EVALUATION OF DIFFERENT ANTHROPOMETRIC INDICES AND THEIR ASSOCIATIONS WITH ELEVATED BLOOD PRESSURE AMONG ADOLESCENTS IN SELANGOR, MALAYSIA

By

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Chair : Associate Professor Dr Gan Wan Ying, PhD

A trend of increasing prevalence of hypertension among children and adolescents was observed globally, including Malaysia. Early detection and prompt treatment of hypertension in children and adolescents helps in reducing associated risks and long term effect. Anthropometry indices have been used in several studies to predict hypertension. This cross-sectional study aims to compare the predictive ability of the 7 anthropometric indices: BMI-for-age z-score (BAZ), Waist circumference (WC), Waist-to-height ratio (WHtR), Conicity Index (C-Index), A Body Shape Index (ABSI), Body Roundness Index (BRI), and Triponderal Mass Index (TMI) in identifying elevated blood pressure in adolescents aged 13 to 17 years old in Selangor. Two schools in Selangor state was randomly selected using probability proportionate to size where a total of 934 respondents were recruited. Self-administered questionnaires was used to get data of sociodemographic background, physical activity and sleep quality. Weight, height, waist circumference and blood pressure were measured. Using the receiver operating characteristic curve and established procedures, the prediction power of anthropometric indicators was according to sex. A total 934 children (387 boys and 547 girls) were examined. The prevalence of elevated BP was 19.6%, hypertension stage 1 was 7.7% and hypertension stage 2 was 4.8%. Multiple logistic regression analysis upon controlling sex, age, ethnicity and physical activity level showed WC (AOR=1.274, 95% CI = 0.746, 2.176) and TMI (AOR=1.310, 95% CI = 1.219, 1.407) were significantly associated with elevated BP. Overall, AUCs of BMI-for-age (AUC= 0.752, CI 95%= 0.717, 0.787), WC (AUC=0.767, CI 95%= 0.735, 0.800), WHtR (AUC= 0.701, CI 95%= 0.664, 0.738), TMI (AUC= 0.731, CI 95%= 0.695, 0.767) and BRI (AUC= 0.701, CI 95%= 0.664, 0.738) indicated good predictive power in assessing elevated BP. Considering the results of AUC, sensitivity, specificity and Youden index, WC was considered as the best anthropometric indices in predicting high BP among adolescents in this study cut off values of 71.12 cm in males and 74.27 cm in

females. These results suggested that WC may be a helpful signal for assessing the risk of high blood pressure in routine screening for adolescents. Future studies are suggested to include dietary factors and stress factors to investigate the association with BP

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LIST OF ABBREVIATIONS

BP	Blood Pressure
WC	Waist Circumference
WHtR	Waist to height ratio
BAZ	BMI-for-age z-score
C-Index	Conicity Index
ABSI	A Body Shape Index
BRI	Body Roundness Index
TMI	Triponderal Mass Index
WHO	World Health Organization
BMI	Body mass index
PA	Physical activity
OR	Odds ratio
AOR	Adjusted odds ratio
NHMS	National Health Morbidity Survey
MOH	Ministry of Health Malaysia
NCD	Non-communicable diseases
SD	Standard deviation
CPG	Clinical Practice Guidelines
SPSS	Statistical Package for the Social Sciences
CI	Confidence Level
SBP	Systolic blood pressure
BDP	Diastolic blood pressure

CHAPTER 1

INTRODUCTION

1.1 Background

Hypertension is a rising concern globally (Song et al., 2019). The biggest cause of morbidity and mortality in the world today is hypertension, which accounts for 10.4 million deaths per year (Stanaway et al., 2018). A systematic review and meta-analysis reported a trend of increasing prevalence of hypertension among children and adolescents was observed globally during the past two decades, with a relative increment of 75% to 79% from 2000 to 2015 (Song et al., 2019). Hypertension that starts in childhood would have high chances to continue into adulthood, but childhood hypertension is largely undiagnosed (AHA, 2003).

Obesity has been shown as a contributing factor and to increase prevalence of several metabolic diseases, including hypertension (Jiang et al., 2016). Obesity is one of the main public health problems worldwide (Powell-Wiley et al., 2021). This is impacting children and adolescents as well where globally, the number of obese children and adolescents has risen tenfold in the past forty years (NCD-RisC, 2017). Additionally, WHO has predicted that by 2022, a greater number of children and adolescents will be affected by obesity than by underweight and this is alarming (NCD-RisC, 2017).

The relationship between hypertension and obesity has been extensively studied in both adults and children across both sexes (Shariq & Mckenzie, 2020). There is a strong link that higher body mass index (BMI) causes higher blood pressure, in which a previous study showed that each 10 BMI unit increase was related with a 10 mmHg rise in systolic blood pressure and a 3 mmHg increase in diastolic blood pressure (Kelly et al., 2015). Similarly, this is supported by another study in China where it was found that among children and adolescents, being overweight or obese significantly raised the risk of developing hypertension (Dong et al., 2019).

