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WAIST TO HEIGHT RATIO (WHTR): AN ANTHROPOMETRIC INDICATOR FOR EARLY DETECTION OF HEALTH RISK FOR MALAYSIA'S NATIONAL HEALTH AND MORBIDITY SURVEY (NHMS).

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ABSTRACT

Background: Body Mass Index (BMI) been recognized to be less sensitive towards differentiating between muscular and the overweight. The purpose of this study was to identify the prevalence of adults who are at health risk by WHtR but had normal BMI and to investigate whether WHtR is a better health risk correlator compared to BMI and WC

Materials and Methods: Data from the Malaysia Health and Morbidity Survey (NHMS) 2015 was used. A descriptive analysis for socioeconomic and anthropometric variables was carried out. Correlations between the variables BMI, WHtR, SBP, DBP, Total cholesterol and Diabetes were checked using Pearson correlation test. The analysis of ROC curve was used to assess the accuracy of BMI, WC and WHtR as early health risk indicators for diabetes, hypertension and high cholesterol.

Result: A total of 18373 respondents were included in this study. Findings showed 19.4% of adults with 'normal weight by BMI' have WHtR greater than 0.5 and are at health risk. Population that are at risk by BMI but not at risk by WHtR are only 2.9% from total population. ROC curve showed greater discriminatory power for WHtR compared with BMI for diabetes and high cholesterol but not DSP and SBP.These findings showed that WHtR had the best performance for diabetes and high cholesterol but not diastolic and systolic pressure.

Conclusion: WHtR is effective in screening early health risk compared to BMI and WC. The Ministry of Health, Malaysia should investigate the benefits of using WHtR in their population-based studies.

Keywords: BMI, Waist Circumference, Waist to height ratio, health risk

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1.0 Introduction

Body Mass Index (BMI) has been used for decades to classify for obesity. It has also been recognized to be less sensitive towards differentiating between muscular and the overweight [1]. BMI was first mentioned in 1981 in John Garrow's book *Treat Obesity Seriously* [2]. The BMI chart has been used to classify severity and stages of obesity. Healthy weight for height is usually defined as BMI between 18.5 and 25 kg/m^{2,} overweight as equal to or more than 25 and less than 30, and obesity as a BMI of equal to or more than 30 [3]. Waist circumference is an assessment tool that can complement BMI measurement for assessment of disease risk [3]. High risk waist circumference is defined as >40 inches (102 cm) for men and >35 inches (88 cm) for women.

Based on World Health Organization (WHO) classification, the prevalence of overweight in Malaysia was 30% and obesity 17.7% based on NMHS 2015. The national prevalence of abdominal obesity was 48.6% [4]. The study showed that the national prevalence of overweight, obesity and abdominal obesity had increased by 0.6%, 2.6% and 2.0% respectively compared to the previous findings of NHMS 2011 [4]. Previously, different BMI ranges has been suggested for Asians and Caucasians [5]. The use of WHtR circumvents such problems because the adjustment of waist circumference for height means that the same boundary values of 0.5 ratio is suitable for all ethnic groups around the world [6].

WHtR is defined as waist circumference in centimetres divided by height in centimetres. The recent findings suggest that the waist circumference should be half of a person's height thus strengthens the ratio of 0.5 for everyone.[6] The cut-off point for WHtR has been suggested as low risk for ratio 0.5 and below, increased risk for ratio between 0.5-0.6 and high risk for ratio 0.6 and above [6]. Waist-to-height ratio (WHtR) has also recently received a lot of attention as an indicator for early health risk (diabetes, hypertension and cardiovascular disease) and a representation for central (visceral) adipose tissue [7]. It was proposed by both Japan and the UK for monitoring health risk. Both countries suggested using WHtR values above 0.5 as an indicator for increased health risk [8]. This boundary value was suggested about 20 years ago, which translate into keeping your waist circumference less than half of your height.[9]

