Available online at http://www.journalijdr.com

IJDR

ISSN: 2230-9926

International Journal of Development Research
Vol. 11, Issue, 12, pp. 52839-52843, December, 2021
https://doi.org/10.37118/ijdr.23618.12.2021

RESEARCH ARTICLE

OPEN ACCESS

PREVALENCE OF METABOLIC SYNDROME AND THE RELATIONSHIP BETWEEN RISK FACTORS AND BODY MASS INDEX IN YOUNG ADULTS

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ARTICLE INFO

Article History:

Received 11th September, 2021
Received in revised form
21st October, 2021
Accepted 04th November, 2021
Published online 28th December, 2021

Key Words:

Leadership Increases
Professionalism at ETCI.

Corresponding author: Viviane Soares

ABSTRACT

Background: The objective of the current study was to evaluate the prevalence of MSand its components, as well as to verify whether the body mass index is a predictor of the components of metabolic syndrome and to identify which factors best identify MS in young adults. **Methods:** This is a cross-sectional study, carried out with 111 young people. For the diagnosis of metabolic syndrome, waist circumference (WC), triglycerides (TG), blood glucose (BG), blood pressure (BP), and HDL-c were evaluated. **Results:** It was found that the prevalence of MS was 3.6%, and the most prevalent factor was HDL-c low (33.3%). Young people classified as pre-obese/obese presented greater WC (Δ=13.5 cm, $p<0.001$), systolic BP (Δ=6 mmHg, $p=0.01$), diastolic BP (Δ=8 mmHg, $p<0.001$), and higher plasma concentration of TG (Δ=24 mg/dL, $p=0.036$). BMI was shown to be a predictor of waist circumference, explaining 74% ($p<0.001$) of the relationship, followed by systolic (R^2=38%, $p<0.001$) and diastolic blood pressure (R^2=26%, $p<0.001$) and serum triglyceride concentration ($p=0.007$). The principal components analysis indicated BP, WC, and TG (explaining 34% of MS and eigenvalues >0,40)as the set of variables that best identified the syndrome. **Conclusions:** Prevalence of MS was lower than indicated in the literature for young adults of the same age group.

Citation: ***Albertino De Jesus, Dr. Lucas Da Costa, S.E, Jose Cornelio Guterres.*** "The role of rectorate leadership in enhancing professionalism and employee empowerment (study case east timor coffee institute, ermera timor-leste, etci-tl)*", International Journal of Development Research*, 11, (12), 52839-52843.

INTRODUCTION

Metabolic syndrome (MS) is characterized by a set of risk factors associated with cardiovascular disease. Since 2001, the scientific community has been trying to define, precisely, the criteria and cut-off points for diagnosing MS (Alberti; Eckel; Grundy; Zimmet *et al.*, 2009). Several research groups have reached a consensus on the number of risk factors and their respective reference values for diagnosing individuals with MS(ALBERTI; ECKEL; GRUNDY; ZIMMET *et al.*, 2009) andin young adults, the prevalence of metabolic syndrome ranges from 10.5 to 18.5% (Do Vale Moreira; Hussain; Bhowmik; Mdala *et al.*, 2020; Fortes; ROSA; Coutinho; NEVES, 2019; OLIVEIRA; SANTOS; MACHADO; MALTA *et al.*, 2020). The prevalence of MS increases with aging and BMI and is linked to a low level of physical activity, low education, and low socioeconomic status(DA SILVA MARIANO; DA SILVA FERREIRA; DO AMARAL; DE OLIVEIRA, 2013; FRANCA; LIMA; VIEIRA, 2016; RAMÍREZ-VÉLEZ; CORREA-BAUTISTA; SANDERS-TORDECILLA; OJEDA-PARDO *et al.*, 2017). Obesity is the trigger point for the development of other risk factors for MS and is linked to the increased risk of cardiovascular disease(DHANA; KOOLHAAS; VAN ROSSUM; IKRAM *et al.*, 2016).Central obesity, usually measured by waist circumference, is considered the main factor of MS, related to some lifestyle habits, such as alcoholism and physical inactivity (DA SILVA MARIANO; DA SILVA FERREIRA; DO AMARAL; DE OLIVEIRA, 2013).There are also several other mechanisms by which CVD develops from MS, and there is a consensus that change in lifestyle is fundamental to changing the course of the disease.In addition to central obesity, the low concentration of high-intensity lipoproteins (HDL-c) is a factor present in young adults(OLIVEIRA; SANTOS; MACHADO; MALTA *et al.*, 2020). It is known that HDL-c is important in the removal of cholesterol from the vascular bed, and one way to raise its levels is the practice of regular physical activity(FORTI; DIAMENT, 2006; SILVA; DINIZ; ALVIM; VIDIGAL *et al.*, 2016). The body mass index (BMI) is a global parameter used to establish the ideal body mass and has a high association with MS and its components (LIMA; VIEIRA, 2016; DO VALE MOREIRA *et al*., 2020; FRANCA), however, cardiometabolic risks can also appear in individuals with a BMI within the expected range(SULIGA; KOZIEŁ; GŁUSZEK, 2016). In view of the gradual increase in MS among young adults and the social context in which they live - without the practice of physical activity, inadequate food consumption, and increased level of stress - the hypothesis was raised that in the young adults evaluated, the prevalence of MS would be lower than established by the literature, but that risk factors would be present in different proportions, and that BMI would be related to the risk factors. Thus, the aims of the present study were to: 1) evaluate the prevalence of metabolic syndrome and its components, 2) verify whether the body mass index (BMI) is a predictor of the components of MS; 3) identify which factors best identify MS in the sample of young adults evaluated.

