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# Utility of anthropometric indicators in predicting osteoporosis in ambulant community dwelling rural postmenopausal women from southern India

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**Abstract**

Osteoporosis is characterised by low bone mineral density (BMD) and is a significant public health problem in India. This cross-sectional study was done to assess the relationship between various anthropometric measures and BMD in 308 rural dwelling South Indian postmenopausal women. Anthropometric variables such as weight, body mass index (BMI), waist circumference (WC), hip circumference (HC) and neck circumference (NC) were measured. BMD was assessed by dual-energy X-ray absorptiometry (DXA) scan at the lumbar spine (LS) and femoral neck (NOF). The mean age $\pm$ SD of study participants was 60.7 $\pm$ 7.8 years. All anthropometric variables showed positive correlation with BMD at NOF and LS ($P < 0.05$). Weight showed the best correlation ($r = 0.482$ for NOF and 0.412 for LS; $P < 0.001$). On multivariate logistic regression, age and weight remained significant for predicting femoral neck osteoporosis while weight and WC were the best predictors for LS osteoporosis. These anthropometric measures may serve as surrogate markers for osteoporosis and thus be used to screen postmenopausal women for referral to a centre with fewer limited resources.

**Keywords**

Anthropometry, osteoporosis, bone mineral density, postmenopausal women, rural south India

## Introduction

Osteoporosis is a chronic debilitating condition which remains a major public health problem in view of the high morbidity and costs of diagnosis and treatment. The prevalence of osteoporosis in south India is estimated to be in the range of 20%–50%,[1,2] depending on the cohort studied. Therefore, screening for the condition in the community or in high-risk groups may help in preventing fragility fractures. Several screening methods have been described.[3–6] Bone mineral density (BMD) measurements by dual-energy X-ray absorptiometry (DXA) forms the basis for treatment in most scenarios. However, its cost and availability preclude its widespread use, thereby undermining the efforts at identifying and treating osteoporosis.

Several studies have shown the correlation between anthropometric measures such as body weight, body mass index (BMI), waist circumference (WC), hip circumference (HC) and BMD.[7–9] Some researchers have suggested risk prediction models based on anthropometric measures.[10,11] While these may not supplant BMD measurements by DXA, they would certainly help in screening and identifying high-risk individuals who can then be referred.

The use of anthropometric indices in a population requires ethnicity-derived cut-off levels. There are only

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a few studies that have assessed the correlation between anthropometric measures and BMD in the Indian population.[12] The aim of our study was to assess such correlation and examine the predictors of osteoporosis of the femoral neck (NOF) and lumbar spine (LS).

## Methodology

### Participants

Our study was a cross-sectional study completed between July and December 2018. Postmenopausal women aged $>50$ years were recruited from the community for screening for osteoporosis. Women with chronic kidney disease, chronic liver disease, malignancy, congestive heart failure and cerebrovascular accident were excluded. Those with a prior diagnosis of osteoporosis, history of fractures or intake of drugs interfering with bone health such as bisphosphonates and anabolic agents were also excluded. The study was approved by the institutional review board. Written informed consent was taken from all participants.

Body weight was measured using an Atlas electronic scale (range = 400 g–200 kg) to the nearest 0.1 kg. Participants were asked to stand straight, relaxed and with minimum clothing. Height was measured to the nearest 0.1 cm by using the wall-mounted stadiometer. The height of the individuals was taken in the standing position, without footwear and keeping the head in the Frankfurt plane. BMI was subsequently calculated as weight in kilograms divided by the square of height in metres ($kg/m^2$).

WC was measured at the midpoint between the lower margin of the last palpable rib and the top of the iliac crest, using a stretch-resistant tape providing a constant 100 g of tension.[13] HC was measured around the widest portion of the buttocks.[14]

Neck circumference (NC) was measured at the mid-level of the neck just below the laryngeal prominence in front and the seventh cervical spinous process behind.[15]

Measurement of BMD at NOF and LS was performed using the DXA scanner at our facility (Hologic–QDR 4500-W Discovery-A; Hologic Inc; Bedford, MA, USA). The National Health and Nutrition Examination Survey (NHANES) III Caucasian normative data were used as the reference database. Based on the International Society of Clinical Densitometry (ISCD) criteria, osteoporosis was diagnosed when T-scores at NOF or LS was $\leq -2.5$.[16] The precision of the DXA scanner for this measurement was 2%.

Using an alpha (level of significance) of 5%, power of 80%, estimated correlation coefficient of 0.337, based on a previous study showing a significant correlation for body weight with NOF BMD,[7] a sample size of 315 was derived.

