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Agreement between hypertriglyceridemic waist and hypertriglyceridemic waist height in rotating shift workers

Concordância entre cintura hipertrigliceridêmica e cintura estatura hipertrigliceridêmica em trabalhadores em turnos alternantes

Abstract

Objective: This study evaluated the agreement between hypertriglyceridemic waist and hypertriglyceridemic waist height phenotypes and the association of these phenotypes with anthropometric, biochemical, and clinical alterations in adult men with increased metabolic risk due to rotating shift exposure. ***Methods:*** The cross-sectional study included 678 male workers. The hypertriglyceridemic waist phenotype was defined as waist circumference ≥ 94 cm and triglyceride concentration ≥150 mg/dL; the hypertriglyceridemic waist height phenotype was defined as a height-waist ratio ≥0.5 and triglyceride concentration ≥ 150mg/dL. Body mass index, blood pressure, total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, triglyceride, and glucose levels were evaluated. The Kappa test was used to assess the concordance between phenotypes, and the Pearson's chi-square tests were used to verify the association between phenotypes and risk components for cardiovascular diseases. For all tests, the significance level was 5%. ***Results:*** The agreement between the hypertriglyceridemic waist and the hypertriglyceridemic waist height phenotypes was significant and substantial. Both phenotypes were significantly related to increased body mass index, total cholesterol, high-density lipoprotein cholesterol, and blood pressure. ***Conclusion:*** We propose the use of hypertriglyceridemic waist-to-height ratio as it demonstrated associations that persisted regardless of the age group and also identified a higher proportion of rotating shift workers with cardiovascular risk components.

Keywords: Risk Factors. Cardiovascular Diseases. Triglycerides. Anthropometry.

Resumo

Objetivos: Avaliar a concordância entre fenótipo de cintura hipertrigliceridêmica e fenótipo cintura estatura hipertrigliceridêmica, e a associação desses fenótipos com alterações antropométricas, bioquímicas e clínicas em homens adultos com risco metabólico aumentado pela exposição ao turno alternante. ***Métodos:*** Estudo transversal realizado com 678 trabalhadores do sexo masculino. O fenótipo de cintura hipertrigliceridêmica foi definido pelo perímetro da cintura ≥ 94 cm e triglicérides ≥ 150 mg/dL; o fenótipo cintura estatura hipertrigliceridêmica pela razão cintura estatura ≥ 0,5; e triglicérides ≥ 150mg/dL. Foram avaliados o índice de massa corporal, pressão arterial, colesterol total, *high-density lipoprotein* colesterol, *low-density* *lipoprotein* colesterol, triglicérides e glicemia de jejum. O teste Kappa foi utilizado para avaliar a concordância entre os fenótipos e o teste Qui-quadrado de Pearson, para verificar a associação entre os fenótipos e os componentes de risco para doenças cardiovasculares. Para todos os testes, o nível de significância adotado foi de 5%. ***Resultados:*** A concordância entre o fenótipo de cintura hipertrigliceridêmica e o fenótipo cintura estatura hipertrigliceridêmica foi significativa e substancial. Ambos fenótipos foram relacionados significativamente com índice de massa corporal, colesterol total, *high-density lipoprotein* colesterol e pressão arterial aumentados. ***Conclusões:*** Sugere-se o uso do fenótipo cintura estatura hipertrigliceridemica, já que demonstrou associações que se mantiveram independentemente da faixa etária e identificou maior proporção de trabalhadores em turnos alternantes com componentes de risco cardiovascular.

Palavras-chave: Fator de risco. Doenças cardiovasculares. Triglicerídeos. Antropometria.

INTRODUCTION

The identification of cardiovascular diseases (CVD) risk is based on the joint analysis of modifiable risk factors, which enables the screening of asymptomatic individuals susceptible to disease development.[1] Several indicators are proposed for CVD risk in the literature, include the hypertriglyceridemic waist phenotype (HW), which is defined as the simultaneous presence of hypertriglyceridemia and elevated waist circumference (WC).[2] The use of HW has been suggested as it is related to small and dense low-density lipoprotein (LDL) cholesterol, insulin, and apolipoprotein B levels.[2] The simultaneous presence of these three components is characterized as an atherogenic metabolic triad and is used to identify individuals at high risk for cardiovascular outcomes.[3,4] Individuals with HW have 1.24- to 2-fold increased risks for stroke and myocardial infarction.[5]

