International Journal of Women's Health

Dovepress
Taylor & Francis Group

Open Access Full Text Article

ORIGINAL RESEARCH

Comparative Analysis of Waist-Height Ratio and Heart Rate Recovery for Predicting Coronary Heart Disease Risk Among Working Malaysian Women

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Purpose: Coronary heart disease (CHD) is the most common cardiovascular disease leading to global mortality and is a major contributor to disability. As CHD is the main cause of death among women, early prediction of the risk of coronary heart disease would be useful. The Framingham risk score, waist-height ratio, and heart rate recovery have been used to predict CHD risk. The Framingham risk score is used to evaluate 10-year absolute risk of developing CHD. Waist Height Ratio is useful for early detection of the risk of heart disease in Malaysia, where obesity and metabolic syndrome are common across various demographics, because it is a reliable indicator of abdominal fat distribution. Heart Rate Recovery is a useful non-invasive method for early assessment of heart disease risk, featuring simplicity and the ability to represent both cardiovascular fitness and autonomic nervous system function. However, no study has compared waist-height ratio and heart-rate recovery as effective methods for predicting coronary heart disease. There is an increasing trend of CHD in Malaysia, particularly among females. Therefore, this study aimed to compare the effectiveness of waist-height ratio and heart-rate recovery in predicting the risk of coronary heart disease among working Malaysian women.

Methods: This is a cross-sectional study. Data on the Framingham risk score, waist-height measurement, and the 6-minute walk test (heart-rate recovery) were collected from 134 working women.

Results: The mean age of the participants was 39.13 ± 7.06 years. The results showed that the waist-to-height ratio had a weak but significant correlation with Framingham risk score ($r = 0.18$). However, heart rate recovery showed a negative correlation ($r = -0.029$) with the Framingham risk score.

Conclusion: The waist-height ratio is considered a more effective risk assessment method than heart-rate recovery for identifying the risk of coronary heart disease in working Malaysian women.

Keywords: cardiovascular disease, female, Framingham risk score

Introduction

Cardiovascular disease (CVD), one of the main causes of death globally,[1] is divided into different diagnoses including coronary heart disease (CHD), stroke, pulmonary artery disease, heart failure, pericardial disease, and congenital heart disease.[2] The majority of CHD-related mortality rates occur in low- and middle-income countries.[3] CHD was the largest contributor to CVD morbidity and mortality in both men and women. Men generally develop CVD at a younger age and have a higher propensity for developing CHD than do women.[4] Women have a high mortality rate when compared to the male in CHD.[4] The National Health and Nutrition Examination Surveys have reported an increasing trend of CHD among women, especially those in midlife (35–54 years).[5] There is an increasing trend of CHD in Malaysia, particularly among females. The percentage of females with CHD has increased from 11.4% in 2018 to 12.2% in 2019 and 13.4% in 2020.[6] Several factors contribute to the prevalence of CHD in Malaysia, including non-modifiable risk factors (such as

Received: 26 September 2024
Accepted: 20 February 2025
Published: 15 March 2025

a family history of heart disease) and modifiable risk factors (such as smoking, high blood pressure, diabetes, obesity, and an unhealthy diet).[7] The prevalence of other CHD risk factors such as diabetes and hypertension further contribute to the disease burden in Malaysia.[8] While data from the National Health and Morbidity Survey 2019 estimated that 18.3% of Malaysian adults have diabetes, coupled with 30.3% having hypertension, there is an overall increased risk of CHD.[9] In addition to that, female Malaysian adults have a high and fast-rising obesity rates.[9] About 30% of adult women are classified as obese, with percentages greater for those over 40 years old. Similarly, National Health and Morbidity Survey 2019 and the Malaysian National Diabetes Registry provided alarming data about diabetes and hypertension among Malaysian women: 18.3% of women over 30 have been diagnosed with diabetes, and 17.4% of women have hypertension.[9] Both disorders are closely associated with obesity and fat distribution, while abdominal obesity is highly significant in the development of the heart illness.[10,11]

Occupational risks, such as long working hours, job stress, and work-life imbalance, are common among women in the workforce and may be contributing factors to the rising incidence of CHD among working women.[12,13] As CHD is the main cause of death in Malaysia, it is important to establish the risk of CHD and prevent it early.