Continuous variables were presented as mean ± SD or median (range), depending on the distribution of the variable. Categorical variables were expressed as frequencies or percentages. Pearson's correlation test was used to analyse the correlation between individual anthropometric variables and BMD assessed by DXA at the NOF and LS. Sensitivity, specificity and receiver operating characteristic (ROC) curves for each anthropometric variable of interest in the prediction of osteoporosis at each of the skeletal sites were estimated. A multivariate logistic regression model was used to predict osteoporosis at the NOF and LS using these anthropometric variables. A $P$ value $< 0.05$ was considered significant. Statistical analysis was performed using Statistical Package for Social Sciences (SPSS) version 25.0.

## Results

Of the 325 participants screened in the present study, 308 fulfilled the inclusion criteria and were included for analysis. The demographic and anthropometric data of the study population are detailed in Table 1. The mean age of the study participants was 60.7 ± 7.8 years and their mean BMI was 26.3 ± 5.36 $kg/m^2$.

Of the 308 participants, 91 (29.5%) had osteoporosis at the NOF and 126 (40.9%) at the LS.

The anthropometric variables of weight, BMI, NC, WC and HC showed a significant positive correlation with BMD at both the skeletal sites, while age showed a significant negative correlation with BMD at these sites (Table 2).

For individual anthropometric variables, the cut-offs at which osteoporosis at the NOF and LS is predicted are shown in Table 3 along with the sensitivity and specificity for these given figures.

**Table 1.** Demographic and anthropometric data of the study population (n = 308).

| Participant no. | Variable | Mean ± SD |
|---|---|---|
| 1 | Age (years) | 60.73 ± 7.8 |
| 2 | Height (cm) | 157.9 ± 81.8 |
| 3 | Weight (kg) | 61.5 ± 11.4 |
| 4 | BMI ($kg/m^2$) | 26.3 ± 5.36 |
| 5 | Neck circumference (cm) | 32.6 ± 2.4 |
| 6 | Waist circumference (cm) | 93.4 ± 11.3 |
| 7 | Hip circumference (cm) | 99.9 ± 10.1 |
| 8 | Neck of femur BMD ($g/cm^2$) | 0.643 ± 0.12 |
| 9 | Lumbar spine BMD ($g/cm^2$) | 0.823 ± 0.16 |

BMD, bone mineral density; BMI, body mass index.

**Table 2.** Correlation between the various anthropometric measures and BMD at NOF and LS.

| | Age | Weight | BMI | Neck circumference | Waist circumference | Hip circumference |
|---|---|---|---|---|---|---|
| NOF BMD (r) | −0.292* | 0.482* | 0.376* | 0.224* | 0.233* | 0.399* |
| LS BMD (r) | −0.129# | 0.412* | 0.333* | 0.215* | 0.182* | 0.337* |

r = Pearson's correlation coefficient
*P <0.01; # - p = 0.05
BMD, bone mineral density; BMI, body mass index; LS, lumbar spine; NOF, neck of femur.

**Table 3.** ROC cut-offs for NOF and LS osteoporosis for the various anthropometric measures.

| | NOF osteoporosis | | | LS osteoporosis | |
|---|---|---|---|---|---|
| | Cut-off | Sensitivity (%) | Specificity (%) | Sensitivity (%) | Specificity (%) |
| Weight (kg) | 49.5 | 95.4 | 33.0 | 93.4 | 22.2 |
| BMI (kg/m$^2$) | 21.25 | 95.4 | 33.0 | 95.1 | 24.6 |
| Neck circumference (cm) | 30.25 | 85.3 | 31.9 | 87.4 | 30.2 |
| Waist circumference (cm) | 82.5 | 89.4 | 28.6 | 88.5 | 22.2 |
| Hip circumference (cm) | 90.5 | 89.9 | 34.1 | 91.8 | 30.2 |

BMD, bone mineral density; BMI, body mass index; LS, lumbar spine; NOF, neck of femur.