WC present in the phenotype is one anthropometric method used to identify abdominal adiposity accumulation.[6] However, other anthropometric methods used to assess abdominal adiposity include waist-hip ratio (WHR)[6] and waist-height ratio (WtHR).[7] Recent studies have shown that WtHR is a better anthropometric indicator to identify excess abdominal adiposity, which is highly correlated with visceral fat,[7] body adiposity excess[8] and the components for CVD risk compared to WC, body mass index (BMI), and WHR.[9,10]

In addition to the classic behavioral factors for CVD risk (physical inactivity, inadequate diet, alcohol consumption, and tobacco use),[1] some occupational groups are more susceptible to cardiovascular risk factors, including those with shift work schedules. This may contribute to an unfavorable cardiometabolic profile due to conflicts with endogenous circadian rhythms and the promotion of metabolic alterations.[11] Shift workers have a higher prevalence of cardiovascular disease risk factors such as increased glucose level, increased blood pressure (BP), altered lipid profiles, and obesity compared to those in day shift workers.[12]

Shift work includes any arrangement of the daily work schedule in addition to standard daytime hours (7 am/8 am to 5 pm/6 pm) such as night and rotating shifts (work shifts at alternate times).[13] In the rotating shift, workers take turns working on all shifts on a specific schedule system. This type of work has a wide variety of working times and can be continuous (24 hours a day, 7 days a week), or semi-continuous (2 or 3 shifts a day), with or without weekends.[14]

Therefore, due to the recent findings regarding the superiority WtHR to identify individuals at cardiovascular risk and the absence of information on the replacement of WC for WtHR in HW in adults, as well as the specificity of the studied population, the present study hypothesized that the HWHtR has a greater capacity than HW to identify individuals with cardiovascular risk factors. This study aimed to assess the agreement between HW and HWHtR, and their association with anthropometric and biochemical factors and clinical alterations in adult men at increased metabolic risk due to rotating shift exposure.

METHODS

Design and study population

A cross-sectional study conducted with rotating shift workers, adult males, from a mining company in Minas Gerais. The study population corresponded to off-road truck drivers who participated in the Fatigue Management Project, in a survey entitled “Metabolic syndrome in mining workers in the state of Minas Gerais”, a screening study to identify the prevalence of cardiovascular risk factors in this population. The 952 shift workers were invited to participate in the study; after exclusions due to refusals, vacations, absences, and resignations, 699 individuals answered the questionnaire and provided biological samples. The exclusion criterion was female sex (n = 21); thus, the analysis included 678 workers.

To maintain the company's continuous 24-hour production process, there are four, 6-hour shifts. Each worker completes a 6-hour shift, followed by 12 hours of rest between the shifts. The work shifts are from 7:00 pm to 1:00 am, from 1:00 pm to 7:00 pm, from 7:00 am to 1:00 pm, and from 1:00 am to 7:00 am. After completing the cycle of four shifts, each worker has 24 hours off (day off) the next day.

Data collection

Data collection was performed in the laboratórios de Cardiometabolismo, e de Epidemiologia das Doenças Parasitárias da Escola de Medicina da Universidade Federal de Ouro Preto (Cardiometabolism and Epidemiology of Parasitic Diseases laboratories at the Medical School of the Federal University of Ouro Preto). The biochemical analyses were performed at the Pilot Laboratory of Clinical Analysis of the School of Pharmacy at the Federal University of Ouro Preto. All eligible workers received, along with the invitation to participate in the study, a letter of recommendation for blood collection and BP, and anthropometric measurements. The participants were requested to fast for 8–10 hours, abstain from physical exercises in the 60 minutes before data collection, and to not smoke in the 30 minutes before BP measurement.

Sociodemographic data were obtained through a structured questionnaire applied face-to-face and were grouped into a) age: two age groups according to the median [50th percentile] of the sample; b) education: elementary school (incomplete elementary school, complete elementary school, incomplete high school), secondary education (complete high school, incomplete higher education), technical, and complete higher education; c) skin color: (self-reported) white, black (black, mulatto, and brown), and others (yellow, indigenous, and mestizo; and d) marital status: married (married or in a stable relationship) and not married (single, separated/divorced, and widowed).