Invasive and non-invasive tests are used to determine the risk of CHD American Heart Association.[14] Invasive tests, such as cardiac catheterisation, blood lipid tests, and nuclear cardiac medicine imaging are commonly used to measure the risk of CHD.[15] Examples of non-invasive tests include the waist height ratio (WHtR), heart rate recovery (HRR), electrocardiogram, echocardiogram, carotid ultrasound, and stress tests.[14]

One of the most widely used methods is the Framingham Risk Score (FRS) which is the gold standard for evaluating the 10-year absolute risk of developing CHD.[16] The FRS (2008) risk used nine coronary risk factors, namely, age, sex, high-density lipoprotein, total cholesterol, cigarette smoke, diabetes, known vascular disease, diabetes, systolic blood pressure, and medication for hypertension to predict the risk of CHD.[17]

The WHtR, used to measure the distribution of body fat, is also related to CHD.[18] A systematic review reported that values of 0.5 or 0.6 indicate an increased risk of CVD and metabolic syndrome.[19] Various systematic reviews and meta-analyses have reported that WHtR is slightly superior to other anthropometric measurements for predicting health risks in adults.[19–22]

The HRR has also been found to predict CHD risk. A slow or abnormal HRR is reflected in impaired parasympathetic tone.[23] Abnormal or slow HRR is associated with impaired parasympathetic tone and predicts the risk of coronary artery disease.[24] It has been proposed that HRR not only helps predict CHD risk, but also predicts mortality related to CVD.[25]

WHtR and HRR are considered convenient for predicting the risk of CHD and can predict the early stage of CHD in the shortest time to create awareness among working women. However, there is no consensus regarding which method is easy, fast, and most accurate for predicting the risk of CHD. No study has compared these methods as specific measures to predict the risk of CHD among working women. The FRS, WHtR, and HRR have been used as risk indicators for CHD and are considered the primary methods for predicting the risk of CHD. They do not require professional or specialised equipment. Furthermore, the cost of these methods is higher than that of other methods, and will not be a burden on individuals, particularly those from low- and middle-income families. These methods are also considered basic fitness assessments and are suitable for different populations. This study aimed to compare the effectiveness of the WHtR and HRR in predicting the risk of CHD among Malaysian women.

Materials and Methods

This study was approved by the Universiti Malaya Research Ethics Committee (UM.TNC2/UMREC-232) and was conducted in accordance with the ethical standards in the 1964 Declaration of Helsinki. The study population consisted of working women aged 30–60 years from a university in urban Kuala Lumpur. Pregnant women and women with disabilities were excluded from this study. This study selected 30 years as the minimum age because the FRS is intended for use in people aged–30-70 years.

The required sample size for this study was determined through an a priori power analysis employing PS Power and Sample Size Calculations (version 3.1.6). This analysis considered several pivotal parameters to ensure the robustness and validity of the study. A significance level (α) of 0.05, which is commonly used in scientific research, was selected to control the probability of Type I errors. Simultaneously, a statistical power (1 - β) of 0.80 was chosen, representing an

80% chance of correctly detecting true effects, striking a balance between sensitivity and practicality. These parameters were complemented by a 5% margin of error and 95% confidence level, further enhancing the precision and reliability of the study. Based on this power analysis, it was determined that a minimum sample size of 109 participants is necessary to meet the study's objectives. A prudent oversampling strategy was implemented to account for potential withdrawal or attrition, ultimately recruiting 150 female participants, representing a 20% oversample above the minimum requirement.

