part of their 60 or more minutes of daily physical activity, children and adolescents should include muscle-strengthening physical activity on at least 3 days of the week. Muscle-strengthening activities can be unstructured and part of play, such as playing on playground equipment, climbing trees, and playing tug-of-war. Or these activities can be structured, such as lifting weights or working with resistance bands.

Bone-strengthening: As part of their 60 or more minutes of daily physical activity, children and adolescents should include bone-strengthening physical activity on at least 3 days of the week. This force is commonly produced by impact with the ground. Running, jumping rope, basketball, tennis, and hopscotch are all examples of bone strengthening activities.

AMOUNT OF PHYSICAL ACTIVITY NEEDED TO LOSE WEIGHT

The amount of physical activity needed to weight loss is related to negative balance between daily energy intake and daily energy expenditure. Energy intake can be calculated as 1.2 or 1.3 times basal metabolic rate (Lazzer et al. 2005). While, energy expenditure can be calculated as suggested previously. As well as physical activity must to consider the following suggestions:

Endurance exercise

Frequency: For moderate-intensity activities, accumulate at least up to 60 min·d^{-1}

Intensity: On a scale of 0 to 10 for level of physical exertion, 5 to 6 for moderate-intensity and 7 to 8 for vigorous intensity. Fat oxidation is at a maximum during moderately intense physical activity (50% V'O_2peak, 65% maximum heart rate, ~130 bpm) walking speed 5 km·h^{-1}. However, short bouts (30-60 s) at 100% V'O_2peak or 100% heart rate favours improvements also on aerobic power.

Duration: For moderate-intensity activities, accumulate at least 60 min·d^{-1} in bouts of at least 15 min each of continuous activity for vigorous-intensity activities.

Type: Any modality that does not impose excessive orthopaedic stress; walking or running is the most common type of activity. Stationary cycle exercise may be advantageous for those

AMOUNT OF PHYSICAL ACTIVITY NEEDED TO LOSE WEIGHT

Muscle-strengthening

Frequency: At least 2 $d \cdot w^{-1}$.

Intensity: Between moderate- (5–6) and vigorous- (7–8) intensity on a scale of 0 to 10.

Type: Progressive weight training program or weight bearing calisthenics (8–10 exercises involving the major muscle groups of 8–12 repetitions each), stair climbing, and other strengthening activities that use the major muscle groups.

Flexibility

Frequency: At least 4 $d \cdot w^{-1}$.

Intensity: Moderate (5–6) intensity on a scale of 0 to 10.

Type: Any activities that maintain or increase flexibility using sustained stretches for each major muscle group and static rather than ballistic movements.

The progression of activities should be individual and tailored to tolerance and preference; a conservative approach may be necessary for the most deconditioned and physically limited obese children and adolescents. Obese children and adolescents should exceed the recommended minimum amounts of physical activity if they desire to improve their fitness.

AMOUNT OF PHYSICAL ACTIVITY NEEDED TO PREVENT WEIGHT REGAIN

While consensus is lacking on the amount of physical activity needed to prevent weight regain, there is an indication that children and adolescents would need 60 or more minutes of daily of physical activity needed to prevent weight regain, there intense activity, to avoid regaining weight. This physical activity also can be done in smaller chunks of time over the day. Engage in more than 1 h of daily physical activity promoting walking or cycling to school, suggesting activities that involve parents or friends and promote even small amounts of moderate to vigorous activities.

Particularly promote enjoyable and fun activities.

As well, discourage sedentary behaviour remain a simple ways to increase physical activity.