HW was defined as the simultaneous presence of WC ≥94 cm and triglyceride concentration ≥150 mg/dL.[1,2,15] Hypertriglyceridemic waist-to-height ratio (HWHtR) was defined as the simultaneous presence of waist-to-height ratio (WtHR) ≥0.5 and triglyceride concentration ≥150 mg/dL.[1,16,17]

Height was measured using a portable stadiometer AlturExata® (AlturExata, Belo Horizonte, Minas Gerais, Brasil) with each participant standing with his upper limbs hanging by his side, head held high, looking at a fixed point at eye level, and his feet together forming a 90° angle with his legs. The heels, shoulders, and buttocks were in contact with the stadiometer.18 Weight was measured using a portable body composition monitor (TANITA® model BC554) with a maximum capacity of 150 kg and accuracy of 0.1 kg (Tanita Corporation of America Inc., Arlington Heights, Illinois, USA). During the measurement, the participants wore as little clothing as possible, standing with their body erect and upper limbs hanging by their side.18 The body mass index (BMI) was calculated using the formula weight (kg)/height (m)^2, with overweight defined as ≥25.0 kg/m2.6

The waist circumference was measured, in triplicate, with a simple and inelastic measuring tape placed at the midpoint between the iliac crest and the last costal arch during expiration. The participants were in an upright position, with their arms extended at their sides and their weight evenly distributed on both lower limbs.15 Mean WC values ≥94 cm were considered as increased WC.15 The waist-height ratio (WtHR) was calculated using the formula WC (cm)/height (cm) and WtHR values ≥0.50 indicating increased WtHR.17

Blood pressure (BP) was measured in triplicate with a digital semiautomatic device (Omron Healthcare, Inc., Intellisense, Bannockburn, Illinois, USA). The measurement protocol followed the recommendations of the Brazilian Society of Cardiology:19 before starting the measurement, the participant rested for 3–5 minutes in a calm environment. He was also previously instructed not to talk during the measurement, to have an empty bladder, and to not drink coffee before the measurement. For the measurement, the participant was seated, with legs uncrossed, feet flat on the floor, back against the chair, and relaxed. The arm was positioned at heart level, supported, with the palm facing upwards. Participants were asked to remove long-sleeved or tight-fitting shirts. For the selection of the cuff size, the brachial perimeter was measured at the midpoint between the acromion and olecranon, with the limb flexed at 90°, with the reading performed with the arm extended. The cuff was positioned 2–3 cm above the cubital fossa, without looseness, and with the compressive part of the cuff centered on the brachial artery. The BP values were determined as the average of the measurements and were classified as increased for systolic blood pressure (SBP) ≥140 mmHg or diastolic blood pressure (DBP) ≥90 mmHg, or antihypertensive drug use.19

Biochemical samples were collected after a 10-hour fast and analyzed at the Pilot Laboratory of Clinical Analysis of the School of Pharmacy at the Federal University of Ouro Preto. Serum levels of total cholesterol, HDL cholesterol, and triglycerides were determined by colorimetric enzymatic methods using Bioclin® kits (Belo Horizonte, Brasil), while LDL cholesterol level was assessed using the Friedewald equation.20 Total cholesterol values ≥190 mg/dL, HDL ≤40 mg/dL, and LDL ≥130 mg/dL, and triglyceride concentration ≥150 mg/dL were considered to be altered.1 Glycemia was assessed using the fasting glucose values, which was determined by a colorimetric enzymatic method using a Bioclin® kit (Belo Horizonte, Brazil), with values ≥100 mg/dL indicating increased glycemia.21

Statistical analysis

Categorical variables are presented as absolute (n) and relative (%) frequency values. Age is presented as means and standard deviation, median, and 25th and 75th percentiles. Kappa tests were performed to assess the agreement between HW and HWHtR, which was classified as described by Landis & Koch.[22] The McNemar test was used to assess the difference between HW and HWHtR frequencies. Pearson's Chi-square tests were used to evaluate the relationship between HW and HWHtR and anthropometric, biochemical, and clinical variables. Data were evaluated according to the total number of participants and the 50th percentile of age. The level of significance was an α of 5%. Statistical analyses were performed using the IBM SPSS Statistics for Windows, version 22.0 (IBM Corp., Armonk, NY, USA).