WHtR is a cost-effective anthropometric measurement that only requires a stadiometer and a tape measure which is cheap while measuring BMI requires a stadiometer and weighing scales which is more expensive. Surprisingly, even a string can be used to measure waist which will be even more cost effective plus it is portable as well [10]. Currently there are 78 prospective and cross-sectional studies showed odd ratio or correlation tended to be higher for WHtR than BMI. Systematic review in terms of specificity and sensitivity analyses of more than 26 studies covering men and women in many ethnic groups showed that WHtR was a better tool than Waist Circumference (WC) or BMI [11]. Many Asian countries such as India, China, Korea and Chile have proposed that WHtR 0.5 be used for screening in other population. All these data also confirmed that the cut off value of WHtR 0.5 for increased risk is appropriate across age, gender and ethnic population in adults [12,13,14].

The purpose of this study was to identify the prevalence of adults who are at risk by WHtR but missed by BMI screening using the Malaysia NMHS. We will also like to investigate whether

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WHtR is a better anthropometric predictor for diabetes, hypercholesterolemia and hypertension compared to BMI and WC.

2.0 Materials and Methods

This study used recent data of the Malaysia National Health and Morbidity Survey (NHMS) 2015. NHMS 2015 is a population representative cross-sectional study. The sampling frame was updated in 2014 prior to sampling process. Based on the frame, areas in Malaysia were divided into Enumeration Blocks (EB). The sampling design used two staged stratified random sampling. Primary stratum made up of states of Malaysia while second stratum made up of urban and rural strata. Sampling involve 2 stages; the Primary Sampling Unit (PSU), which was Enumeration Block (EBs) and the second sampling Unit (SSU) which was Living Quarters (LQs) within the selected EBs. A total of 10,428 LQs were selected from the total EBs in Malaysia. Twelve LQs were randomly selected from each selected EBs. Pregnant women, post-natal (less than 60 days at time of visit), bed ridden due to chronic / prolonged illness,, injury/ accident, having physical disability that can affect the normal standing including on wheel chair, body deformities such as no hand and leg, spondylolysis except deaf, blind and mute were excluded from this study. Data collection was from March 2015 until June 2015.

Structured questionnaires were used to collect data. There were two types of questionnaires; face to face interview and self-administered. The face to face interview questionnaires were programmed into an application and the data collection was done using tablet. The self-administrated questionnaires were prepared in hardcopies. Prior to data collection, a training course was conducted for all data collectors.

Clinical assessment (weight, height, waist circumference, blood pressure measurement, fasting blood sugar and fasting cholesterol) was done by trained nurses. For assessment of weight, Tanita personal Scale HD 319 was used. For measurement of height, SECA Stadiometer 213 was used. Both tools were validated and calibrated. For waist circumference, measurements were taken with a tape measure at the point midway between the iliac crest and the lower rib. Waist circumference cut off point was defined as

WHtR is defined as waist circumference in centimetres divided by height in centimetres. The cut-off point for WHtR has been suggested as low risk for ratio 0.5 and below, increased risk for ratio between 0.5-0.6 and high risk for ratio 0.6 and above. These risks refer to health risk such as diabetes, high systolic and diastolic pressure and high cholesterol. Healthy weight for height is usually defined as BMI between 18.5 and 25 kg/$m^{2,}$ overweight as equal to or more than 25 and less than 30, and obesity as a BMI of equal to or more than 30.

Data was analysed using SPSS version 23 including the calculations of proportions and their respective 95% confidence intervals (95%ci). For the purpose of this paper, variables such as weight, height, WC, BMI, blood test (fasting glucose and cholesterol), blood pressure and sociodemographic data (race, marital status, education level, occupation, sex, age group, location and household income) were used.

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A descriptive analysis for socioeconomic and anthropometric variables was carried out. Correlations between the variables Body Mass Index (BMI), WHtR (waist-to-height ratio), SBP (systolic blood pressure), DBP (diastolic blood pressure), fasting blood cholesterol and Diabetes were checked using Pearson correlation test. The logistic analysis used analysis of ROC curve (receiver operating characteristics) to assess the accuracy of BMI and WHtR as early health risk indicators for diabetes, systolic pressure, diastolic pressure and cholesterol.