METHODS

Sample: This is a quantitative, epidemiological, cross-sectional, and inferential study, carried out between November 2018 and April 2019, with students from a university course in the field of health. During the data collection period, 198 students were enrolled. The course has been running for 17 years, with annual student enrollment, and classes during the day. There are three laboratories dedicated to academic practice and one shared laboratory for the performance of research groups related to cardiovascular health. Initially, 122 young adults (18-40 years old) participated in the study, approximately 62% of the total students enrolled. The sample consisted of convenience and the inclusion criteria considered were that the students were over 18 years old and were enrolled at the University Center. Participants with reports of heart disease, chronic lung disease, and cognitive impairment were excluded. The exclusions were made based on the information collected during completion of the identification form. The sample calculation, considering a sample power of 80%, a mean effect size of 0.5, and a significance level of 5%, indicated that the required number of participants was 102.

Study design: The young adults were invited to participate in the study during classes, at a time authorized by the Institution. After explaining the study and its objectives, those who agreed to participate signed the Free and Informed Consent Term (FICT), approved together with the project at the Ethics and Research Committee of the University Center under No. 2,989,854/2018. The study was conducted by Helsinki Declaration from 1964 revised at 2000. An identification form was completed with the date of birth, ethnicity, smoking history (never smoked, smokes, or ex-smoker) (BRASIL. MINISTÉRIO DA SAÚDE. SECRETARIA DE ATENÇÃO À SAÚDE. DEPARTAMENTO DE ATENÇÃO BÁSICA; AMP; AMP; CONTROLEAB - O TABACO),alcohol consumption (abstinent – no, or more than once a month - yes) (ABREU *et al*., 2020), and clinically diagnosed comorbidities according to the participant's report (presence of heart and lung diseases, cognitive impairment). In addition to this information, the results of anthropometric measurements and hemodynamic parameters were also processed on the form. The results of the biochemical parameters were printed via *on-line* results from the laboratory that collected the biological material. Anthropometric measurements such as body mass, stature, and waist circumference were collected at the Physiotherapy Assessment and Intervention Laboratory, at a date and time pre-scheduled with the participants. Blood collection was performed by a specific professional for this function and analyzed in a partner laboratory for clinical analysis on a scheduled day and time, according to the availability of the students.

Anthropometric measurements: Body mass was measured on a digital scale (Filizola, model 2096 PP, São Paulo, Brazil), with a precision of 0.1 kg and a capacity of up to 150 kg.The students wore light clothing, and looked straight ahead until the value stabilized on the scale display. Stature was measured in meters (m), using a stadiometer (Sanny, São Paulo, Brazil). BMI (kg/m^2) was calculated from data on body mass (kg) and stature (m). The cut-off points considered for eutrophic and overweight/obese individuals were ≤24.99 kg/m² and ≥25 kg/m², respectively (ORGANIZATION, 2003). Waist circumference was measured with an inextensible anthropometric tape (Teklife, model TL200, São Paulo, Brazil), positioned at the midpoint between the upper iliac crest and the last costal arch, at the end of expiration at rest (ORGANIZATION, 2000). The reference values for the Brazilian population are men ≥90 cm and women ≥80 cm(ALBERTI; ECKEL; GRUNDY; ZIMMET *et al.*, 2009).