Ethical considerations

This study was approved by the Research Ethics Committee of the Federal University of Ouro Preto (CAAE:0018.0.238.000-11). All participants signed an informed consent form.

RESULTS

Among the population of 952 rotating shifts workers, 678 participated in the study, corresponding to a 28.8% (n = 274) loss. Through data from the previous year's periodic examinations, we verified that the age, body mass index, glucose, diastolic BP, total cholesterol and fractions and triglycerides did not differ between participants and non-participants (data not shown). The study population comprised 678 workers aged 21 to 58 years, with mean and median ages of 35.0 (± 7.1) and 34 (30–40) years respectively. Regarding self-reported skin color, 35.3% (n = 247) were white; 57.8% (n = 404) were black; and 6.9% (n = 48) were yellow, indigenous, or mestizo. Most participants were married (67.1%, n = 469). Regarding education, 10.6% (n = 74) had completed elementary school; 65.7% (n = 459) had completed high school; 21.3% (n = 149) had completed technical courses; and 2.4% (n = 17) had completed higher education.

Based on HW, 129 (19.0%) shift workers were at risk for developing cardiovascular diseases, while the HWHtR identified 201 (29.6%) workers. The total sample and both age groups showed higher frequencies of HWHtR compared to HW. At least 35% of workers showed alterations in anthropometric indicators of body fat (WC, WtHR, and BMI) and two lipid levels (triglycerides and total cholesterol). Comparisons of age groups showed higher frequencies of alterations in phenotypes, HW and HWHtR, anthropometric indicators of body fat (WC, WtHR, and BMI), glucose, and BP in workers aged 34 years or over ($p < 0.05$) (Table 1).

Table 1. Frequency of anthropometric, biochemical, and clinical alterations,overall and according to age group among 678 rotating shift workers at a mining company in Minas Gerais, 2010.

Anthropometric, biochemical, and clinical characteristics	Total		< 34 years		≥ 34 years		p-value*
	Absolute frequency (n)	Relative frequency (%)	Absolute frequency (n)	Relative frequency (%)	Absolute frequency (n)	Relative frequency (%)	
HW presence	129	19.0	45	13.6	84	24.1	≤ 0.001
HWHtR presence	201	29.6	81	24.5	120	34.5	0.005
Waist circumference ≥ 94 cm	276	40.7	98	29.7	178	51.1	≤ 0.001
height-waist ratio ≥ 0.50	484	71.4	197	59.7	287	82.5	≤ 0.001
Triglycerides ≥ 150 mg/ dL	240	35.4	105	31.8	135	38.8	0.058
Body mass index ≥ 25 kg/m^2	436	64.3	188	57.0	248	71.3	≤ 0.001
Total cholesterol ≥ 190 mg/ dL	325	47.9	148	44.8	177	50.9	0.117
HDL cholesterol ≤ 40 mg/ dL	177	26.1	84	25.5	93	26.7	0.707
LDL cholesterol ≥ 130 mg/ dL	184	27.8	80	24.4	104	31.0	0.056
Glycemia ≥ 100 mg/ dL	29	4.3	6	1.8	23	6.6	0.002
Altered blood pressure[a]	198	29.2	68	20.6	130	37.4	≤ 0.001

a: SBP ≥ 140 and/or DBP ≥ 90 or antihypertensive drugs use. HW: hypertriglyceridemic waist phenotype. HWHtR: hypertriglyceridemic waist height phenotype. HDL: high density lipoprotein. LDL: low density lipoprotein. * Pearson's chi-square test p-value when assessing the differences between age groups. LDL was assessed in 663 individuals. since 15 have triglycerides> 400 mg/dL.

In the total sample, the HW was related to alterations in BMI, total cholesterol, HDL, glucose, and BP. HWHtR was related to alterations in BMI, total cholesterol, HDL, LDL, and BP (Table 2). In workers under 34 years of age, HW was related to alterations in BMI, total cholesterol, and BP, while HWHtR was related to BMI, total cholesterol, HDL, and BP (Table 3). In workers aged 34 years or older, HW was related to alterations in BMI, total cholesterol, glucose, and BP and HWHtR to BMI, total cholesterol, HDL, and BP (Table 3).

