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Measurement of Resting Energy Expenditure in Healthy Children

Mellecker RR and McManus AM

Background: The role that the components of energy expenditure play in the etiology of childhood obesity has highlighted the need for greater accuracy and standardized protocols for the measurement of resting energy expenditure (REE). However, protocols used to assess REE in children are varied, and consensus on a suitable method for measuring REE in children has not been reached. This study was undertaken to determine the effect of measurement time and measurement device (mask or mouthpiece) on REE in healthy children. *Design:* Following a 12-hour fast and abstinence from exercise, 23 children (age, 7–12 years) completed two 35-minute protocols: one with a face mask and the other with a mouthpiece/noseclip. Energy expenditure was measured continuously via indirect calorimetry, while device acceptability was assessed using a 6-point comfort rating scale. Results: Repeated measures ANOVA indicated that there was no significant difference in REE when measured after 10, 15, 20, or 25 minutes of rest compared to 30 minutes for either the mask or mouthpiece/noseclip (REE range, 1371–1460 kcal/d). Examination of the percentage coefficient of variation (CV) in energy expenditure for each time period by device showed that the least variation existed after 20 minutes of measurement using the mask (CV 6%). Paired *t* test analysis indicated significantly less discomfort when wearing the mask compared to the mouthpiece/noseclip. *Conclusion:* It would appear that a 20-minute protocol using a mask may increase compliance and prove to be a more practical protocol for measuring REE in children. (*JPEN J Parenter Enteral Nutr.* 2009;33:640-645)

Editorial Comments

The obesity epidemic in children continues to rise. Eating more calories than estimated requirements and low physical activity are 2 of the many causes of childhood obesity. Lately, researchers have been taking a closer look at the available energy expenditure equations used to establish estimated energy requirements in children. However, studies that were conducted to formulate the equations were performed in the 1930s and 1950s. Children of the same age now are heavier (about 4 kg) and taller (3.6 cm) than the subjects in the studies that were done 60–80 years ago.[1] Current standardized protocols are lacking because of the difficulty in obtaining accurate readings from indirect calorimetry performed on healthy children. Children easily become bored and restless, causing the results of testing to be inaccurate.

Indirect calorimetry measures the volume of oxygen consumption (VO_2) and the volume of carbon dioxide production (VCO_2) of an individual to calculate resting energy expenditure (REE). These values are used in the Weir equation to calculate REE. REE accounts for 75%–90% of the total energy expenditure. The remainder is accounted for by environment, thermal effect of food, and physical activity.[2] Indirect calorimetry is conducted through the use of a metabolic cart. To obtain a valid test with a metabolic cart, a subject must lie still for a period of at least 30 minutes. A "steady state" period of gas exchange, in which VO_2 and VCO_2 vary by less than 10% in a 5-minute interval, is needed to consider the testing valid. This "steady state" best represents the 24-hour energy expenditure.[3] To measure expired gases, subjects must wear either a mask over the mouth and nose, wear a mouthpiece/noseclip, or breathe under a hooded-type canopy. Many researchers and subjects find the devices to be very uncomfortable, making a 30-minute testing period practically unbearable. Finding a comfortable measuring device and decreasing the length of time may help with compliance of testing in young children and possibly produce more accurate results.

This study aimed to investigate the effects of both measurement time and device (mask or mouthpiece/noseclip) on REE in healthy children. Twenty-six children (13 boys, 10 girls) between the ages of 7 and 12 years volunteered to participate in the study. They were healthy with no history of illness and were not taking any medication. The children were multiethnic, including Caucasian, Eurasian, and Asian. Measurement took place in a quiet, dimly lit, thermoregulated room in a laboratory. The children had to abstain from exercise for 24 hours and have fasted for 12 hours. Heights and weights were obtained. Six children were overweight, and none were obese. They had to complete two 35-minute REE protocols lying in a supine position, relaxed and awake. Half the group was

assigned testing with the mouthpiece/noseclip device first and then the mask, and the other half was assigned the mask first and then the mouthpiece/noseclip device. The researchers had the children choose their own video for entertainment throughout the testing period. The children were asked to rate the comfort of each device based on a 6-point facial scale. The first 3 faces were smiling, indicating comfort, and the last 3 faces were frowning, indicating discomfort.

