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PREDICTING BODY MASS INDEX USING ARM SPAN: AN ALTERNATIVE APPROACH FOR ANTHROPOMETRIC STUDIES

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ABSTRACT

Body Mass Index (BMI) is a widely used anthropometric indicator for assessing body composition and nutritional status. However, its reliance on stature can pose challenges, particularly in populations where accurate height measurement is difficult, such as the elderly and individuals with musculoskeletal impairments. Arm span has been proposed as a reliable alternative to stature for BMI calculation. This study aims to evaluate the effectiveness of arm span as a surrogate for stature in BMI estimation among young adult females in Kolkata, India. It also examines the correlation between stature-based BMI and arm-span-based BMI, assessing their predictive accuracy for body weight. A total of 100 female graduate students (aged 20–23 years) participated in this cross-sectional study. Height, arm span, and weight were measured following standard anthropometric protocols. Statistical analyses included correlation analysis, linear regression modelling, and receiver operating characteristics (ROC) analysis, with significance set at $p < 0.05$. The correlation between BMI calculated from arm span and BMI from stature was strong ($R^2 = 0.918$), indicating that both methods yield comparable results. Regression models demonstrated that arm span and arm-span-based BMI explained 38.5% of weight variation ($R^2 = 0.385$), while stature and stature-based BMI explained 40.2% ($R^2 = 0.402$). Additionally, arm span was a strong predictor of stature ($R^2 = 0.698$). ROC analysis confirmed the high predictive power of BMI classification using arm span (AUC = 0.92, accuracy = 91.67%). The findings support the use of arm span as a viable alternative to stature in BMI estimation. Although stature-based BMI demonstrated slightly higher predictive accuracy, arm-span-based BMI provided comparable results, making it a practical substitute in populations where height measurement is

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challenging. Further research incorporating additional anthropometric variables may enhance predictive accuracy.

Keywords: *body mass index; arm span; stature; anthropometry; regression analysis; nutritional assessment*

INTRODUCTION

Body mass index (BMI) is one of the most widely used anthropometric indicators for assessing body composition, nutritional status, and the risk of obesity-related diseases [1]. It is calculated as the ratio of weight (kg) to the square of height (m^2). Despite its simplicity and broad applicability, BMI has been criticized for its limitations, particularly in cases where accurate stature measurement is difficult or unreliable [2, 3].

Stature, or standing height, is a key component in BMI calculation. However, obtaining precise height measurements of certain populations, such as the elderly, individuals with musculoskeletal deformities, and those with mobility impairments, may be difficult [4]. Aging leads to height reduction due to spinal compression, intervertebral disc degeneration, and postural changes, making BMI calculations based on direct height measurements less reliable in older adults [5]. Similarly, patients with conditions such as osteoporosis, scoliosis, or limb amputations may have distorted stature values that do not accurately reflect their actual body size [6]. Indian studies [7] have reported a significant difference between arm-span- and stature-based BMI in elderly population, but arm-span-based BMI is an effective measure for nutritional aspects in persons who are unable to stand. In addition to that, a study from southern India [7] reported overestimation of stature-based BMI among the elderly population. A northern Indian study [8] confirmed that arm span can be used as a substitute for height for calculation of BMI.

To address these challenges, researchers have explored alternative anthropometric measurements that can serve as proxies for stature. Arm span, defined as the distance between the tips of the middle fingers when both arms are extended laterally, has been proposed as a reliable substitute for height [9]. Several studies have demonstrated a strong correlation between arm span and stature, with variations influenced by factors such as sex, ethnicity, and age [10, 11]. This alternative measurement is particularly valuable in geriatric populations and clinical settings where standing height measurement is impractical or unreliable [4].

Arm-span-based BMI is calculated using an estimated stature derived from arm span measurements. Various regression models have been developed to predict height from arm span, allowing for BMI computation even when direct height measurements are unavailable [12, 13]. The applicability of arm-span-based BMI extends to epidemiological research, clinical practice, and public health assessments, offering a feasible approach for body composition analysis in diverse populations. An earlier study [14] from northern West Bengal considered the BMI from arm span and stature corroborative [15], a study from southern West Bengal reported consistency in BMI evaluation between arm span and stature for both sexes.