Hemodynamic parameters: The measurement of systolic blood pressure (SBP) and diastolic blood pressure (DBP) was performed usinga semiautomatic device (OMRON, model HEM 705CP, Kyoto, Japan), following the Brazilian Guidelines for Hypertension (MALACHIAS; SOUZA; PLAVNIK; RODRIGUES *et al.*, 2016). After five minutes of rest, sitting, with the right arm in the supine position, two measurements were taken at 1-minute intervals, with the first measurement being discarded [(14)]. To characterize hypertension and for it be considered a factor for MS, values equal to or greater than 130 x 85 mmHg were required, or of the participant was under treatment (ALBERTI; ECKEL; GRUNDY; ZIMMET *et al.*, 2009).

Biochemical parameters: Blood collection was always performed in the morning, after fasting for at least 8 hours, by a specialized professional in the laboratory responsible for the analyses. The blood was collected at only one moment, and a volume of 09 mL was collected for distribution in the lipidogram dosages (collection of 5 mL for analysis of 1mL of plasma) and fasting glucose (collection of 4 mL for analysis of 1mL of plasma).The samples were transported to the laboratory where they were centrifuged and prepared to estimate the plasma concentration of the parameters. The measurement of HDL-c and triglycerides was carried out using the enzymatic colorimetric method with automatic equipment. The reference values of HDL-c, in mg/dL, for men is ≤ 40 and for women ≤ 50. For the plasma concentration of triglycerides, values above 150 mg/dL were considered (ALBERTI; ECKEL; GRUNDY; ZIMMET *et al.*, 2009). Fasting blood glucose was measured with the plasma sample, using an enzymatic procedure, with hexokinase. Hyperglycemia was considered when the values were ≥ 100 mg/dL (ALBERTI; ECKEL; GRUNDY; ZIMMET *et al.*, 2009).

Diagnosis of MS: MS was considered when students presented at least three risk factors or were undergoing treatment, with waist circumference being adopted as the main risk factor (ALBERTI; ECKEL; GRUNDY; ZIMMET *et al.*, 2009).

Statistical analysis: The data processing was performed by three researchers, two of whom typed the collected data and the third performed the crossing of the information (comparison of the measures) to check if there were errors during the construction of the spreadsheet for data analysis. For the analysis, the variables sex, BMI, and risk factors for metabolic syndrome were considered. The dependent variables were the risk factors for metabolic syndrome (WC, blood pressure, fasting glucose, triglycerides, and HDL-c) and the independent variable was the body mass index. The data are described as mean, standard deviation, frequencies, and percentages. For comparison between groups (sex and BMI), the *Student-t* test for independent samples (normal distribution) or the*Mann-Whitney* test (asymmetric distribution) was used. The Chi-square test or correction of *Likelihood Ratio* verified the association between categorical variables (age group, ethnicity, alcohol consumption, and smoking history) and sex. For the analysis of multiple linear regression, the *stepwise* method was used, considering the BMI as an independent variable and the risk factors as dependent variables. The coefficient of determination (R^2) was calculated, and sex and age were used as adjustment factors. The principal component analysis, a multivariate analysis technique, was used to evaluate the interrelationships between the variables and condense them into smaller sets, providing the most important components (sets of variables) that explain the majority of the total variation. The literature takes into account variables that have eigenvalues ≥ 0.40. The p value considered was <0.05 and the analysis was conducted in *Statistical Package for Social Science* (SPSS).

RESULTS

At the end of the study, 111 young adults were evaluated at all stages and there were 11 losses; eight due to lacking anthropometric measurements and 03 due to lacking blood pressure measurements. In the numerical variables, body mass (Δ= 7.5 kg, p=0.004) and height (Δ= 0.13 cm, p<0.001) were higher in young males (Table 1). There was no association between the variables age group, ethnicity, smoking history, and alcohol consumption with sex.