Substantial agreement was found (Kappa coefficient: 0.716) when evaluating the agreement between HW and HWHtR, but HWHtR identified 10.6% more individuals at risk for CVD. the substantial agreement of the Kappa coefficient was maintained in both age groups (<34 years and ≥ 34 years) (table 4)

Table 2. Relationships of hypertriglyceridemic waist and hypertriglyceridemic waist height phenotypes with anthropometric, biochemical and clinical alterations of 678 rotating shift workers at a mining company in Minas Gerais. 2010.

Anthropometric, biochemical and clinical characteristics	Total					
	Hypertriglyceridemic waist phenotype			Hypertriglyceridemic waist height phenotype		
	Presence n (%)	Ausence n (%)	p-value	Presence n (%)	Ausence n (%)	p-value
Body mass index ≥ 25 kg/m^2	128 (99.2)	308 (56.1)	≤ 0.001	183 (91.0)	253 (53.0)	≤ 0.001
Total cholesterol total ≥ 190 mg/dL	83 (64.3)	242 (44.1)	≤ 0.001	132 (65.7)	193 (40.5)	≤ 0.001
HDL cholesterol ≤ 40 mg/ dL	43 (33.3)	134 (24.4)	0.038	71 (35.3)	106 (22.2)	≤ 0.001
LDL cholesterol ≥ 130 mg/ dL	38 (30.9)	146 (27.0)	0.389	64 (33.9)	120 (25.3)	0.027
Glycemia ≥ 100 mg/ dL	11 (8.5)	18 (3.3)	0.008	13 (6.5)	16 (3.4)	0.067
Altered blodd pressure[a]	57 (44.2)	141 (25.7)	≤ 0.001	83 (41.3)	115 (24.1)	≤ 0.001

a: SBP ≥ 140 and/or DBP ≥ 90 or antihypertensive drugs use. HDL: high density lipoprotein. LDL: low density lipoprotein.

Table 3. Relationships of hypertriglyceridemic waist and hypertriglyceridemic waist height phenotypes with anthropometric. biochemical and clinical alterations. by age group. among 678 rotating shift workers of a mining company in Minas Gerais. 2010.

Anthropometric, biochemical and clinical characteristics	< 34 years						≥ 34 years					
	Hypertriglyceridemic waist phenotype			Hypertriglyceridemic waist height phenotype			Hypertriglyceridemic waist phenotype			Hypertriglyceridemic waist height phenotype		
	Presence n (%)	Ausence n (%)	p-value	Presence n (%)	Ausence n (%)	p-value	Presence n (%)	Ausence n (%)	p-value	Presence n (%)	Ausence n (%)	p-value
Body mass index ≥ 25 kg/m^2	45 (100)	143 (50.2)	≤ 0.001	73 (90.1)	115 (46.2)	≤ 0.001	83 (98.8)	165 (62.5)	≤ 0.001	110 (91.7)	138 (60.5)	≤ 0.001
Total cholesterol ≥ 190 mg/dL	29 (64.4)	119 (41.8)	0.004	58 (71.6)	90 (36.1)	≤ 0.001	54 (64.3)	123 (46.6)	0.005	74 (61.7)	103 (45.2)	0.003
HDL cholesterol ≤ 40 mg/ dL	16 (35.6)	68 (23.9)	0.094	31 (38.3)	53 (21.3)	0.002	27 (32.1)	66 (25.0)	0.198	40 (33.3)	53 (23.2)	0.043
LDL cholesterol ≥ 130 mg/ dL	10 (22.2)	70 (24.7)	0.715	25 (31.6)	55 (22.1)	0.085	28 (35.9)	76 (29.6)	0.290	39 (35.5)	65 (28.9)	0.223
Glycemia ≥ 100 mg/ dL	1 (2.2)	5 (1.8)	0.588*	1 (1.2)	5 (2.0)	0.544*	10 (11.9)	13 (4.9)	0.025	12 (10.0)	11 (4.8)	0.065
Altered blood pressure[a]	15 (33.3)	53 (18.6)	0.023	25 (30.9)	43 (17.3)	0.009	42 (50.0)	88 (33.3)	0.006	58 (48.3)	72 (31.6)	0.002

a: SBP ≥ 140 and/or DBP ≥ 90 or antihypertensive drugs use. HDL: high density lipoprotein. LDL: low density lipoprotein.. *Fisher´s exact test.

