Anthropometric indices for predicting cardiovascular risk factors: Ellisras longitudinal study

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Funding information
National Research Foundation

Abstract
Objectives: The aim of the study was to determine which anthropometric indices can best predict the presence of common cardiovascular risk factors among young adults in the rural village of Ellisras in the Limpopo Province, South Africa.

Methods: A total of 624 young adults (306 males and 318 females) aged 18 to 29 years took part in this cross-sectional study. Anthropometrics were measured according to the standard procedures. Blood pressure and blood parameters were collected and measured. The stepwise logistic regression was used to determine anthropometric indices that can predict the presence of common cardiovascular risk factors and a receiver-operating characteristic (ROC) curve was plotted to assess discrimination abilities of anthropometric indices for cardiovascular risk factors.

Results: The waist-to-hip ratio (WHR) in multivariable adjusted models was not found to be associated with cardiovascular risk factors compared to body mass index (BMI), waist circumference (WC), and waist-to-height ratio (WHtR). The area below the ROC curve for the abovementioned indices was above 0.62.

Conclusions: The central obesity indices, WC and WHtR, are better predictors of dyslipidemia and hypercholesterolemia, whereas BMI was a better predictor of hypertension among young adults living in rural South Africa between the ages of 18 and 29 years.

1 | INTRODUCTION

Obesity is considered to be one of the major risk factors for cardiovascular disease (CVD) (Sowers, 2003). Evidence has shown the appropriateness of central obesity indices such as waist circumference (WC) and waist-to-hip ratio (WHR) as more precise predictors of CVD and metabolic syndrome (Ho, Lam & Janus, 2003). The capability of body mass index (BMI), WC, WHR, and waist-to-height ratio (WHtR) to discriminate the main cardiovascular risk factors, such as dyslipidemia, hypertension, and type 2 diabetes has been determined, principally, using receiver-operating characteristic (ROC) analysis (Woo, Ho, Yu, and Sham, 2002; Hsieh and Muto, 2006).

A previous study in a rural area of South Africa reported that approximately a fifth of the women and a third of the men in the same community had a 20% or more chance of suffering a CVD event in the next 10 years (Alberts, Urdal, Steyn, Stensvold, Tverdal, Nel & Steyn, 2005). The preliminary finding on obesity of the Ellisras rural population has been previously reported (Monyeki, Monyeki, Brits, Kemper and Makgae, 2008). However, the relationships between...
anthropometric indices with lipid profiles of the Ellisras population have not been reported. Therefore, this study aimed to determine which anthropometric indices can best predict the presence of common cardiovascular risk factors among young adults in the rural village of Ellisras in the Limpopo Province, South Africa. We hypothesized that all abdominal obesity indices will be best at predicting CVD risk factors because, in previous Ellisras studies, abdominal obesity indices were better at predicting obesity prevalence compared with other indices, and obesity is an important risk factor for CVD risk factors.

2 | METHODS

2.1 | Sample

A total of 624 young adults aged 18 to 29 years (306 males with a mean age of 23.6 years, and 318 females with a mean age of 23.79 years) who are part of Ellisras longitudinal study (ELS) participated in this study. The details of ELS is explained elsewhere (Monyeki, Cameron, and Getz., 2000). The Ethics Committee of the University of Limpopo granted ethical approval prior to the survey with ethical clearance number MREC /P/204/2013: IR. The participants signed consent forms prior to data collection.

Participants who were pregnant at the time of measurements, those who were hospitalized or constantly taking medication, and those with severe diseases, including cancer among others, were excluded.

2.2 | Measurements

2.2.1 | Anthropometric

All participants underwent a series of anthropometric measurements of height, weight, hip, and waist circumferences according to the standard procedures recommended by the International Society for the Advancement of Kinaanthropometry (Norton and Olds, 1996).

2.2.2 | Blood pressure

Using an electronic Micronta monitoring kit, three blood pressure (BP) readings of systolic blood pressure (SBP) and diastolic blood pressure (DBP) were taken at an interval of 5 minutes apart (National High Blood Pressure Education Program, 2004), the average from the three BP readings was calculated.

2.2.3 | Biochemical analysis

Participants fasted for 8 to 10 hours before blood collection. All blood collections were done in schools by registered nurses from Witpoort Hospital in the morning. Blood samples were then placed in a cooler box with ice (2-8°C) on site before being transported to the laboratory at the Witpoort Hospital situated in Ellisras. Fasting blood samples were centrifuged at 2500 rpm for 15 minutes prior to analysis and stored in a biofreezer at −80°C for later analysis.

Fasting blood glucose (FBG) was drawn into fluoride tubes and then measured using an Accu-Chek (Barrett, Huffman and Johnson, 2011). The total cholesterol (TC) and high-density lipoprotein cholesterol (HDL-C) levels were measured by an enzymatic (cholesterol esterase, oxidase, and peroxidase) spectrophotometric technique. Low-density lipoprotein cholesterol (LDL-C) was calculated from the Friedewald equation (in mmol/l) \( \text{LDL-C} = \text{TC} - \text{HDL-C} - \text{TG}/2.2 \), provided that the triglycerides (TGs) did not exceed 4.5 mmol/L. (Friedewald, Levy and Fredrickson, 1972). TGs were measured using a standard enzymatic colorimetric method. All measurements were done using an AU480 Chemistry System from Beckman Coulter (Brea, Calif).

The instruments were calibrated according to standard procedures. Cardiovascular risk factor cutoff points were adopted from Ho et al. (2003). Anthropometric indice cutoff points were adopted from Dobbelsteyn, Joffres, MacLean and Flowerdew (2001) and Ashwell, Gunn and Gibson (2012).