This study had obtained ethical approval from the Medical Research and Ethics Committee (MREC), Ministry of Health, Malaysia, with the registration number NMMR -14-1064-21877. Prior to each interview, the purpose of the survey and methods used during the survey were explained to the respondent and information was handed out via the participants information sheet, before informed written consent was taken.

3.0 Result

Table 1. Distribution of respondents among Malaysian adults aged 18 years and over according to socio-demographic and metabolic health risk factors.

Variable	Estimated population	n	%	95%CI	
				Lower	Upper
Socio-demographic					
Sex					
Male	9765343	8858	52.5	51.57	53.42
Female	8835734	9515	47.5	46.58	48.43
Age group (years)					
18 - 24	3518522	2522	18.9	17.98	19.89
25 - 44	8543657	7275	45.9	44.62	47.25
45 - 64	5087543	6438	27.4	26.38	28.34
65+	1451354	2138	7.8	7.23	8.41
Ethnicity					
Malay	9118586	11375	49	46.29	51.76
Chinese	4227623	2867	22.7	20.37	25.27
Indian	1272586	1305	6.8	5.89	7.93
Others Bumi	2069963	1655	11.1	9.61	12.85
Others	1912319	1171	10.3	8.68	12.14
Locality					
Urban	14090521	10557	75.8	74.67	76.8
Rural	4510555	7816	24.2	23.2	25.33
Household income group (RM)					
Less than RM1000	2498054	2946	13.4	12.47	14.45
RM1000 - 1999	3079301	3364	16.6	15.49	17.68
RM2000 - 2999	3034378	3119	16.3	15.09	17.61
RM3000 - 3999	2388824	2333	12.8	11.8	13.96

RM4000 - 4999	1830483	1651	9.8	8.9	10.87
RM5000 - 5999	1471458	1287	7.9	7.04	8.88
RM6000 - 6999	954462	873	5.1	4.42	5.95
RM7000 - 7999	754222	711	4.1	3.46	4.75
RM8000 - 8999	625671	547	3.4	2.77	4.08
RM9000 - 9999	334183	292	1.8	1.39	2.31
RM10000 and above	1630041	1250	8.8	7.45	10.28
Metabolic health risk					
Diabetes					
Normal	12391858	11553	66.7	65.32	68.07
Impaired fasting glucose	1642471	1723	8.8	8.24	9.49
Diabetic	4541325	5053	24.4	23.32	25.61
Cholesterol					
desirable	9507549	8627	53.5	52.19	54.88
borderline high	4580190	4586	25.8	24.89	26.71
high	3670635	4362	20.7	19.67	21.71
Systolic					
normal	6176794	5199	33.8	32.7	34.94
pre hypertension	8130197	8016	44.5	43.38	45.63
stage 1	2786609	3299	15.3	14.53	16
stage 2	856108	1054	4.7	4.3	5.11
hypertension crisis	318714	444	1.7	1.51	2.01
Diastolic					
normal	10107434	9327	55.9	54.69	57.18
pre hypertension	5360932	5514	29.7	28.63	30.73
stage 1	1851249	2056	10.2	9.62	10.91
stage 2	534421	605	3	2.66	3.29
hypertension crisis	213559	257	1.2	1	1.4

Table 1 shows the socio-demographic profile of the respondents during the NHMS 2015 study. A total of 18,373 adults aged 18 years and above in Malaysia participated in this research. The mean age of adults was 43.8 years with standard deviation of 16.2. Nearly three quarters of the respondents reside in urban areas, with equal distribution according to sex. In terms of ethnicity, 49.0% of the respondents were Malays, followed by Chinese (22.7%), Other Bumiputras (11.3%), Others (10.3%) and Indians (6.8%). Majority of the respondents were Malaysian citizens. It was also noted that more than half of the respondents had low income (MYR4999).

Nearly two third of the respondents had normal fasting sugar while those who were diabetic were 24.4%. Nearly half of the respondents had desirable cholesterol levels while 20.7% had high cholesterol. The systolic pressure was high in prehypertension stage (44.5%) while 33.4% had normal systolic pressure. More than half of the respondents had normal diastolic pressure (55.9%) while those who were in prehypertension stage were 29.7%.