South Asian children and adolescents have been shown to have a higher body fat percentage at similar BMI compared with Caucasians placing them at greater risk of metabolic diseases, including hypertension (Eyre et al., 2017; Heo et al., 2020). This shows that Asian are more at risk compared to Caucasian in developing hypertension. Among adolescents, the prevalence of hypertension is quite alarming, especially in Asian countries such as India (7.6%), China (13.45%), and Indonesia (8%) (Daniel et al., 2020; Kurnianto et al., 2020a; Yang et al., 2021a). In Malaysia, Liew et al. (2019) found that the prevalence of hypertension among adolescents was 24.5% with the highest being recorded among Malays (28.7%). This was comparatively higher than a previous study conducted in 2011, where the prevalence was found to be 11.7% (Rampal et al., 2011).

Reducing related risks and long-term effects of hypertension in children and adolescents requires early detection and prompt treatment. Among the early detection methods, anthropometry indices have been used in several studies to predict hypertension (Nkwana et al., 2021; Ononamadu et al., 2017; Tee et al., 2020). For many years, the primary metrics used to evaluate a child's growth have been their height and weight (Erdal et al., 2020). This is referring to the conventional BMI that is still promulgated as the main epidemiological measure of obesity(Nuttall, 2015). In adolescents, BMI-for-age z-score (BAZ) is more suitable to be applied (Freedman et al., 2009). However, the disadvantage of BMI or BAZ is that it cannot reflect fat distribution and adiposity level in an individual (Nevill et al., 2021).

Alternatively, abdominal obesity indices, which includes waist circumference (WC), waist-to-height ratio (WHtR) and conicity index (C-Index) have been proposed, because they alter the BMI's limiting factor (Lee et al., 2015; Lo et al., 2016). Recent review showed that WHtR has the strongest association with adiposity, in which it is a better predictor of hypertension than BMI and WC (Hwaung et al., 2020). Conicity index was also positively associated with hypertension in the adult population (Nkwana et al., 2021).

Some new anthropometric indices have been proposed for screening hypertension, including body roundness index (BRI), a body shape index (ABSI) and Triponderal mass index (TMI). Body Roundness Index (BRI) and A Body Shape Index (ABSI) were proposed for that they can predict the distributions of body fat and were associated with hypertension (Chang et al., 2016; Nkwana et al., 2021). A recent study has shown that TMI can be used to characterize adolescents with overweight and hypertensive (Malavazos et al., 2021). However, it is still challenging to identify hypertensive risk factors and to determine which anthropometric measurements are appropriate at various stages of development in childhood and adolescence due to the mixed findings.

1.2 Problem Statement

Many nations and ethnic groups have explored the connection between anthropometric indicators of obesity and hypertension (Eyre et al., 2017; Ononamadu et al., 2017; Sardinha et al., 2016; Tee et al., 2020). A study conducted among Indian children found that BMI, WC, WHtR, triceps skin fold thickness and wrist measurements has equal sensitivity and specificity in detection of hypertension (Kajale et al., 2014). However, a study among Nigerian secondary school children found that WC and waist to hip ratio were significant predictors of hypertension compared to BMI (Uwaezuoke et al., 2016). Comparatively, Rodea-Montero et al. (2014) found that WHtR was the best comparing to BMI and WC in a study among Mexican adolescents. The findings of several studies indicate that the appropriate anthropometric index for predicting hypertension is still disputed and inconclusive.

In Malaysia, there are few and conflicting results from research that evaluated how well anthropometric indices predict the likelihood that adolescents may develop hypertension. Tee et al. (2020) evaluated the anthropometric

indices for the screening of hypertension among adolescents; however, only four indices (BMI, WC, WHtR, ABSI) were assessed, in which results showed that WHtR was the best index to predict hypertension. Nevertheless, another study done by Cheah et al. (2018) showed that BMI and WC were the best index in predicting hypertension. Therefore, the findings are contradicting and the best predictive anthropometric index is still inconclusive.

Cut off values are important in the predicting power of the indices. According to studies from many nations and ethnic groups, certain anthropometric indices and the associated cut-off values for identifying high blood pressure are superior than others (Nkwana et al., 2021; Ononamadu et al., 2017; Tee et al., 2020). Multiple cut-off values and the use of different anthropometric measures to predict high blood pressure may be necessary due to ethnic heterogeneity among populations from different locations. It is important to generate a cut off value that is suitable for Malaysian population since our body composition and fat distribution may differ from the existing optimal cut off values that has been established in other studies from other countries (Eyre et al., 2017; Heo et al., 2020) .

Overall, most of the studies on anthropometric indices and hypertension were conducted in the adult age group (Andrade et al., 2016; Bertoli et al., 2017; Calderón-García et al., 2021). The association among adolescents is not fully understood. Therefore, this study aimed to compare the predictive ability of the 7 anthropometric indices: BAZ, WC, WHtR, C-index, TMI, BRI, and ABSI in identifying elevated blood pressure among adolescents from age 13 to 17 years old.