2.2.4 | Statistical analysis

The stepwise logistic regression was used to determine anthropometric indices that can predict the presence of common cardiovascular risk factors, and an ROC curve was plotted to assess discrimination abilities of anthropometric indices for cardiovascular risk factors. The analysis was performed using the R software.

3 | RESULTS

Table 1 demonstrates the prevalence of cardiovascular risk factors. Among Ellisras young adults, the prevalence of hypercholesterolemia and dyslipidemia was seen to be higher (15.7% and 64.9%, respectively) than hypertension and diabetes (1.9% and 1.6%, respectively).

| Cardiovascular risk factors         | N (%) |
|-------------------------------------|-------|
| Hypertension                        | 12 (1.9) |
| Diabetes                            | 10 (1.6) |
| Hypercholesterolemia                | 98 (15.7) |
| Dyslipidemia                        | 405 (64.9) |

Note: N, number of participants.
In Table 2, chi-squared statistics was calculated for each potential variable that could be selected for the model using the stepwise logistic regression method of bidirectional elimination. The variable with the highest significance was added to the model. Analysis of logistic regression adjusted for age and gender (Table 2) showed that WHR was not a statistically significant predictor of cardiovascular risk factors. As for the statistically significant variables, BMI, WC, and WHtR had the lowest $P$ values, suggesting a strong association of BMI, WC, and WHtR with the probability of having one of the cardiovascular risk factors. The positive coefficient for the variable BMI was 0.17, indicating that for a one-unit increase in BMI, we expect a 0.17 increase in the log-odds of hypertension.

In Figure 1, the ROC curve plots were generated by plotting sensitivity (probability of correctly detecting a risk factor) against the one minus specificity (probability of correctly detecting a nonrisk factor). The area under the ROC curve for all the models had values more than 0.5 above the diagonal line, suggesting that our models are fair in discriminating.

### Table 2

| Risk Factor       | Coefficient Estimate | $P$ Value  |
|-------------------|----------------------|------------|
| Dyslipidemia      | 0.0346 (<.0001)      |            |
| Hypertension      | 0.17 (.0002)         |            |
| Hypercholesterolemia | 2.85 (.0033)     |            |

**Odds ratio and 95% confidence interval**

| Risk Factor       | Odds Ratio | 95% CI      |
|-------------------|------------|-------------|
| Dyslipidemia      | 1.04 (1.02-1.05) |            |
| Hypertension      | 1.19 (1.08-1.31) |            |
| Hypercholesterolemia | 17.33 (2.81-126.38) |            |

Abbreviations: BMI, body mass index; WC, waist circumference; WHtR, waist-to-height ratio.

### Figure 1

ROC curves for cardiovascular risk factors. AUC, area under the curve; DP, dyslipidemia; HPC, hypercholesterolemia; HP, hypertension. ROC, receiver-operating characteristic curve.

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### DISCUSSION

The current study found WHR to be a nonsignificant predictor in association with any of the cardiovascular risk factors. De Koning, Merchant, Pogue and Anand (2007) have demonstrated that the risk of incident cardiovascular diseases increases with a rise in WHR. Precisely, a 0.01 rise in WHR is associated with a 5% increase in the risk of future cardiovascular disease after adjusting for age and cohort characteristics. It is likely that the difference in findings may be due to the older ages of the participants in the other study and, also, because of the very small proportion in our sample who had hypertension and diabetes. This was also one of the study’s limitations.

The current study found that WC and WHtR were significant predictors of dyslipidemia and hypercholesterolemia, respectively. This may be due to the fact that WC is more closely correlated with abdominal visceral adipose tissue than other anthropometric indices (Wei, Gaskill, Haffner and Stern., 1997). A study by Di Gravio et al. (2018) found that adiposity rebound in children derived from BMI predicts later cardiometabolic risk markers. The cardiometabolic risk associated with abdominal obesity is attributed to the presence of visceral adipose tissue, which encourages insulin resistance, dyslipidemia, and hypertension (De Koning et al., 2007). In support of these reports, the current study found BMI to be a good predictor of hypertension.

In conclusion, for the prediction of dyslipidemia and hypercholesterolemia in Ellisras young adults, the central obesity indices WC and WHtR were better than BMI, whereas BMI was a better predictor of hypertension. Future similar studies in rural areas should include other ways of detecting abdominal obesity in addition to
anthropometric indices and investigate this matter on a longitudinal basis.

ACKNOWLEDGMENTS

The authors are indebted to the Ellisras longitudinal study administrators, TT Makata, SP Seleka, and W Makata. The authors also thank the Department of Pathology and Medical Science at the University of Limpopo for letting us use their laboratory and biochemical analysis machines. The authors acknowledge the University of Limpopo and National Research Foundation for assistance with funds.

CONFLICT OF INTEREST

The authors declare no potential conflict of interest.

AUTHOR CONTRIBUTIONS

B.S. and P.M. did formal analysis; K.M. contributed to fund acquisition, investigation, project administration, and resources; K.M., H.K., and D.S. did the supervision; B.S. contributed to visualization and writing of the original draft; and P.M. and D.S. contributed to reviewing and editing of the manuscript.

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How to cite this article: Sebati B, Monyeki K, Kemper HCG, Sekgala MD, Mphekgwana P. Anthropometric indices for predicting cardiovascular risk factors: Ellisras longitudinal study. Anm J Hum Biol. 2019;31:e23293. https://doi.org/10.1002/ajhb.23293