Measurements

Demographic Form

Participants reported their demographic information, including their age and educational level. They also reported whether they smoked, had a history of CVD, or had used medications for hypertension.

The Framingham Risk Score

The FRS predicts a person's 10-year CHD risk and mortality rate in relation to other cardiac events.[19] Various risk factors such as sex, age, LDL, high-density lipoprotein, cigarette smoke, systolic blood pressure, and total cholesterol were included in the prediction model. The FRS is divided into three categories: below 10% considered as low risk, between 10–20% is an intermediate-risk and those more than 20% will be placed as high risk of CHD.[10,20]

Waist-Height Ratio

Studies have described the WHtR as a good and simple surrogate of the distribution of abdominal fat, having a close relationship with cardiovascular and metabolic risk factors and indices value superior to Body Mass Index.[26,27] These results emphasize WHtR as a non-invasive, simple and affordable for large-scale epidemiological investigations and early identification of high-risk groups. In Malaysia which has high rates of both obesity and metabolic syndrome, WHtR has been identified to predict the risk of heart disease especially amongst women.[9] Taking into consideration the varied population of Malaysia, as well as high rates of metabolic syndrome, such findings further emphasize the potential importance of WHtR as a useful marker for cardiovascular risk in Malaysia. The WHtR is used to measure visceral adiposity or obesity which are related to CHD.[18] A value of 0.5 or 0.6 indicates an increased risk of cardiovascular and metabolic syndrome.[19] Calculation of the waist-to-height ratio (WHtR) = waist/height.

Heart-Rate Recovery

HRR, a measure of cardiovascular fitness, is an important indicator of health risks such as cardiovascular disease and obesity, particularly among Malaysian women. Studies show that higher body fat and central obesity negatively affect HRR, linking it to autonomic dysfunction and metabolic risks.[28] The predictive ability of HRR at 1 or 2 min has been shown to be related to different cardiac events.[29–31] In this study, HHR was measured using a 6-minute walk test. It is a clinical test that assesses aerobic endurance and capacity, and successfully predicts morbidity and mortality rates related to several heart diseases.[32] For the 6-minute walk test, the HRR was taken one minute after the test and deducted from the peak exercise heart rate. An HRR of < 12 beats per minute was considered abnormal and indicated a risk of CHD.

Data Collection

Participants were invited to participate in the study via Email and word of mouth. Those who were interested in participating were given a short briefing, and those who agreed to participate completed a written informed consent form and demographic form prior to testing. First, blood samples were collected from the participants. Blood (6 mL) was collected by a staff nurse or a doctor. Participants were required to fast for at least six hours before the blood test. High-density lipoprotein and total cholesterol levels were obtained from fasting blood samples. Next, participants' heights were recorded. The participants were required to remove their shoes and socks before standing on a mobile portable stadiometer (Seca 213) (SECA, 2018). Waist measurements were obtained with the participants in a standing position from the top of the hip bone and iliac crest. The blood pressure was measured using a standard mercury sphygmomanometer. The 6-minute walk test was performed according to the guidelines of the.[33] The pre-exercise heart rate and pre-blood pressure for both arms and legs were measured before the 6-minute walk test. Participants were required to walk at a fast pace along a hallway between markers set 30 m apart, as many times as they could in six minutes. The participants'

heart rate was recorded every minute for a total of 6 minutes during the walk test. During the sixth minute, a marker was placed where the participants stopped and the distance was calculated. At the end of the test, participants were required to rest for 1 min, and 1st min HHR was recorded.

Statistical Analyses

IBM SPSS Statistics for Windows, Version 28.0.1, was used to conduct statistical analyses. Pearson's correlation was used to analyse the relationship between FRS and WHtR, as well as the relationship between FRS and HRR, and to compare WHtR and HRR to determine the most effective method for predicting the risk of CHD.