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Table 2. Distribution of respondents among Malaysian adults aged 18 years and over according to anthropometry indicator.

Variable	Estimated population	n	Median	Interquartile	
				Q1	Q3
Anthropometric indicator					
Weight	18601077	18373	63.60	54.50	74.30
Height	18601077	18373	160.20	154.00	166.80
BMI	18601077	18373	24.70	21.58	28.42
Waist circumference	18601077	18373	85.00	76.00	93.00
WHtR	18601077	18373	0.53	0.48	0.58

The median for WHtR for Malaysian population was 0.53. Median BMI was 24.7 kgm^2 while median for waist circumference was 85.0 cm.

Table 3: Cut-off points for ethnicity and BMI

Variable	Malay	Chinese	Indian	Other Bumiputra	Others
Men					
BMI	23.7	24.4	23.3	NA	NA
WC	82.9	82.9	86.2	NA	NA
WHtR	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**
Women					
BMI	24.9	23.9	24.6	NA	NA
WC	79.8	78.7	82.1	NA	NA
WHtR	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**

Table 3 shows the simplicity of WHtR cut-off points in comparison with cut-off points for BMI (Kee C.C et al,2011). It showed the ratio of 0.5 was the same for all the major ethnic groups in Malaysia while BMI had a different cut-off point for each ethnicity.

Table 4: Percentage of WHtR for age groups among respondents

Age Group (years)	WHtR	
	No Risk (n /%)	Risk (n/%)
18-24	1415 (59)	983(41)
25-44	2227(32)	4742(68)
45-64	886(15.9)	5230(84.1)
> 65	344(16.6)	1730(83.4)

Table 4 showed that risk of WHtR increases as the age increases with the highest risk reported among those aged 45-64 years old.

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Table 5: Adults misclassified by BMI revealed by WHtR

BMI Group	WHtR						Percentage of each sex at risk by WHtR but missed by BMI screening	Percentage of each sex at risk by BMI but not at risk by WHtR
	≤ 0.5			> 0.5				
	Estimate population	Count	Prevalence %	Estimate population	Count	Prevalence %		
Men							(1636/8858)=18.5	(272/8858)=3.1
Normal	3555045	2912	68	1670430	1636	32		
Overweight & obese	324777	272	7.2	4215091	4038	92.8		
Women							(1922/9515)=20.2	(264/9515)=2.8
Normal	2709405	2365	60.2	1792537	1922	39.8		
Overweight & obese	229312	264	5.3	4104480	4964	94.7		
All adults							(3558/18373)=19.4	(536/18373)=2.9
Normal	6264450	5277	63.8	3462967	3558	35.6		
Overweight & obese	554089	536	6.2	8319572	9002	93.8		
Total	6818539	5813	36.7	11782539	12560	63.3		

Table 3 shows results for adults misclassified by BMI but revealed by WHtR. There were 19.4% of respondents there were missed by BMI revealed by WHtR. About 2.9% adults were shown to be at risk by BMI but not at risk by WHtR.