Despite its potential, the use of arm span in BMI estimation is not without challenges. Differences in arm-span-to-height ratios among populations necessitate population-specific equations for accurate height prediction [16]. Additionally, factors such as limb deformities or disproportionate limb-to-trunk ratios may introduce variability in estimations. Therefore, a comprehensive understanding of the relationship between stature and arm span is crucial for improving the accuracy and validity of arm-span-based BMI calculations.

This article aims to critically evaluate the use of arm span as a surrogate for stature in BMI estimation, highlighting its advantages, limitations, and potential applications in anthropometric research and clinical practice among the younger females from Kolkata, India. The study will also compare traditional BMI with arm-span-based BMI to assess its effectiveness.

MATERIALS AND METHODS

A total of 100 adult female graduate students (ages 20–23 years; mean age 21.91 ± 0.92 years) from a college in Kolkata, India, were recruited based on their consent for this non-invasive anthropometric measurement. The inclusion criterion was being a female without chronic diseases or musculoskeletal conditions. Exclusion criteria included pregnancy, lactation, or orthopaedic disorders. Verbal informed consent was obtained from all participants

Height, arm span and weight were measured following the standard technique [17]. For height, the participant stood barefoot with heels, buttocks, and scapula against the wall, and eyes looking straight ahead in Frankfurt plane. Arm span was measured with arms extended horizontally at shoulder level, while the participant maintained a forward gaze, and the distance between the tips of the middle fingers of both hands was recorded. Each measurement was taken twice, and the average was calculated to the nearest 0.1 cm and recorded.

Data analysis was done on correlation, linear regression model, ROC analysis, and cut-off was set as $p = 0.05$.

RESULTS

Table 1 shows the overall characteristics of the participants of the present study. Understanding the relationship between arm span, BMI, and weight is crucial in anthropometric studies, biomechanics, sports science, and healthcare. This analysis evaluates these relationships using linear regression models, emphasizing the role of arm-span-based BMI and stature-based BMI in predicting weight and overall body composition.

Table 1. Anthropometric characteristics of the studied participants

Physical measurements	Mean ± SD	Range
Weight (kg)	59.46 ± 10.85	37.0 – 86.0
Age (years)	21.91 ± 0.92	20.0 – 24.0
Standing height (cm)	157.24 ± 6.54	144.2 – 174.8
Arm span (cm)	158.1 ± 7.02	144.2 – 178.0
BMI (stature)	24.11 ± 4.04	14.63 – 33.33
BMI (arm span)	23.87 ± 3.85	14.82 – 33.78

The correlation heatmap (ure 1) confirms a high correlation between BMI (stature) and BMI (arm Span), meaning that both methods of BMI calculation follow the same trend. The computed arm-span-based BMI regression results [weight = 0.50 × arm span + 1.15 × BMI based on arm span – 62.10] and stature-based BMI [weight = 0.52 × stature + 1.08 × BMI based on stature – 58.90] revealed that arm span and BMI based on arm span explain 38.5% of the variation in weight (R^2 =0.385), which indicated that both predictors were significant ($p < 0.001$). Likewise, stature and BMI based on stature explain 40.2% of the variation in weight (R^2 =0.402), which explained that both predictors were significant ($p < 0.001$).

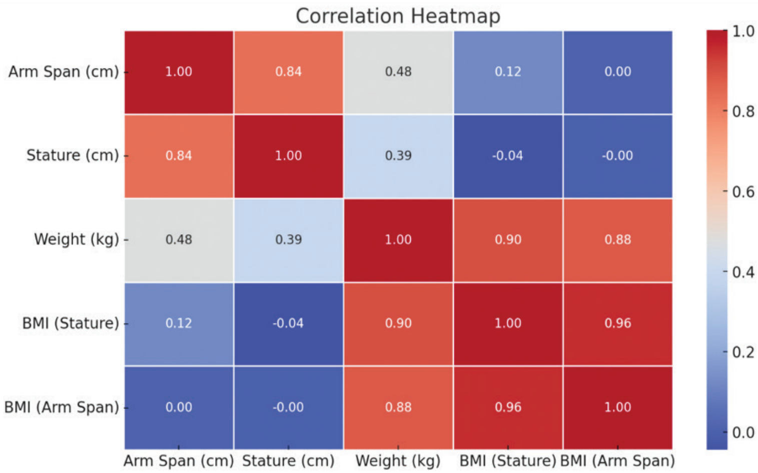

Figure 1. Correlation between arm span (BMI) and stature (BMI)

