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# Variability in results from predicted resting energy needs as compared to measured resting energy expenditure in Korean children

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**Abstract**

Energy needs are influenced by many factors, including ethnicity. Multiple studies have shown that the accuracy of an energy prediction equation varies with the ethnic background of the study population. Therefore, it is crucial to identify the most accurate energy prediction equation to use for a given population. This study compared measured resting energy expenditure to results from commonly-used energy prediction equations to identify the most accurate equation to use for Korean children. Based on previous literature showing wide variation in accuracy of energy prediction equations in different ethnic groups, we hypothesized that results from measured- vs. predicted energy needs would be significantly different in this population. Subjects were 92 South Korean children (38 boys, 54 girls) age 7.7 ± 2.7 years (mean ± SD). Measurements included: resting metabolic rate (TrueOne 2400 metabolic cart), weight/height (digital scale/stadiometer); body fat (BIA, Inbody720), blood pressure (sphingomanometer), triceps skinfold thickness (MD-500 skinfold calipers), muscle mass (Heymsfield's formula) and body surface area (Dubois formula) calculations. Resting energy needs were predicted using the Harris-Benedict, WHO/NAO/FAO, Altman and Dittmer, Maffeis, and Schofield-HW equations, and the Dietary Reference Intake recommendations. Measured and predicted energy needs were significantly correlated ($P < .001$ for all; range $R^2 = 0.54\text{-}0.56$), yet significantly different for all equations studied ($P < .05$) except the Maffeis and Schofield-HW equations. Differences (means ± SD) between measured vs. predicted energy needs ranged from 9.5 ± 123.2 (Schofield-HW) to 199.6 ± 132.7 (WHO/NAO/FAO) kcal/day, where a value closer to zero indicates increased accuracy of the prediction equation to correspond to measured energy needs. Although results from equations studied were significantly correlated with measured resting energy needs, notable discrepancies existed which, over time, could produce undesirable weight changes in Korean children.


*Keywords:* Energy prediction equation; Korean; Children; Resting energy expenditure; Overnutrition
*Abbreviations:* DRI, Dietary Reference Intake; MREE, measured resting energy expenditure; PREE, predicted resting energy expenditure; REE, resting energy expenditure.

## 1. Introduction

The increasing rates of childhood obesity are a growing concern to developed nations. According to Wang et al, increases in prevalence of childhood overweight and obesity affect the majority of developed nations and herald a mounting global epidemic in school-age children [1]. The highest prevalence of overweight in children (20-35%) can be found in North America and Europe, and these numbers are expected to continue climbing [2]. Even countries that have traditionally reported lower prevalences of childhood overweight are seeing increases in overweight. For example, over a 6 year period, China has experienced a 4.7% rise in

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the prevalence of overweight in urban children [1]. Additionally, in South Korea the prevalence of obesity (described as >120% of ideal body weight) in both preschool children and elementary school children increased by 150% between 1998 and 2005 [3]. Therefore, accurate prediction of energy needs in children is vital to ensure proper nutrition needs for optimal growth are met, while still avoiding overnutrition and, subsequently, obesity development.

Unfortunately, measurement of energy expenditure in a non-research setting is challenging. Methods such as doubly-labeled water are expensive and require subjects to return for follow-up [4]. Twenty-four hour chamber calorimetry is time-consuming, expensive, and requires the subject to travel to a laboratory. Hood calorimetry is a faster and less expensive means of obtaining measured resting energy expenditure (MREE), but it requires trained personnel, expensive and cumbersome equipment, and obtaining MREE requires the subject to stay still and at rest for an extended period of time [5,6]. This latter component can be especially problematic when accurately assessing the energy needs of children. The development of the portable calorimeter (MedGem) circumvents some of these challenges. However, even this method is costly and has been shown to have widely variable results among certain populations, when compared to hood calorimetry [7-9]. Alternatively, an energy prediction equation is a simple, inexpensive method for rapidly determining energy needs in children that requires minimal participant burden.

Energy needs can be influenced by multiple variables, including ethnicity and body composition [10-12]. When examined by body composition compartments, fat-free mass is the primary determinant of energy expenditure [10]. Therefore, the ethnic differences in energy expenditure may, in part, be explained by associated differences in body composition and fat-free mass [13]. However, some studies have reported ethnic differences in energy needs even after adjusting for lean mass [14,15]. This suggests that there are other ethnic distinctions, besides variations in lean tissue mass, contributing to the ethnic differences in energy needs. Therefore, accuracy of any given energy prediction equation may vary according to the ethnicity of the population.

Several equations are commonly used to predict energy needs in children. These include the Harris-Benedict equations, the WHO/NAO/FAO formula, the Altman and Dittmer equations, Maffeis equations, Schofield-HW equations, and the Dietary Reference Intake (DRI) recommendations [16-21]. These have been validated for pediatric use, however the age ranges of the validation populations have varied. For example, the Maffeis equations were originally validated in pre-adolescent children, while the WHO/NAO/FAO formula was validated in children ranging in ages from 3 to 18 years old [19,17]. Additionally, these equations are not always validated in multiple ethnic populations. For example, the Harris-Benedict equation was originally validated in Caucasian adults [16]. Since then it has been shown to be less accurate in predicting energy needs as compared to indirect calorimetry in both African-American and Asian women [12,22]. And finally, some of these equations, specifically the Harris-Benedict and the Altman and Dittmer equations, were developed prior to the increasing prevalence of adiposity seen in children in the last few decades. These equations therefore may not take into account the reduced energy needs associated with the decreased metabolic activity of adipose tissue [23]. Given these factors, it is important to determine the energy prediction equation that is currently most accurate for use in any given age group and ethnic population.

We hypothesized that anthropometric measures representing fat-free mass would be most strongly correlated with resting energy expenditure and that results from the majority of the energy prediction equations studied would be significantly different from measured energy needs. The objectives of this study are to 1) assess resting metabolism in healthy, Korean children; 2) to determine the body composition measures that are most strongly correlated with resting energy expenditure in this population; 3) identify the prediction equation that is most strongly correlated with measured energy needs for use in this population; and 4) to develop a preliminary prediction equation that most accurately predicts energy needs in this population of healthy Korean children.

## 2. Methods and materials

### 2.1. Subjects

Subjects were preschool children attending kindergarten in Gangneung city and 3rd and 5th-grade students attending school in Samchuck, in Gangwon-Do province, a rural area of South Korea. They were recruited through their respective schools, as previously described by Lee et al. [24]. Ninety-two (38 boys, 54 girls) healthy children, aged 4-11 years, participated in this study. None of the girls had reached menarche. Written, informed consent was obtained from both the children and their legal guardians. This study was approved by the Kangnung National University and by the School Board officials prior to implementation.

### 2.2. Anthropometrics

Anthropometric measurements were carried out by the same investigator and included weight, height, mid-arm circumference, triceps skinfold thickness, and body composition assessment (methods as previously described) [24]. Weight and height were measured using a digital scale and stadiometer (Inbody720, Biospace Corp., Korea). Weight was obtained with the subject in light clothing and measured to the nearest 0.1 kg. Height was obtained without shoes and measured to the nearest 0.1 cm. Triceps skinfold thickness measurements were performed three times on the left arm by using a skinfold caliper (MD-500, YAMASA, Japan). Body fat was measured using bioelectrical impedance analysis (Inbody720, Biospace Corp. Korea). Muscle mass was