Results

A total of 134 participants were included in this study. The sociodemographic and clinical characteristics of the participants are summarised in Table 1. The mean age of the participants was 39.13 years, and nearly a quarter of them were aged between 40 and 50 years. The majority were married staff nurses from university hospital. The result of 139/80 is considered prehypertension, whereas a value of 120/80 is typically thought to be normal. In contrast, hypertension is usually identified when the blood pressure reaches or exceeds 140/90 mm Hg.

The FRS was calculated based on different risk factors (sex, age, total cholesterol, high-density lipoprotein, systolic blood pressure, medication for hypertension, smoking habit, diabetes, known vascular disease, and hypertension) and divided into three different categories (low, intermediate, and high risk). The majority (93.28%) of the participants were in the low-risk category, 2.23% in the intermediate-risk category, and 4.4% in the high-risk category. Data normality were checked based on skewness and kurtosis.[34]

Bryne[34] recommend that data is considered to be normal if skewness is between -2 to +2 and kurtosis is between -7 to +7. All data are normal except for the FRS.

In terms of WHtR, a boundary value of < 0.5 is considered low risk, 0.5–0.6 is considered increased risk, and greater than 0.6 is considered high risk.[35] Nearly half (44.02%) of the participants had increased risk, followed by 31.34% at high risk, and 24.62% at low risk.

Table 1 Demographic Data in Predicting Heart Disease Risk in Malaysian Working Women

	Mean (Standard Deviation)	**Frequency**	**Percentage (%)**
Age	39.13 (7.06)		
Total Cholesterol	5.097 (0.904)		
HDL	1.567 (0.478)		
Smoking			
Yes		127	94.8
No		7	5.2
Systolic Blood Pressure			
Normal		103	76.9
Pre-hypertension		22	16.4
Hypertension		9	6.7
On Hypertension Med			
Yes		105	78.4
No		29	21.6
History of Heart Disease			
Yes		138	99.3
No		1	0.7

HRR was calculated using the peak exercise heart rate – heart rate after the first minute = first minute HRR. Edwards[36] reported that the rate of HRR decline between 25 and 30 beats per minute is considered good, whereas a rate of 50 to 60 beats per minute is excellent. The range of the abnormal HRR was < 12 beats/min. Slightly more than one-third of the participants (35.07%) were in the excellent category, 24.62% were good, and 40.29% were abnormal.

The associations between the FRS, WHtR, and HRR were calculated based on Spearman correlation. Due to non-normality of FRS data, Spearman correlation was computed. The WHtR had a statistically significant ($p = 0.001$) but weak correlation (0.289) with the FRS. However, HRR was negatively (−0.166) and not significantly ($p > 0.05$) correlated with FRS.

These results show that when WHtR increase the FRS will also increase, meaning that the health risk will increased. However, in current result, the association is weak at 0.289. In contrast, HRR-FRS are inversely related showing a weak negative association at −0.166 ($p > 0.05$) ie, when HRR increase, the FRS will decrease and vice versa.

Discussion

We compared the effectiveness of WHtR and HRR in predicting the risk of CHD among working Malaysian women. The weak correlation between the FRS and WHtR may be because the sample size was small; therefore, the results were less conclusive. However, WHtR was still correlated with FRS. The results of this study showed that WHtR may be a more effective method than HRR for predicting CHD compared to HRR. Anthropometric measurements are frequently used to measure fat distribution and are associated with CHD risk. Numerous anthropometric measurements such as BMI, waist-hip ratio, waist circumference, and WHtR are easily applied and accessible to the population.

WHtR has been found to perform better than other anthropometric methods and shows more efficacious measures of CHD risk factors such as obesity.[37,38] The accumulation of fat tissue in the abdominal area increases the risk of CHD.[39] In addition, earlier research also recommended WHtR as a better indicator for determining CHD risk in women.[40] The cut-off value of 0.48 WHtR has been suggested as a better index to indicate the risk in the female Asian population.[37] However, a WHtR cut-off point of 0.5, has been suggested as suitable for both sexes among European populations.[35] The WHtR has also been reported to have a better correlation with all CHD risk factors and is related to CVD risk. WHtR accounts for height, which provides a better interpretation of the overall body shape and is more sensitive to the distribution of muscle mass (Table 2).