1.3 Research Questions

This study addressed a few important research questions as follows:

1. What are the associations between BAZ, WC, WHtR, C-index, TMI, BRI, and ABSI with high blood pressure in adolescents aged 13 to 17 years old?
2. Which of these anthropometric indices (BAZ, WC, WHtR, C-index, TMI, BRI, and ABSI) are the best predictors of high blood pressure in adolescents aged 13 to 17 years old?
3. What is the optimal cut off value for each anthropometric indices in the prediction of high BP among adolescents aged 13 to 17 years old?

1.4 Significance of the Study

As hypertension is increasing globally and in Malaysia, early detection of hypertension is important. Anthropometry indices are simple methods which can be obtained using basic measurements that can be easily measured even in the school settings.

By identifying the best anthropometric measure and the cut-off values, further action can be taken to implement the anthropometric measure in schools and hospitals as a predictive tool. The anthropometric index can be used as a primary screening to identify the high risk individuals in developing hypertension. Anthropometric index is a cheaper and easier way to determine the risk group as it does not need any biochemical values.

Findings of this study can be used by healthcare professionals to assess hypertension risk easily, subsequently reducing the risk in adolescents by targeting the anthropometric indices. This research will advance knowledge in the area and provide data for subsequent intervention studies on adolescents. The information obtained from this study can be used by policy makers to plan preventive measures by implementing the anthropometric index in predicting hypertension among adolescents.

1.5 Research Objectives

1.5.1 General Objective

To compare the predictive ability of the 7 anthropometric indices: BAZ, WC, WHtR,C-index, TMI, BRI, and ABSI in identifying elevated blood pressure in adolescents aged 13 to 17 years old in Selangor.

1.5.2 Specific objectives

1. To assess BAZ, WC, WHtR, C-index, TMI, BRI, ABSI and blood pressure levels in adolescents.
2. To determine the associations between the 7 anthropometric indices (BAZ, WC, WHtR, C-index, TMI, BRI, and ABSI) with blood pressure among adolescents after adjustment of covariates.
3. To compare the performance of different anthropometric indices in predicting elevated blood pressure in adolescents.
4. To identify the optimal sex specific cut off values for anthropometric indices in predicting elevated blood pressure in adolescents.

1.6 Research Hypotheses

1. Obesity indices are associated with elevated blood pressure among adolescents after adjustment for covariates.
2. There are differences in the performance of different anthropometric indices in predicting elevated BP in adolescents.

1.7 Conceptual Framework

Figure 1.1 explains the framework of this study. Anthropometry indices (BAZ, WC, WHtR, C-index, TMI, BRI and ABSI) are the independent variables and blood pressure is the dependant variable. The confounding variables in this study would be the lifestyle factors including physical activity level (PAL), sleep quality, fast food consumption frequency and sociodemographic factors, which includes age, sex, ethnicity, education, and socioeconomic status. The anthropometry indices are associated with blood pressure and are used as a predictive tool in predicting hypertension.

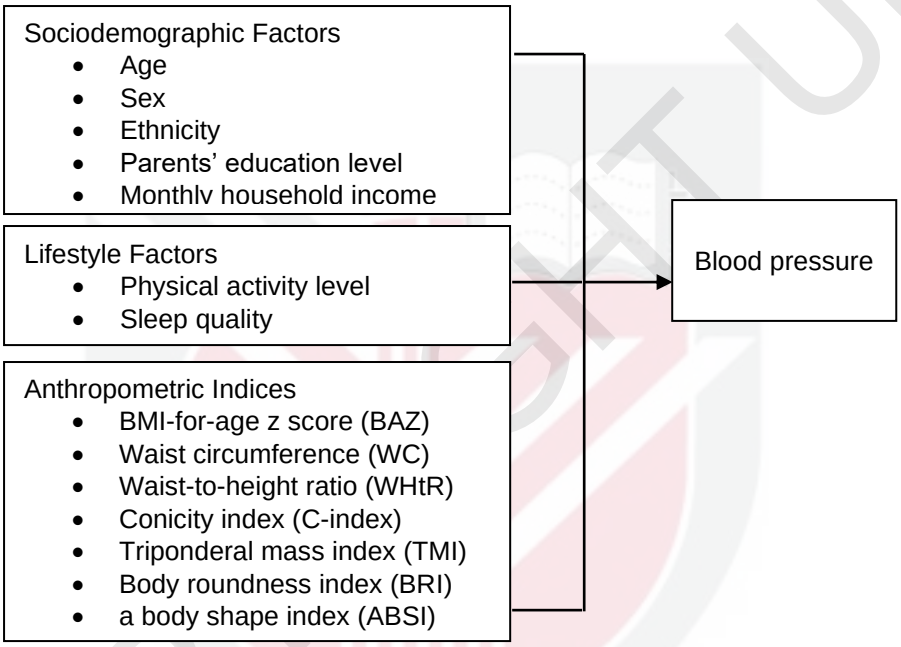

Figure 1.1: Conceptual framework of this study

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