**Table 4.** Multivariate logistic regression analysis using all the anthropometric variable for prediction of osteoporosis at NOF and LS.

| | NOF osteoporosis | | | LS osteoporosis | | |
|---|---|---|---|---|---|---|
| Variable | OR | 95% CI | *P* value | OR | 95% CI | *P* value |
| Age | 1.07 | 1.03–1.11 | <**0.01** | 1.01 | 0.97–1.04 | 0.48 |
| Weight | 0.84 | 0.77–0.91 | <**0.01** | 0.87 | 0.82–0.93 | <**0.01** |
| BMI | 1.00 | 0.9–1.10 | 0.90 | 0.96 | 0.87–1.06 | 0.49 |
| NC | 0.94 | 0.8–1.10 | 0.48 | 0.92 | 0.80–1.07 | 0.30 |
| WC | 1.04 | 0.99–1.08 | 0.06 | 1.07 | 1.03–1.12 | <**0.01** |
| HC | 1.05 | 0.99–1.12 | 0.07 | 1.02 | 0.96–1.07 | 0.42 |

BMI, body mass index; CI, confidence interval; HC, hip circumference; NC, neck circumference; OR, odds ratio; WC, waist circumference; Values in bold are statistically significant.

The anthropometric variables were assessed on a multivariate regression model for prediction of osteoporosis at the NOF and LS. On the multivariate model for prediction of osteoporosis at the NOF, only age and weight remained significant, while in the model for prediction at the LS, weight and WC remained significant (Table 4).

## Discussion

We found a positive correlation between body weight and BMD at both skeletal sites. Previously published literature support this finding.[17–19] On the other hand, not all studies demonstrate a uniformly decreased fracture risk in obese individuals. Recently conducted observational studies[20,21] and two large meta-analyses[22,23] have shown that though low BMI was associated with increased hip fractures, the gradient of risk was not uniform and the risk increased steeply at a BMI < 22 kg/m$^2$. A more interesting finding was that the association between BMI and fracture risk is dependent on BMD and varied across the level of BMI and is specific to the skeletal site. Low BMI was associated with hip fractures while high BMI was associated with upper arm fractures.

We also found a positive correlation between WC, HC, NC and BMD at both skeletal sites. Tariq et al.,[24] on the other hand, found a significant positive correlation between HC and BMD but not between WC and BMD. The NHANES survey 2005–2006 measured the association between the various obesity measures and BMD

and found that all the obesity measures correlated more strongly with NOF BMD than LS BMD and the HC was the most important obesity measure to correlate with BMD.[25]

NC can be easily measured and is being increasingly used as a predictor of metabolic syndrome.[15] However, it has never been studied in relation to BMD and osteoporosis.

We derived cut-offs for all these individual anthropometric variables from the ROC curves and the sensitivity and specificity at these cut-offs have been tabulated.

On the multivariate logistic regression model for predicting NOF osteoporosis, weight and age remained the only significant variables, while in the model for predicting LS osteoporosis, weight and WC remained the significant variables in prediction. Dargent-Molina et al.,[11] in the EPIDOS study, used a logistic regression model to devise a score to predict NOF osteoporosis and also found that weight alone predicts NOF osteoporosis just as well as the complete score. Similarly, Wildner et al.[10] used a linear regression modelling and showed that age and weight remained the best predictors for hip osteoporosis.

Given the ease of measurement of these anthropometric variables at an individual as well as rural community level in middle-income countries such as India and given the cost and unavailability of DXA scanners at all places, these could be used to screen a population at risk for osteoporosis (e.g. postmenopausal women).

The present study had some limitations. It was a cross-sectional study involving only a rural population and calculating DXA and BMD T scores rather than clinical fracture outcomes as reference standard.

## Conclusion

The present study showed that anthropometric measures, such as weight, WC, HC and NC, had a significant independent positive correlation with BMD as measured by DXA scan. On regression modelling, age, weight and WC remained significant predictors of osteoporosis at the NOF and LS. These measures may server as surrogate markers for low BMD and may be used to screen high-risk postmenopausal women in a resource-limited setting, especially in low- and middle-income countries.

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*Article*

# Cardiovascular and stroke disease risk among doctors: a cross-sectional study

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**Abstract**

The leading causes of death in the world are cardiovascular disease (CVD) and stroke according to the World Health Organization, as is also the case in India. There is also a high prevalence of major conventional risk factors in India, where 18.3%, 9.0% and 14.1% of adults are diagnosed with hypertension, diabetes and smoking, respectively. The aim of the present study was to look at the risk of CVD among doctors in our country using a validated tool developed by the National Health Service (NHS) in the UK, the QRISK3 calculator.

**Keywords**

Cardiovascular disease, doctors, India, QRISK3

## Methods

A cross-sectional study was conducted over a period of two months between 1 December 2017 to 31 January 2018 using a standardized questionnaire based on the QRISK3 score developed by the NHS in the UK. The QRISK3 calculator is an online, open source software which allows the user to input 22 parameters; it calculates the 10-year risk percentage of CVD and

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