Risk factors for metabolic syndrome were compared according to sex and BMI classification. For sex, WC (Δ= 4.1 cm, p=0.04), and SBP (Δ= 14 mmHg, p<0.001), values were higher in young males (Table 3). Young people classified as pre-obese/obese presented greater WC (Δ= 13.5 cm, p<0.001), SBP (Δ= 6 mmHg, p=0.01), DBP (Δ= 8 mmHg, p<0.001), and higher plasma concentration of triglycerides (Δ= 24 mg/dL, p=0.036). Among the young people evaluated, 58 (52.3%) did not present any risk factor for MS; 37 (33.3%) presented one risk factor; 12 (10.8%) presented two risk factors; and 04 (3.6%) had MS, all of them female. The prevalence of risk factors is shown in figure 1. The most prevalent risk factor was low HDL-c (33.3%), followed by an increase in waist circumference (15.3%). BMI was shown to be a predictor of waist circumference, explaining 74% (p<0.001) of the relationship, followed by systolic (R^2=38%, p<0.001) and diastolic blood pressure (R^2=26%, p<0.001). In addition, BMI was also a predictor of serum triglyceride concentration (p=0.007). The principal component analysis was used to evaluate the interaction between variables and established three factors or sets of variables that could be used in isolation in the assessment of MS (Table 4). The first factor showed an interaction between WC, SBP, DBP, and triglycerides, explaining 34% of MS; the second showed an interaction between blood glucose and HDL-c with 173% of the total variance, and the last factor established, in isolation, HDL-c as a possible variable for assessing MS, explaining 16.8% of the total variation.

Table 1. Characterization of the sample (n=111)

	Female (n=91)	Male (n=20)	p*
Age (years)	21.1 (3.3)	20.8 (2.6)	0.69
Mass (kg)	61.4 (10.5)	68.9 (9.4)	0.004
Stature (m)	1.64 (0.06)	1.77 (0.06)	<0.001
BMI (kg/m²)	22.8 (3.9)	22.0 (2.3)	0.20
Age Range			
18 ┤ 20	27 (29.7)	07 (35.0)	
20 ┤ 30	62 (68.1)	12 (60.0)	0.70
30 ┤ 40	02 (2.2)	01 (5.0)	
Ethnicity, n (%)			
White	32 (35.2)	06 (30.0)	
Black	07 (7.7)	03 (15.0)	0.71
Brown	51 (56.0)	11 (55.0)	
Indigenous	01 (1.1)	0 (0)	
Alcohol consumption, n (%)			
Yes	36 (39.6)	11 (55.0)	
No	55 (60.4)	09 (45.0)	0.21
Smoking history, n (%)			
Never smoked	84 (92.3)	18 (90.0)	
Ex-smoker	05 (5.5)	01 (5.0)	0.81
Current smoker	02 (2.2)	01 (5.0)	

BMI- body mass index. * Data for p <0.05.

Table 2. Comparison of risk factors for metabolic syndrome according to sex and BMI (n=111)

	Sex			BMI		
	Female (n=91)	Male (n=20)	Δ	Eutrophic (n=89)	Pre-obese/ Obese (n=29)	Δ
WC (cm)	71.8 (8.2)	75.9 (6.4)*	4.1	69.0 (5.6)	82.5 (5.2)*	13.5
SBP (mmHg)	104 (11)	118 (10)*	14.0	105 (12)	111 (11)*	6.0
DBP (mmHg)	72 (8)	71 (6)	1.0	70 (7)	78 (8)*	8.0
Glucose (mg/dL)	85 (8)	87 (8)	2.0	85 (8)	86 (6)	1.0
Triglycerides (mg/dL)	86 (50)	90 (70)	4.0	80 (45)	104 (71) *	24.0
HDL-c (mg/dL)	52 (6)	50 (6)	2.0	52 (6)	52 (7)	0.0

Table 3. Multiple linear regression between risk factors for MS (dependent variables) and BMI (independent variable)

	BMI			
Variables	β	95%CI	Adjusted R² (%)	P*
Waist circumference	1.88	1.64 – 2.09	74	<0.001
Systolic blood pressure	1.42	0.94 – 1.91	38	<0.001
Diastolic blood pressure	1.13	0.77 – 1.48	26	<0.001
Fasting glucose	0.05	-0.35 – 0.45	2	0.80
Triglycerides	3.78	1.05 – 6.52	4	0.007
HDL-c	- 0.03	-0.36 – 0.31	1	0.88