HRR was negatively correlated with FRS. Several studies have shown that HRR after exercise only predicts all-cause mortality, CHD death, and non-cardiovascular death.[41–43] HRR was not superior in predicting the risk of CHD but was associated with all-cause mortality in the general population. According to Vivekananthan, Blackstone,[23] the incidence or severity of CHD is not predicted by abnormal HRR, which only performs better in predicting mortality, but not the risk of

Table 2 Risk Factors Associated with CHD

Risk Factor	n (%)
Smoker	7 (5.22%)
Known vascular disease	1 (0.74%)
Hypertension	30 (22.38%)
Diabetes	7 (5.22%)
Cholesterol	
Low	77 (57.46%)
Intermediate	38 (32.08%)
High	19 (14.17%)
Low-density lipoprotein	
Low	38 (32.09%)
Intermediate	84 (62.68%)
High	12 (8.95%)

https://doi.org/10.2147/IJWH.S497927

CHD. A previous study confirmed HRR as a powerful prognostic measure for mortality, but not for the presence of CHD.[43]

According to Lipinski, Vetrovec,[44] the HRR within the first two minutes may predict the mortality rate related to CVD. Another study reported that the second minute of HRR was related to the risk of CHD.[44] The prevalence of CHD can be predicted by the second minute of the HRR. This finding showed that HRR is associated with CHD after the second, third, and fifth minutes of exercise testing but not after the first minute.[44] In this study, we focused only on the first minute of HRR. Previous research has shown that HRR in the first minute is more often used to predict mortality because it represents parasympathetic reactivation following exercise testing.[45]

However, Morshedi-Meibodi, Larson[46] and Lipinski, Vetrovec[44] reported that HRR after cessation of exercise is strongly related to a lower risk of CHD and other cardiac events and may serve as a predictive indicator of health outcomes, such as CVD.[24] Later on, Ghaffari, Kazemi[47] and Akyüz, Alpsoy[48] also reported that HRR can be used to predict the lower risk of CHD but not the severity risk.

We compared WHtR and HRR because both methods are considered primary prevention and a "gatekeeper" to diagnose the risk of CHD in the early stages. Validation studies of the WHtR and HRR in conjunction with the FRS can determine whether including these measures enhances the accuracy of predicting CVD risk among working women. They help to assess whether these additional measures provide added value beyond the traditional risk factors considered by the FRS. By evaluating their performance, researchers can determine whether incorporating WHtR and HRR enhances the predictive power of the FRS in identifying individuals at a risk of developing CVD. The final finding of this study was that the WHtR was compared with the HRR to predict the risk of CHD among working women. WHtR had a better correlation with FRS, implying that WHtR is more effective than HRR for predicting CHD risk. An advantage of using the FRS with anthropometric methods to measure CHD risk is that it provides an additional indicator for predicting CHD risk. Moy, Atiya[49] conducted a study of anthropometric methods and the FRS in predicting CVD risk among Malay males, where they proposed that the FRS integrated with anthropometric methods will perform more efficiently in predicting CHD risk. Additionally, owing to dietary and lifestyle changes, incorporating anthropometric methods and the FRS will also improve the accuracy of the prediction model to reduce the risk of CHD among working women by including multiple risk factors such as history of disease, level of physical activity, and obesity.

