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The Use of Arm Span as a Substitute for Height in Calculating Body Mass Index (BMI) for Spine Deformity Patients*

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Abstract

Objective: To compare arm span and height in body mass index (BMI) calculation in patients with spinal curvature and investigate their impact on interpretation of BMI.
Study Design: Prospective case-control cohorts.
Summary of Background Data: The BMI value is based on weight to height ratio. Spine deformity patients experience height loss and its use in calculating BMI is likely to produce errors. A surrogate for height should therefore be sought in BMI determination.
Methods: Ninety-three spine deformity patients were matched with 64 normal children. Anthropometric values (height, arm span, and weight) and spinal curve were obtained. BMIs using arm span and height were calculated, and statistical analysis performed to assess the relationship between BMI/height and BMI/arm span in both groups as well as the relationship between these values and Arm Span to Height difference (Delta AH).
Results: There were 46 males and 47 females, the average age was 15.5 years in Group 1 versus 33 males and 31 females, average age 14.8 years in Group 2. Major scoliosis in Group 1 averaged 125.7° (21° to 252°). The extreme curves show vertebral transposition, with overlapping segments making it more than 180°. A logistic regression showed that there was linearity in BMI scores (R^2 = 0.97) for both arm span and height (R^2 = 0.94) in group 2 patients. For group 1 patients there was a significant difference in the BMI values when comparing BMI/arm span versus BMI/height ($p < .0001$). Mean BMI values using height was overstated by 2.8 (18.6%). The threshold at which BMI score must be calculated using arm span as opposed to the height (Delta AH) was determined to be 3 cm.
Conclusions: Spine deformity patients experience height loss, which can impact their true BMI values thereby giving an erroneous impression of their nutritional status. The arm span should be used in patients with Delta AH >3 cm to properly assess nutritional status.

Keywords: BMI; Arm span; Height; Spine deformity; Nutrition assessment

Introduction

Body composition mirrors the nutritional status in growing children and young adults. The values for height and weight are required to assess growth and nutritional status [1,2].

There are direct methods of assessing body composition such as dual x-ray absorptiometry, computed tomography, and magnetic resonance imaging [3]. However, they are expensive and not easily accessible in most developing and underdeveloped countries [2].

Body mass index (BMI) is an anthropometric indicator based on the weight to height ratio [4]. It is a reliable indicator of body fatness and the preferred indicator of body thinness to classify malnutrition [4-6]. Studies have shown that BMI does not measure body fat directly however it correlates to direct measures of body fat [7]. BMI threshold that will classify an individual below 20 years to be undernourished differs with age and gender. The WHO growth standard classification of underweight in boys is between ≤13.75 to 17.50 and girls ≤12.75 to 16.50 [8].

Height is known to be a significant parameter in the assessment of nutritional status and maturity [2,9]. However, in children and young adults with spinal deformities such as

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kyphosis and scoliosis, height does not reflect the true body size and the use of height measurement in predictive equations such as BMI is likely to produce errors [2].

Presently, there are no guidelines on the degree of spinal curvature or height loss beyond which the measurement of height would be invalid in BMI calculation, and the threshold for height loss when BMI calculation can lead to misclassification of malnutrition in growing children and young adults. Alternative anthropometric indicators that are used when body height cannot be determined are therefore very important in predicting age-related nutritional deficiency in individuals whose skeletal condition makes it impossible to measure their precise height.

Body height in such cases is then estimated from reliable anthropometric indicators such as hand and foot length, sitting and knee height, length of sternum, vertebral column length, and arm span [10,11].

Arm span is the physiological measurement with the closest correlation to standing height. It has been used in place of height either by direct substitution or by application of a fixed correction factor based on arm span–height ratio or by regression equation [12,13]. Direct substitution has been mostly favored with errors that are not clinically important.

Monyeki and Sekhotha [9] established correlation between arm span and height in Ellisras rural children aged 8–18 years. Their correlation was similar to that of Turkish children aged 7–14 years and Oromu, Ambara, Tigre, and Somali ethnic groups in Ethiopia [14].

Another study among south Indian women showed that arm span was the most reliable body parameter for predicting height of an individual [15]. However, the study suggested the need to develop separate models for each population on the account of ethnic and racial differences. Thus, arm span and body height have been found to vary in different ethnic and racial groups.

Using standing height to calculate BMI in patients with spinal deformity could be inappropriate because of the reported height loss. A simple and reliable measure of height in such patients is necessary. Several studies are available that use arm span to derive height in pulmonary function test (PFT) calculations. In assessing true nutritional status there have been many experiences of physical findings not tallying with anthropometric measurement. This informed the need to find a more accurate measure for the BMI as it is one of the major assessment tools in determining nutritional status. However, very limited data are available when calculating the true BMI to determine the nutritional status of individuals with spine deformity.

The target population in our study was the spine deformity patients who were evaluated at the FOCOS Hospital in 2014 and first quarter of 2015. These patients hailed from different nationalities, including Ethiopia, Sierra Leone, Ivory Coast, Nigeria, and Ghana. The majority of these patients came to the hospital with signs of severe malnutrition. For an overall successful surgery, a good nutritional status is required. An assessment was done on each patient at initial presentation to ascertain his or her caloric, protein, and other nutrient needs, and a nutritional intervention plan was developed. Surgery was scheduled after they have met their specific nutritional targets. This study compared the use of arm span and height in BMI calculation in patients with severe spinal deformities and investigated the impact on interpretation of BMI.

Materials and Methods

Study population

Pediatric patients scheduled to undergo spine deformity surgery at the FOCOS orthopedic hospital in Accra Ghana were enrolled in the study. The nutrition and dietetic department of the hospital assessed the patients and provided nutrition intervention methods. Patients with pathologies such as poliomyelitis or paralysis were excluded.

A comparison group of healthy children and teenagers without spine deformity were enrolled from a local junior and senior high school in Accra Ghana. The groups were matched by age and gender. Students who had any lower limb deformity or spine deformity were excluded. Informed consent was obtained from the students and parents. Age, gender, and country of origin were recorded. The study was approved by the Noguchi Memorial Institute for Medical Research institutional review board.

Anthropometry

Weight was measured on an electronic scale (Omron BF 511) to the nearest 0.1 kg. A nonstretchable tape measure was used to measure height to the nearest 0.1 cm.

Arm span was measured using standard methods with a steel tape. Participants were positioned back against the wall with arms spread against the wall at shoulder level and parallel to the floor with the palms facing forward. The measurement from the tip of the middle finger on one hand to the tip of the middle finger on other hand was recorded.

The height, arm span, and weight were measured for all participants in the control group, after their backs were checked for any spine deformity. A scoliometer was used on each subject's back, and where the angle of rotation recorded was 5° and above the participant was disqualified. The same measurements were taken among the study group cases and recorded.

BMI calculation was performed using both the height and arm span values with the standard formulae

H-BMI (H) and A-BMI

Statistical Analysis

Arm span BMI and height BMIs were calculated for both groups, and a linear regression was done between groups. Paired *t* test was conducted among the control