BMI- body mass index; β– beta coefficient; R²- Coefficient of determination; *HDL-c- High density lipoprotein- cholesterol.* * Data for p<0.05

Table 4. Principal component analysis of the risk factors involved in metabolic syndrome (n=111)

	Factor 1 (WC, SBP, DBP, and TG)	Factor 2 (Glucose and HDL-c)	Factor 3 HDL-c)
Waist circumference	0.74	-0.06	-0.04
Systolic blood pressure	0.78	-0.11	-0.08
Diastolic blood pressure	0.81	0.16	-0.01
Fasting glucose	0.10	0.70	-0.63
Triglycerides	0.48	-0.11	0.38
HDL-c	-0.10	0.71	0.67
Eigenvalues	2.04	1.04	1.01
Total variance (%)	34.0	17.3	16.8
Cumulative variance (%)	34.0	51.3	68.1

WC- waist circumference; SBP- Systolic Blood Pressure; DBP- Diastolic Blood Pressure; HDL-c - high density lipoprotein. Factor load considered ≥0.40.

DISCUSSION

The main findings of the present study showed a prevalence of MS of 3.6% and the most prevalent risk factor in the sample was low HDL-c. Regarding the components of MS, WC and SBP were higher in young males. When the components were compared according to the BMI, the pre-obese/obese young people presented higher means for WC, SBP, and, also, DBP, and triglycerides. Multiple linear regression models indicated BMI as the predictor that could best explain or indicate waist circumference, followed by systemic blood pressure and triglycerides. Component analysis generated three factors, and factor 1 (WC, SBP, DBP, and triglycerides) was the one that best explained the variation in the components of metabolic syndrome. The prevalence of MS in the current study, among young adults, was below the results of other studies carried out in Brazil (DO VALE MOREIRA; HUSSAIN; BHOWMIK; MDALA *et al.*, 2020; FORTES; ROSA; COUTINHO; NEVES, 2019; FRANCA; LIMA; VIEIRA, 2016; OLIVEIRA; SANTOS; MACHADO; MALTA *et al.*, 2020)and only women presented three or more components of the metabolic syndrome. In Brazil, a country with a continental aspect, the prevalence rates are also different between regions when considering young adults in the productive age range (DO VALE MOREIRA; HUSSAIN; BHOWMIK; MDALA *et al.*, 2020; OLIVEIRA; SANTOS; MACHADO; MALTA *et al.*, 2020).

MS is considered a worldwide emergency and the prevalence is different in each country and continent, mainly due to the lifestyle habits that changed after industrialization, such as reduced physical activity, consumption of multi-processed foods, alcohol abuse, and the increase in stress (ABREU; ELEOTÉRIO; OLIVEIRA; PEDRONI *et al.*, 2020; ANSARIMOGHADDAM; ADINEH; ZAREBAN; IRANPOUR *et al.*, 2018; KWASNY; MANUWALD; KUGLER; ROTHE, 2018; RANASINGHE; MATHANGASINGHE; JAYAWARDENA; HILLS *et al.*, 2017). The prevalence of MS in young people from several countries was established in a recent study and showed that there is a prevalence between 5-7% (NOLAN; CARRICK-RANSON; STINEAR; READING *et al.*, 2017). The result in the present study was lower, since the component with the highest prevalence was low HDL-c. It is worth mentioning that HDL-c is a carrier protein and if it is not sufficient or does not have the structural and functional quality to perform this transport, the formation of atheromatous plaques is suggested, as well as an association with other cardiovascular diseases(VITALI; KHETARPAL; RADER, 2017). However, genetically, the mechanisms by which the link with CVD occurs are not yet clear in the literature. There are speculations regarding the performance of other conflicting factors, for example, the quality of the HDL-c molecule and the ability of serum cholesterol efflux(VITALI; KHETARPAL; RADER, 2017). In any case, the high prevalence of this parameter should not be overlooked as it can interfere in lipid metabolism pathways, with cardiovascular consequences. With advancing age, the prevalence of MS seems to increase, especially after the age of 40 (DE CARVALHO VIDIGAL; RIBEIRO; BABIO; SALAS-SALVADÓ *et al.*, 2015)and there is no association with sex. In the present study, the most prevalent factors were low HDL-c and high WC and this result was also found by clusters in a sample of the Brazilian population in the same age group (FRANCA; LIMA; VIEIRA, 2016; OLIVEIRA; SANTOS; MACHADO; MALTA *et al.*, 2020),which may suggest that young people already present risk factors, and this situation may anticipate the increase in the prevalence of MS.HDL-c has an important function of transporting excess cholesterol from the cardiovascular bed and the best way to increase its concentrations in the bloodstream is the practice of physical activity, of both moderate and vigorous intensity (SILVA; DINIZ; ALVIM; VIDIGAL *et al.*, 2016). Pre-obese/obese young adults presented higher values for WC, blood pressure, and triglycerides. The BMI classification is commonly used to compare eutrophic individuals with pre-obese/obese individuals and also to evaluate the correlation with the components of MS (DE CARVALHO VIDIGAL; RIBEIRO; BABIO; SALAS-SALVADÓ *et al.*, 2015). There is evidence that young adults with BMI values for pre-obesity/ obesity, have a higher prevalence of MS.