Figure 1: Diagnostic accuracy of diabetes based on anthropometric indicators

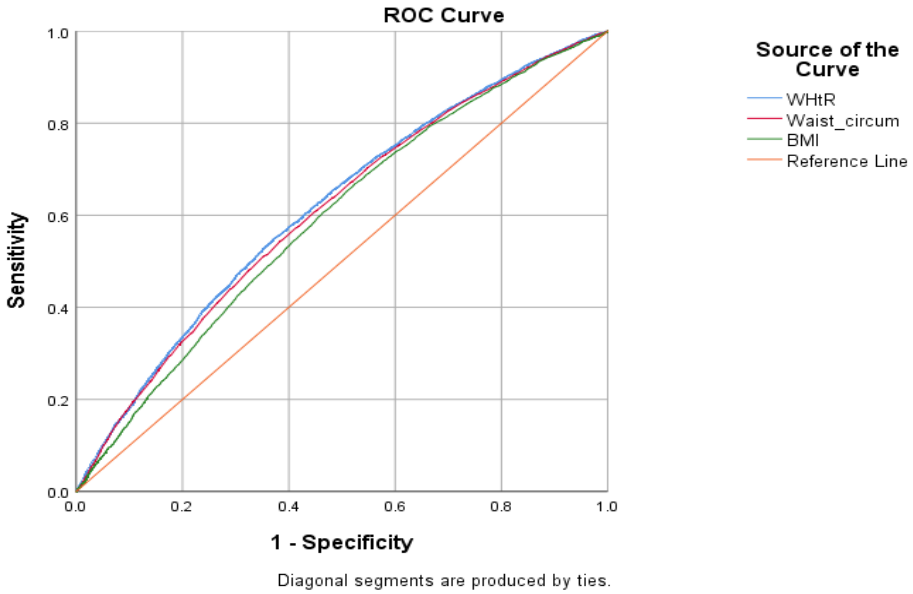

Figure 1 shows the area under ROC curve for BMI, WC and WHtR indicators, in relation to identify diabetes. All three anthropometric indicators presented with satisfactory performance and WHtR indicator was the one with greater discriminatory power (AUC=0.618, P<0.05).

Figure 2: Diagnostic accuracy of systolic based on anthropometric indicators

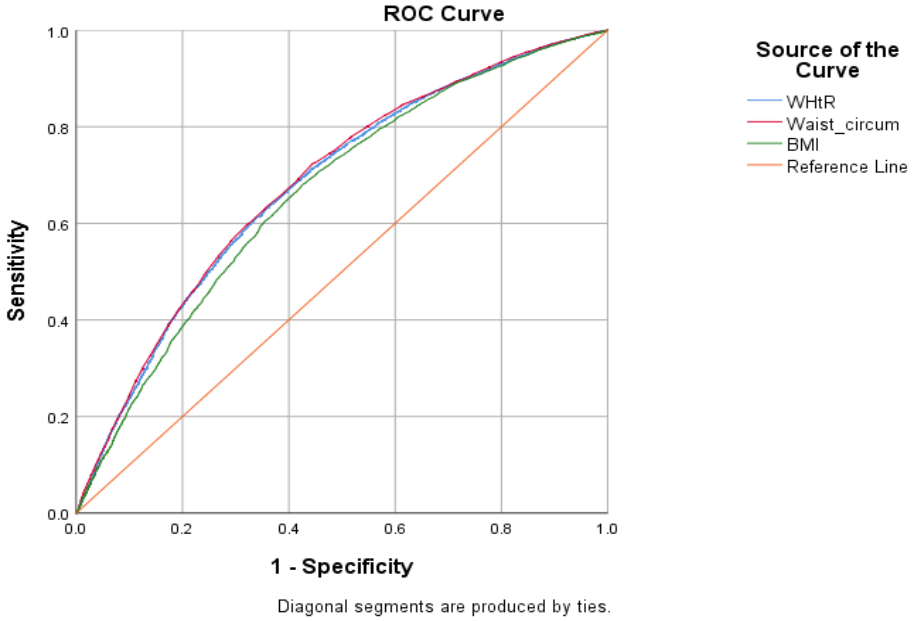

Figure 2 shows the area under ROC curve for BMI, WC and WHtR indicators, in relation to identify high systolic pressure. All three anthropometric indicators presented with satisfactory performance and WC indicator was the one with greater discriminatory power (AUC=0.684, P<0.05).