Respiratory gas samples and volume were analyzed using an Oxycon Pro Metabolic Cart (VIASYS Healthcare, Germany). Oxygen uptake and VCO_2 values were integrated to an 8-breath average of 5-minute blocked sections. The final 3 data points in the last minute of each blocked time were averaged and used for computing REE using the Weir equation. Group analyses of variance with repeated measures (RM ANOVA) were used to assess the effects of measurement time and device on REE. The coefficient of variation (CV) was calculated for REE, VO_2, and VCO_2 for each time block, and measurement time by device. RM ANOVA was used to determine differences in the CV values. Main effects were deconstructed using analysis of simple effects and Tukey HSD tests. Paired *t* tests were used to compare REE values between the mask and mouthpiece and comfort ratings.

Three data sets had to be excluded from analysis because of unstable values through testing either from difficulty breathing with the mouthpiece/noseclip device or an improperly fitted mask. Within the group ANOVAs on measurement time and REE, results showed that there was no significant main effect for measurement time for either the mask or mouthpiece/noseclip. A significant main effect for measurement device was apparent, with the mask showing a lower percent CV than the mouthpiece/noseclip. Percent CV was lowest at the 20-minute measurement point with the mask. A paired *t* test was then used to compare REE values at 20 minutes between the devices. They were not significantly different. A paired *t* test was also used to compare the perceived comfort of the measurement devices, and the mask was found to be more comfortable than the mouthpiece/noseclip.

Based on the above findings, the researchers felt the study confirmed that a 20-minute protocol is an optimal length of time for measuring REE in healthy children. They found the children were most restless in the first 5 minutes of testing. Sixty-five percent of the children rated the mask to be comfortable, whereas only 31% rated the mouthpiece/noseclip as comfortable. Therefore, a mask should be used as the measuring device when obtaining REE in healthy children.

To improve compliance with REE testing among children, this study took into consideration comfort level of the subjects. If the children were comfortable during testing, then results would be more accurate. A kid-friendly rating scale was used. The children were also able to choose a video to watch during testing. By having the children choose their entertainment, they may fidget less and lie still for a longer period of time. As long as accuracy is not compromised, a shorter test period may be beneficial. For most children, a 20-minute testing period may be better tolerated than a 30-minute testing period. The researchers found that the 20-minute interval was just as accurate as a 30-minute testing interval. Some studies found a 5- to 10-minute adjustment period is needed before testing begins.[4-6]

The study did have a small number of volunteers, and the researchers recognized this limitation. The subjects were also not culturally diverse; however, ethnicity is not a factor that affects REE results in children.[5] None of the participants in the study were younger than 7 years or obese. Therefore, a 20-minute protocol with use of a mask may not be as effective when indirect calorimetry is performed on infants, toddlers, or obese children. Compliance could also be improved if the testing were done on sleeping children. An adjustment period would not be needed, and testing could be done in 15 minutes.[7] Not having the children fast for 12 hours and performing the REE tests 2-3 hours postprandial is also another way of improving compliance.[1]

Most studies done on a large number of children tend to use the hooded-canopy device, which maybe more comfortable than using a mask or a mouthpiece/noseclip.[1,4-6] This study could be applied when obtaining REE on overweight healthy children between 7 and 12 years of age. A study is needed that compares the use of the hooded canopy to the mouthpiece/noseclip or mask with a large number of multiethnic children aged 2 to 12 years.

Elizabeth L. Bogucki, MS, RD, CSP, LDN
Children's Hospital of Philadelphia
Philadelphia, PA

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