In addition to the direct relationship between MS and BMI, individuals with MS showed a reduction in the level of physical activity and signs of systemic inflammation when compared with healthy people (WEBER, 2018). Multiple linear regression indicated BMI as a predictor for MS factors and best explained WC, followed by SBP, DBP, and TG. This relationship is already indicated in the literature (OFER; RONIT; OPHIR; AMIR, 2019; RAMÍREZ-VÉLEZ; CORREA-BAUTISTA; SANDERS-TORDECILLA; OJEDA-PARDO *et al.*, 2017), but when it was associated with the analysis of main components, it signaled the importance of life habits as essential aspects in the prevention and promotion of cardiovascular health through the reduction in factors of MS. The principal component analysis indicated that the set of variables to detect MS (WC, SBP, DBP, and TG) was fundamental, and it is probably possible to use this set to the detriment of other factors, making the evaluation faster and more cost-effective. In another study, the variables that showed the greatest sensitivity and specificity for the diagnosis of MS were WC and fasting glucose (Chuengsamarn; Rattanamongkoulgul; Villarroel, 2010). Principal component analysis is a technique whose objective is to summarize a set of variables so that they can be used in a more practical way and if there is an interest in reducing cost-benefit in the diagnosis of any clinical condition.

The limitations of the current study are related to the fact that the majority of the sample was composed of females. The cross-sectional design of the study, naturally, has a low capacity to present causality when compared to follow-up studies.Despite these limitations, the current study jointly analyzed the five factors which are related to MS and triggers for cardiovascular diseases. It was possible to profile the sample studied with the possibility of future prevention strategies. The detection of a high prevalence of low HDL-c, which, in most cases, is neglected, without effective clinical intervention, and the verification of the increase in body mass is a reason that contributes to the emergence of other risk factors in the studied sample. In addition, the need for public policies is suggested to promote cardiovascular health, involving regular exercise and consumption of fruits and vegetables, in addition to avoiding stress, as demonstrating potential to achieve good results among young people and minimize the losses that may occur in the future. The effort to construct strategies, which include the performance of a multi-professional team, culminates in greater success from interventions related to lifestyle changes, higher quality food consumption, increased level of physical activity, improvement in quality of sleep, and reduction in tobacco and alcohol consumption.

CONCLUSION

Although the prevalence of MS was lower than indicated in the literature for young adults of the same age group, there are already risk factors such as low HDL-c and high waist circumference. This result suggests that young people can develop MS early. Pre-obese/obese young people presented higher values for waist circumference, systolic and diastolic blood pressure, and triglycerides. BMI was a predictor of components, except for fasting blood glucose. The principal component analysis established the best set of components (WC, SBP, DBP, and TG) that can be used to detect metabolic MS. These variables are closely related to the lifestyle habits that young people develop due to the social context of high food consumption, reduced physical activity, alcohol abuse, and the presence of stress.

Acknowledgements: Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq)

Consent for publication: No personal data is noted herein.

Competing interests: The authors declare that they have no conflict of interest.

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