Figure 3: Diagnostic accuracy of diastolic based on anthropometric indicators

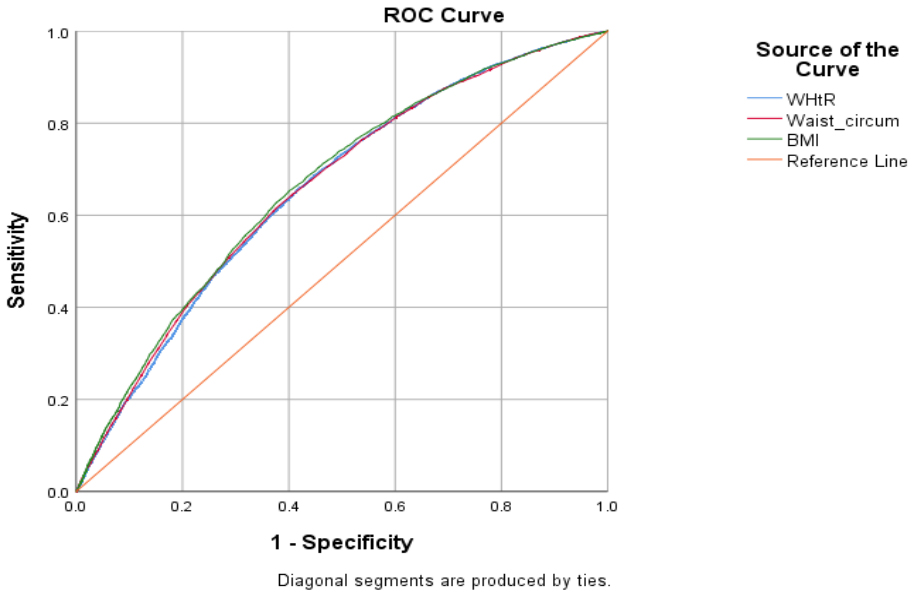

Figure 3 shows the area under ROC curve for BMI, WC and WHtR indicators, in relation to identify diastolic pressure. BMI indicator presented with greater satisfactory performance and discriminatory power (AUC=0.666, P<0.05).

Figure 4: Diagnostic accuracy of cholesterol based on anthropometric indicators

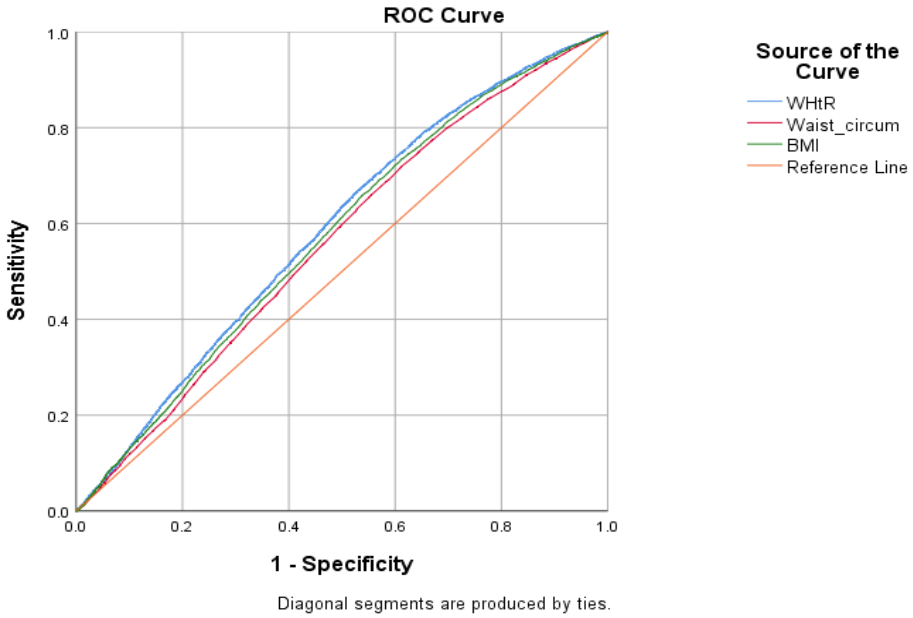

Figure 4 shows the area under ROC curve for BMI, WC and WHtR indicators, in relation to identify high cholesterol. All three anthropometric indicators presented with satisfactory performance and WHtR indicator was the one with greater discriminatory power (AUC=0.587, P<0.05).

Table 6: Correlation between systolic blood pressure (SBP), diastolic blood pressure (DBP), total cholesterol, diabetes with anthropometric indicators (WHtR, WC and BMI).