Examination of the linear regression plot between arm span and stature (Figure 2) revealed the regression equation: Stature = 0.778 × Arm span + 34.24, indicating that arm span explains approximately 69.8% ($R^2 = 0.698$) of the variance in stature. This demonstrates a strong and consistent linear relationship between arm span and stature, with arm span accounting for nearly 70% of the variation in stature.

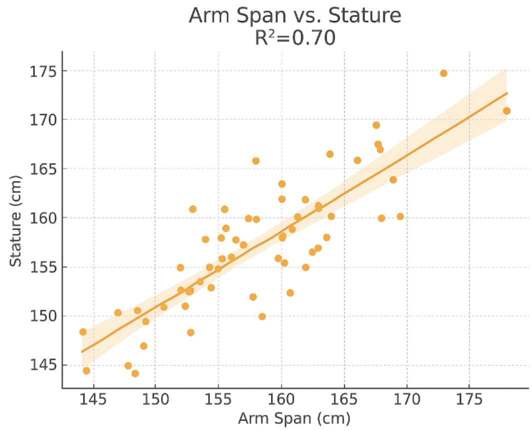

Figure 2. Linear regression model between arm span and stature

Arm span explains 32.8% of the variation in BMI calculated from arm span. Both BMI measurements have similar distributions (boxplot: Figure 3).

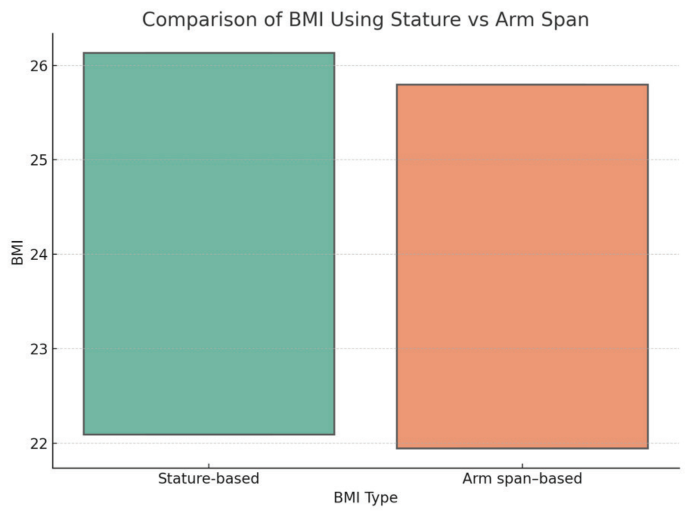

Figure 3. Variation in BMI calculated from arm span

Examination of the BMI based on arm span and stature demonstrated very close association [BMI (arm span) = 0.912 × BMI (stature) + 1.87], and BMI calculated from arm span and stature were nearly identical ($R^2 = 0.918$) (Figure 4), indicating a very strong correlation, which means that both BMI measures provide nearly the same information.

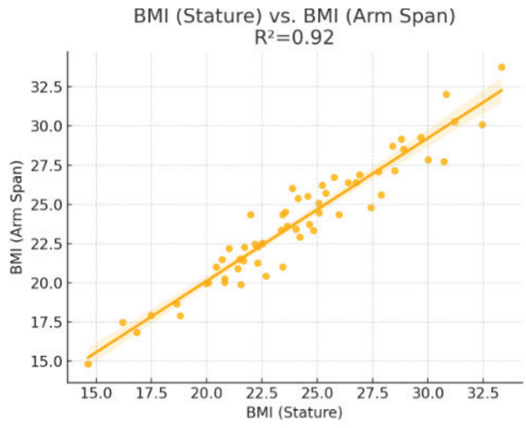

Figure 4. Linear regression model between BMI based on arm span and stature

Logistic regression model using BMI classification was performed in terms of binary as (normal weight) : BMI (stature) < 25 and (overweight/obese) : BMI (stature) ≥ 25 and fitted with ROC (receiver operating characteristics) curve (Figure 5), and the result evinced (ROC curve AUC = 0.92) that the model had excellent predictive power, as its accuracy was 91.67%, which indicated that the model classifies BMI categories correctly in most cases. The ROC curve also demonstrated strong separation between classes, meaning that the model effectively distinguished between normal-weight and overweight/obese individuals. Thus, weight is likely to be the most influential predictor, followed by stature and arm span.