Table 4. Agreement between the hypertriglyceridemic waist and hypertriglyceridemic waist height phenotypes. overall and by age group among 678 in rotating shift workers at a mining company. Minas Gerais. 2010

Hypertriglyceridemic waist-height phenotype	Hypertriglyceridemic waist phenotype					
	Total		< 34 years		≥ 34 years	
	Presence n (%)	Ausence n (%)	Presence n (%)	Ausence n (%)	Presence n (%)	Ausence n (%)
Presence	129 (19.0)	72 (10.6)	45 (13.6)	36 (10.9)	84 (24.1)	36 (10.3)
Ausence	0 (0.0)	477 (70.4)	0 (0.0)	249 (75.5)	0 (0.0)	228 (65.5)
Kappa coefficient	0.716		0.654		0.754	

DISCUSSION

In the present study, approximately one-fifth of the participants had HW (19.0%) and almost one-third of had HWHtR (29.6%), despite being a young rotating shift work population. Age influenced the presence of phenotypes; workers aged 34 years and over had higher frequencies compared to those in younger workers. To our knowledge, no other studies have assessed these phenotypes in rotating shift workers. Comparison of our findings with those of adult men showed a reported prevalence of HW ranging between 14.0 and 24.7% [4,16,23] and 28.8% for HWHtR.[16] The frequencies of these phenotypes were similar to those reported previously, an unexpected observation as rotating shift workers have higher altered frequencies of risk factors associated with the development of. cardiovascular diseases compared to day shift workers.[12] However, the "healthy worker effect" may be present or may underestimate the occurrence of health problems as active workers are healthier and more apt to work compared to those who are out of the labor market for health problems.

The variation in prevalence between previous and the present study can be explained by different cutoffs for WC, WtHR, and triglycerides. For example, the International Diabetes Federation (IDF)[24] uses specific WC cutoffs for different populations (South American men WC ≥90 cm), whereas the National Cholesterol Education Program - Adult Treatment Panel III (NCEP-ATP) uses a different value (men WC ≥102 cm),[25] as does the World Health Organization (WHO)[25] and the Ministry of Health,[26] (men WC ≥94 cm).

There remains no consensus on the cutoff for WtHR; thus, different cutoffs are used in the literature. The present study used the cutoff (WtHR ≥0.50) suggested by Browning et al.[17] to allow comparison with shift workers worldwide,[27] mainly for participants having a differentiated rotating shift schedule (6h/12h). Browning et al.[17] performed a systematic review of the cutoff to identify mortality, cardiometabolic disease, or cardiometabolic risk outcomes and proposed a single value for different ethnicities (WtHR ≥0.50).[17] Recent Brazilian studies have reported higher values (0.52 and 0.54). The Brazilian population-based study in adult men, which proposes a WtHR of ≥0.52, used BMI as an outcome.[28] The Brazilian study that proposed a WtHR of ≥ 0.54 included active and retired employees from teaching and research institutions ranging in age from 35 to 54 years, using the presence of two factors of the metabolic syndrome as an outcome.[29] The WtHR is used in the HWHtR phenotype because it reflects abdominal fat accumulation (visceral fat); however, none of these previous studies analyzed this variable. Based on the above considerations, future studies are needed to identify a WtHR cutoff value with better sensitivity and specificity to identify visceral fat.

The results of the present study showed a higher prevalence of alterations in BMI, total cholesterol, HDL, LDL, glucose, and BP among individuals with HW and HWHtR compared to those in individuals without these phenotypes. The association of these risk factors with the phenotypes is explained by the fact that WC and WtHR reflect visceral fat; hence, when increased, they result in high levels of very-low-density lipoprotein (VLDL) secretion, producing increased secretion of adipokines and mediators inflammatory cells and insulin resistance.[30] These events contribute to atherosclerotic processes such as endothelial vasomotor dysfunction, hypercoagulability, glucose intolerance, and dyslipidemia.[30] High triglyceride levels are also associated with low HDL levels and high small and dense LDL particles levels.[1] However, there is no biological explanation for the observed difference: the association of HW with only glucose and HWHtR with only LDL. Other studies have shown an association between HW[4,16,23] and HWHtR[16] with alterations in lipid profile, glycemic profile, BP, and body fat indicators.