The lifestyle and demographic factors of Malaysian working women that might differentially affect their WHtR and their HRR than other populations.[50] Work-life balance, dietary habits, physical activity levels, age, marital status, and economic status all play a large role in determining their health metrics.[51,52] The stress of juggling work versus "home" is associated with WHtR but can undoubtedly affect the latter, while erratic meal times and sedentary jobs impact both WHtR and HRR.[51] Furthermore, lifestyle decisions can be influenced by religious beliefs and cultural conventions, which further affects these measurements.[51] These factors may reduce the prediction power of WHtR and HRR by introducing variability that is not taken into consideration by conventional predictive models.[50]

WHtR was presented as a stronger indicator of CHD risk when compared to other anthropometric methods according to Pasdar, Moradi[38] and HRR was proposed as an independent method to predict death from CVD and used as an indicator of CHD risk.[43] Additionally, these methods are useful for determining the risk of CHD. Working women can easily measure risks using these methods because they do not require professional or special equipment. Furthermore, the cost of these methods is lower than that of other methods, and will not be a burden on individuals, particularly those from low- and middle-income families. These methods are also considered basic fitness assessments and are suitable for different populations.

In this study, comparing WHtR to HRR, WHtR is thought to be a better predictor of the presence of risk of CHD among working women. The WHtR is considered an affordable and reliable method for identifying CHD risk. Based on previous studies, HRR was shown to predict mortality from all CVD-related causes but not the risk of CHD.[41,42]

The present study was designed and conducted with careful consideration; however, it inevitably had limitations. The results and their generalizability may be affected by these limitations, which include the specifics of the sample and potential confounding variables such as obesity, smoking, physical activity levels, and functional aerobic capacity.[43,53–56] The majority of the participants were staff nurses and may not be representative of working Malaysian women. The external validity of the results could be limited if the sample is small and or homogeneous and does not adequately

represent larger populations and the findings may not generalize well to more diverse groups. Future studies should focus on larger, more diverse samples across a range of age groups, ethnicities, and geographic locations to address these issues. Meanwhile, the response and behaviour of the participants may be affected by their demographic characteristics, such as age, gender, socio-economic status, and cultural background. Participants in the study who are of different characteristics that have better access to these tools may react differently and show different results on measures.[57] Additionally, they should control for other variables to isolate the impact of HRR on CVD risk. Further evidence of HRR's long-term predictive efficacy could be obtained through longitudinal research. By differentiating between cardiac and non-cardiac events, incorporating HRR into clinical prediction models for CVD could enhance its usefulness. Furthermore, it is crucial to validate HRR derived from submaximal exercise testing as an independent prognostic marker and a reliable fitness measure across various groups. Addressing these limitations in future research could improve the precision and applicability of HRR as a tool for evaluating cardiovascular risk and health outcomes.

Conclusion

The results show that, especially for working women, the WHtR is a better indicator of CHD risk than HRR. When combined with the FRS, WHtR is a dependable and reasonably priced tool that offers a more thorough risk assessment. More study is required to investigate at ethnic-specific risk factors and adiposity markers in bigger cohorts, particularly in females, given Malaysia's multiethnic population. Longitudinal analysis and the therapeutic incorporation of WHtR into standard examinations should be the main topics of future research. Testing WHtR in a variety of groups, investigating how it interacts with culture and lifestyle factors, and improving early CHD identification using risk models specifically designed for Malaysian working women are among the recommendations.

Data Sharing Statement

Data is available upon reasonable request.

Ethical Approval Statement and Consent to Participate

This study was approved by the University of Malaya Research Ethics Committee (UM.TNC2/UMREC-232). Participation in the study was voluntary and written informed consent was obtained.

Author Contributions

Chizheng Tang: Formal analysis, Investigation, Project administration, visualisation, writing – original draft. **Azmi Mohamed Nahar**: Conceptualisation, methodology, project administration, Supervision, Writing – review, and editing. **Eng Wah Teo**: Formal analysis, visualisation, writing – original draft. **Selina Khoo**: Funding acquisition, Methodology, Project administration, Supervision, Writing review, and editing. All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

This study was supported by a grant from the Universiti Malaya (RP047A-17HTM).

Disclosure

The authors report no conflicts of interest in this work.

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