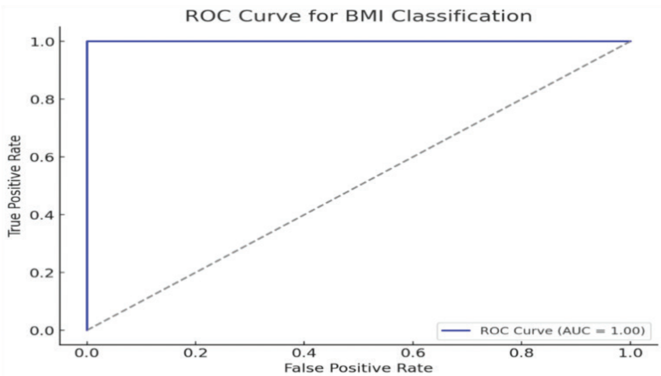

Figure 5. ROC demonstrated strong separation between classes

DISCUSSION AND IMPLICATIONS

The present study investigated the validity of using arm span as a surrogate for standing height in the calculation of body mass index, particularly in populations where height measurement may be inaccurate or impractical. The findings of this study demonstrated a high level of agreement between stature-based BMI and arm-span-based BMI, supporting the reliability of arm span as an alternative anthropometric indicator.

These results are in concordance with those of Arlappa et al. [7] who reported significant differences between BMI derived from height and from arm span in older adults. Their study concluded that stature-based BMI often overestimates the nutritional status in this age group due to age-related height loss, and that arm span provides a more accurate estimate of BMI in geriatric assessments. This supports the clinical and nutritional utility of arm span in aging populations, particularly those with spinal curvature or osteoporosis.

Similarly, Harriet et al. [18] found that, among spine deformity patients where true height is compromised due to physical abnormalities, BMI calculations based on standing height provided erroneous assessments of nutritional status. Their recommendation to use arm span in individuals with a delta arm span height (ΔAH) greater than 3 cm aligns with our findings that arm span is a more stable anthropometric measurement.

In a population-based context, Chatterjee and Bandyopadhyay [15] examined the fisherman community in the Sundarban delta and emphasized that the ratio between stature-based and arm-span-based BMI could serve as a reliable tool for assessing nutritional status and population variability. The current study's observation of only slight differences between the two BMI methods further supports this view, indicating consistency across diverse ethnic and occupational groups.

Furthermore, Adebajo et al. [19], in a study on Nigerian university students, highlighted the presence of sexual dimorphism in arm span and height but not in BMI. Interestingly, they reported a significant correlation between arm span and BMI in males but not in females. While our study did not specifically investigate sex differences, this suggests a potential area for further exploration, especially when developing population- and sex-specific predictive models.

Finally, the study by Rahmayani et al. [20] among Indonesian children aged 7–12 years established a strong correlation between height and arm span, reaffirming that arm span can be used as an effective substitute for height in growth monitoring and nutritional assessment during childhood. This finding extends the applicability of arm span beyond adult populations and highlights its relevance across the lifespan.

Taken together, these comparative findings affirm that arm span is not only a practical and non-invasive measure but also a scientifically supported alternative to height for estimating BMI in various demographic groups. While stature remains the conventional parameter, arm span proves especially valuable in contexts involving physical deformities, aging, or cultural settings where measuring of height is challenging.

The results indicate that both arm-span-based BMI and stature-based BMI significantly contribute to predicting weight. The slightly higher R^2 value for stature-based BMI suggests it is a marginally better predictor of weight than arm-span-based BMI. However, both models significantly improve explanatory power compared to using arm span alone. The present study described young females. Additionally, the moderate R^2 values for BMI regressions suggest that arm span and stature alone do not fully account for BMI variations, implying that additional anthropometric variables such as body fat percentage, muscle mass, and limb proportions may enhance predictive accuracy.

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