	Anthropometric parameters		
	WHtR	WC	BMI
SBP, mm Hg	0.353	0.338	0.294
DBP, mm Hg	0.317	0.325	0.336
Total cholesterol	0.173	0.122	0.147
Diabetes	0.226	0.205	0.180

There was statistical significance but weak correlation (p<0.001) among both evaluated anthropometric with regards to parameters of Systolic Blood Pressure, Diastolic Blood Pressure, Total Cholesterol and Diabetes variable.

4.0 Discussion

WHtR value of 0.5 coincides with the all the literature review available for adults regardless of age, ethnicity and gender. This ratio correlates with current international findings ratio of 0.5 [18,19]. This study showed that there were 20% of Malaysian population that were missed by BMI screening but found to be at risk by WHtR.

These findings showed that WHtR is a better correlate of health risk than BMI. These health risk refers to diabetes and hypercholesterolemia [20,21]. All three assessed anthropometric indices showed accuracy as a screening method for health risk. When we compared the areas under ROC curve, WHtR was the predictor for the better performance for diabetes and high cholesterol. There was not much significant difference for diastolic pressure and systolic pressure. In this way, the data confirmed that WHtR indicator has similar with discriminatory factor with BMI and WC in terms of diabetes, hypertension and high cholesterol screening. [22,23]

WHtR has proved to be a simple marker that can efficiently screen large population for NCDs in programs for health promotion. Therefore, Ashwell and Gibson recommend substituting the use of BMI with WHtR, arguing that is it simple, easy to interpret, low cost risk assessment tool, which is able to identify large number of people at metabolic risk. [24]

International literature confirms high explanatory power for BMI in the prevalence of metabolic disease, and is higher when all three measurements (BMI, WC and WHtR) are combined [25,26,27]. In this study, WHtR ability to determine prevalence of NCDs are higher than of BMI

Limitation of this study was that three blood pressure measurements were taken almost simultaneously. The criteria for clinical diagnosis of hypertension warrants that at least two readings are performed at different moments.

In the sample analysed, using the value of 0.53 allows identifying a large portion of overweight and obese individuals, since it correctly classifies 92.8% of men and 94.7% of women, which showed it is a valuable anthropometric marker for diagnosis of this nutritional disorder and health risk. It is already known and well documented in the literature worldwide that gender and age are risk factors for overweight, regardless the anthropometric marker used [28]. These findings agree with those observed in this study, in which a tendency of increase in WHtR is observed with increasing age [29]

In view of considering NHMS 2015 survey as one of the largest population-based survey in Malaysia, it can be concluded that a cut-off point of 0.5 for WHtR should be sufficient and acceptable to indicate Malaysian population that are at risk or increased health risk regardless of ethnicity, gender and age.

5.0 Conclusion and recommendation

WHtR is a simple tool that can be used for primary screening that identifies more people at early health risk compared to BMI and WC. These health risk includes diabetes, hypertension, stroke, dyslipidaemia and CVD [30]. However, anthropometric measurement is the first step in identifying and screening people at early health risk. More definite scores or clinical risk factors should be considered when further screening is required such as age, sex, ethnicity and socio-economic status [31].

The study showed the effectiveness of WHtR in screening early health risk compared to BMI and WC. The Ministry of Health, Malaysia should consider the potential benefits of WHtR and include using WHtR in their population-based studies.

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Ethnics declarations

Ethnics approved and concent to participate

This study was conducted following good clinical practice. The study protocol was approved by the Medical Research and Ethics Committee (MREC), Ministry of Health, Malaysia, with the registration number NMMR -14-1064-21877. .Prior to each interview, the purpose of the survey and methods used during the survey were explained to the respondent and information was handed out via the participants information sheet, before informed written consent was taken.

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Declaration

These authors declare that there is no conflict of interest in any form. There is no conflict of interest with the funder; no influence in the design, data collection, data analysis or the manuscript writing.

Authors contribution

Author 1: Topic selection and proposal drafting .Author 2: Analysis and methodology .Author 3: Results writing .Author 4: Discussion and Author 5: Referencing and editorial

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