In rotating shift workers, both HW and HWHtR were good indicators of alterations in BMI, total cholesterol, and BP as the associations were maintained regardless of age group. Both phenotypes were indicators of altered BP, in a population of predominantly black-brown men at higher risk. The literature shows higher frequencies of BP in men compared to women among individuals under 50 years of age,[31] and between individuals with black skin color.[32] Regardless of age group, only HWHtR maintained an association with HDL. In individuals aged 34 years or older, only HW showed an association with impaired glucose. Other studies based on the HW and HWHtR phenotypes did not assess differences between age groups.[4,16,23]

Besides HW and HWHtR, other methods to assess the risk of cardiovascular disease development include the Framingham score and metabolic syndrome. The Framingham score uses information on age, HDL level, total cholesterol level, BP, smoking, and diabetes.[33] Metabolic syndrome uses information on WC; levels of glucose, triglycerides, LDL; and BP.[24,25] Compared to these risk screening methods, HW and HWHtR are low-cost, as only serum triglyceride levels are required, without sophisticated equipment for measuring WC and height; therefore, they are easier to use for screening individuals at potential risk for cardiovascular diseases, especially in poorer communities.

The HWHtR was superior to the HW both in the present and previous studies. Previous studies demonstrated the superiority of WtHR compared to WC as a better anthropometric indicator to identify excess abdominal adiposity, which is highly correlated with visceral fat.[7] Excess visceral adiposity is associated with metabolic disorders and cardiovascular diseases[30] and is a better predictor of diabetes, dyslipidemia, and CVD risk compared to WC.[9] The results of the present study showed that, besides the association with BMI, total cholesterol and BP, the HWHtR maintained the association with HDL regardless of age group. Moreover, the HWHtR identified 10.6% more individuals at risk of cardiovascular disease, indicated that the HWHtR is more appropriate for screening.

Screening for cardiovascular risk in these workers is important since they have increased risks due to the region´s population characteristics[34] and shift schedule.[12] The participants worked in a region in which the population had a high prevalence of overweight, increased WC, and sedentary lifestyles.[34] Furthermore, rotating shifts are an additional risk factor for CVD development[12] by promoting increased exposure to modifiable CVD risk factors, especially inadequate nutrition and decreased physical activity.[35] Similarly, these shifts contribute to sleep deprivation and consequent alterations in circadian rhythm, causing imbalances of hormones including leptin, ghrelin, melatonin, and cortisol.[11] Alterations in these hormones promote hunger and satiety dysregulation that contribute to weight gain, fat deposition, visceral fat accumulation, increased BP, glucose metabolism dysfunctions, and dyslipidemias.[11]

The limitations of this study include the lack of data on the metabolic triad markers (low and dense LDL cholesterol, insulin, and apolipoprotein B levels) for comparison of phenotypes to confirm affirm the equivalence or superiority of the HWHtR compares to the HW. Therefore, further studies are needed to evaluate the discriminatory power of HWHtR for metabolic triad markers. As this study was conducted only in rotating shift workers, the potential of HWHtR as a universally accepted tool for the identification of adults at cardiovascular risk requires further validation by evaluating its utility in a representative sample of the Brazilian general population, including both sexes and different age groups.

CONCLUSION

The use of HW and HWHtR phenotypes can be applied to clinical practice since they show substantial agreement and use simple and low-cost indicators (WC, height, and triglyceride concentration). The HWHtR demonstrated associations with BMI, total cholesterol, HDL, and BP in the total population and maintained these associations regardless of age group. The HWHtR also identified 10.6% more individuals at risk of cardiovascular disease. Therefore, we propose the use of HWHtR in prevention action plans in this population.

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Contributors

Fajardo VC participated in the study design, data collection, data analysis and interpretation, manuscript writing, final review and manuscript approval for submission. Carvalho SR participated in the study design, data collection, data analysis and interpretation, manuscript writing, and manuscript approval for submission. Diniz AP participated in the data analysis and interpretation, manuscript writing, final review and manuscript approval for submission. Menezes Junior LAA participated in the data analysis and interpretation, manuscript writing, final review and manuscript approval for submission. Nascimento Neto RM participated in the study design, final review and manuscript approval for submission. Freitas SN participated in the study design, final review and manuscript approval for submission.

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