Energy Expenditure in the Performing Arts

Two papers in this issue of Medical Problems of Performing Artists examine energy expenditure while playing a wind instrument and dancing. Measurement of the amount of energy required to play an instrument, dance, or sing has been done in the past, but these two papers advance our understanding of how performing artists carry out their professional activities. Since most of us don’t think about our daily lives in terms of METs or kilojoules, I will first review some basic information about human energy intake and expenditure before examining how energy expenditure studies can expand our knowledge base.

The energy that adults ingest every day as we eat food is used in one of three ways: some is turned into heat by the processes that go on in every cell regardless of activity level (commonly called the basal metabolic rate, BMR), most of the rest is used to move us around in various forms of physical activity, and if any is left over, it’s stored as fat. (Conversely, if energy expenditure exceeds energy intake, some combination of fat and lean body mass is converted into energy to make up the difference.) The energy content of food can be measured in calories; 1 Calorie (1,000 calories) is defined as the amount of energy needed to raise the temperature of 1 kg of water by 1°C Celsius; it is equivalent to 4.184 kJ. BMR can be estimated by an equation: for men,

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BMR = 66 + (13.7 \times \text{weight in lbs}) + (5.0 \times \text{height in inches}) - (6.8 \times \text{age in yrs})
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for women,

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BMR = 655 + (4.35 \times \text{weight in lbs}) + (4.7 \times \text{height in inches}) - (4.7 \times \text{age in yrs})
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Depending on all of the relevant factors, BMR is typically between 1,000 and 2,000 Calories (Cal) per day for most people.

The amount of energy used in various activities depends on the intensity and the amount of time spent doing any particular activity. Most routine daily activities, commonly referred to as activities of daily living (ADLs), boost energy expenditure by about 50% to 100%. Walking around, preparing and eating food, reading while sitting and working at a computer would be typical ADLs that fall into this range. Note that a 180-lb man will burn up more calories for a given activity level than will a 140-lb woman, since the man has a higher BMR. Since we spend a significant part of each day asleep, during which we are basically burning calories at BMR, a sedentary lifestyle results in elevating our total energy expenditure (TEE) to only about 1.5 times BMR. The ratio of TEE to BMR averaged over 24 hrs is the physical activity level (PAL), which should be at least 1.75 for optimal health.

Various types of exercise, whether done as part of one’s job or as “recreational” activities, require modest to prodigious amounts of energy expenditure, again depending on intensity and duration. When comparing different kinds of exercise, the term metabolic equivalent (MET) is often used to express the relative increase in energy expenditure compared to BMR. For example, running at 6.0 mph (10 minutes per mile) equals 10 METs. Thus, someone whose BMR is 1,200 Cal/day who runs 6 mph for 1 hr would consume about 500 Cal (1200 Cal/24 hrs) × 10 = 500 Cal/hr. Assuming this person otherwise is fairly sedentary, with 8 hrs of sleep and 15 hrs of sedentary activity, the PAL would be 1.75, within the recommended range. Here are some other examples of the energy expenditure associated with exercise:

- Bicycling at 10 to 11.9 mph 6 MET
- Bicycling at 14 to 15.9 mph 10 MET
- Swimming at 50 yds/min 8 MET
- Swimming at 75 yds/min 11 MET
- Running at 10 mph (6 min/mile) 16 MET

Note that going faster requires a substantial increase in energy expenditure, oftentimes out of proportion to the gain in speed. PALs much above 2.4 are difficult to maintain over time, although cyclists in a race like the Tour de France maintain PALs of about 4.5 for 3 weeks. A 180-lb man with a BMR of 1,800 Cal/day would be burning over 4,300 Cal/day at a PAL of 2.4, which would require about 2.5 hrs of bicycling at the higher speed listed above. It’s unusual for a 180-lb cyclist to be chosen to ride in the Tour, but if one did, he would be burning over 8,000 Cal/day.

The energy required to perform some artistic activities are also included in the Ainsworth reference. I’ve rearranged the list into categories that make more sense in our field.

Dance
- Disco, folk, square, line, traditional Irish, polka, contra 4.5 MET
- Ballet, modern, jazz, ballroom 4.8 MET
- Traditional American Indian, fast ballroom 5.5 MET

Instrumental Music
- Cello, horn, woodwinds, classical guitar (sitting) 2.0 MET
- Piano, organ, violin, trumpet, conducting 2.5 MET
- Rock guitar (standing) 3.0 MET
- Trombone 3.5 MET
- Drums 4.0 MET

Vocal Music
- Singing (sitting) 1.5 MET
- Singing (standing) 2.0 MET

It’s not clear from the Ainsworth article exactly how many data points...
were collected for each of these activities and exactly what was being performed. This is one of the ways that the papers by Baadjou and Massidda advance our knowledge: they have provided fairly specific information about the music and dances being performed. Thus, we find out that with more detailed measurement, the figures for some of the instrumental performances turn out to be somewhat different. We can't say that the figures provided by Ainsworth et al. are wrong, but we can say that the data provided by Baadjou are more reproducible.

Baadjou et al. measured energy expenditure as a way to determine which of two playing postures was more efficient (i.e., used less energy to produce the same result). Contrary to the authors’ hypothesis, the theoretically more efficient posture—and the one preferred by most of the musicians—actually used more energy. The exact reasons for this unexpected finding are somewhat unclear, but Baadjou suggests that it may be due in part to the fact that the “better” posture (that used more energy) required the use of more large muscles. Another possibility is that the musicians were still learning the new posture, and therefore they weren’t using their muscles in the most efficient manner yet. It’s also possible, if not likely, that the rather heterogeneous group of subjects in this study made it more difficult to find the expected benefit of “better” posture.

Using a mixture of professional and amateur male and female musicians who played a variety of instruments is a good strategy if one is studying a robust intervention that has a high probability of causing a significant change. But when the difference between the control and intervention groups is smaller, the chances of finding a significant difference in the expected direction may be greater with a more homogeneous group. It might also be worthwhile to take a step back and measure the efficiency of more and less experienced instrumentalists, just to confirm the widely held assumption that better musicians use energy more efficiently. It’s possible that just the opposite is true—i.e., that we make better music when we put more energy into it.

The measurement of energy expenditure during Latin American dance is the primary objective of the paper by Massidda et al. As suggested by the authors, this is useful information for at least two reasons. First, the finding that this style of dance requires moderate (3–6 MET) to vigorous (6–9 MET) levels of exertion is at variance with the previously published data. We now have more accurate data to help guide those who do this type of dancing, especially at a competitive level. Using examples from the list above, one could advise dancers preparing for this type of competition that they could improve their fitness by running at about 5 mph, biking at 10 to 14 mph, or swimming at 50 yds/minute. Conversely, it would be reasonable to tell people who are interested in dancing as a form of exercise that even a moderate intensity of Latin American dancing would provide a “good workout.” And some (many!) people will find this more enjoyable than the more traditional exercise options.

While the efficiency of energy expenditure during Latin American dance was not studied in the Massidda paper, it would be interesting to do an analysis of the amount of energy expended by more- and less-experienced dancers. This has been studied in various sports, and while there is some association between efficiency and performance, it’s not easy to quantify, and trying to change an athlete’s form to improve efficiency is very difficult. Nonetheless, this may be a fruitful area for further research in performing arts medicine. Even if it isn’t, it would give the general public a lot of information about enjoyable ways to get their 150 minutes of exercise per week.

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