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Women from the Peruvian Highlands with Normal Body Mass Index and Cardiometabolic Risk Factors

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Abstract

Cardiometabolic diseases constitute a public health problem of great magnitude at a global and national level, including heart and cerebrovascular diseases, diabetes and some types of cancer, generating a significant impact on public health. To evaluate cardiometabolic risk factors in females with a normal Body Mass Index. Prospective, explanatory, transversal and analytical. The sample was from 228 women with a normal body mass index. For body composition, anthropometric measurements (girth and height) are taken to calculate the waist/body and waist/height index. The lipid profile is obtained to analyze the Total Cholesterol/HDL, LDL/HDL and TG/HDL Index. Adherence to the Mediterranean diet was evaluated using the Chilean Mediterranean Diet Index questionnaire. For data analysis, the Spearman Rho test and factorial analysis of multiple correspondences were used. The categories "High Ries according to ICT" and "High Ries according to %MG" grouped together closely, just like "Limit of %MG" and "High Ries according to CC". Groups were identified between "High risk according to ColT/HDL" and "High risk according to LDL/HDL", as well as between "Moderate risk according to ICT" and "High risk according to CC". The variables ICT, %MG, I ColT/HDL, I LDL/HDL and CC are related and contribute in a similar way to the risk classification. Study participants presented three cardiometabolic risk factors and greater association factors with high and/or high risk according to ICT, CC and %MG.

Keywords: Waist-to-height ratio, lipid indices, metabolism, normal weight, cardiovascular health. Artificial

Introduction

Cardiometabolic diseases (NDEs) are the leading cause of premature death in the world, with a devastating impact on the lives of millions of people. Every year, around 17.5 million people die from NDEs, and it is estimated that this figure could rise to 23 million by 2030 if urgent action is not taken. Women are especially vulnerable to NDEs, accounting for 35% of NDE-related

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deaths, even exceeding the incidence of all cancers combined. NDEs can affect women of any age, and in Peru, INEI statistics from 2020 reveal that women have a higher cardiometabolic risk than men. Cardiometabolic risk factors (MCRF) are multiple and are closely related to modern lifestyles. Overweight or obesity, dyslipidemias, physical inactivity, high blood pressure, diabetes, smoking, and excessive alcohol consumption are some of the main FRCMs. High cholesterol is a particularly important risk factor. The World Heart Federation estimates that, in 2022, approximately 39% of adults had high cholesterol, and that, in 2019, 4.4 million people died from high LDL cholesterol. (1) (2) (1) (3)

In Peru, the situation is worrying. Although in 2021 32.6% of Peruvian women between 15 and 49 years of age maintained an optimal weight according to the Body Mass Index (BMI), this figure represents a decrease compared to 2016, in which 40.1% was recorded. This trend, possibly linked to lifestyles, is a cause for alarm. To properly assess cardiometabolic risk, it is necessary to use anthropometric indices complementary to BMI, such as body fat percentage, abdominal circumference, waist-to-hip ratio, and waist-to-height ratio. A study conducted in Peru suggests the use of these indices to assess abdominal obesity, an important risk factor. The presence of multiple cardiometabolic risk factors is not unusual. A study conducted with university students in Venezuela revealed that at least 3 and even 4 risk factors were present in most participants, highlighting alterations in serum levels of at least one component of the lipid profile. Low intake of fruits and vegetables also increases the risk of developing NDEs. In Peru, only 10.5% of people aged 15 and over consume at least five servings of fruits and/or vegetable salads a day, and in the Sierra, the figure is even lower, with only 6.5% meeting the recommendations of the World Health Organization. NDEs not only pose a threat to individual health, but also to the economic and social development of countries. Urgent action is needed to prevent and control NDEs, promoting healthy lifestyles, improving access to health care, and strengthening public policies related to cardiovascular and metabolic health. Only through a joint and sustained effort will it be possible to combat this global epidemic and protect the health of present and future generations. (4) (5) (6) (4)

Materials and Methods

The present study is prospective, explanatory, quantitative, cross-sectional and analytical. A total of 228 young adults, aged between 18 and 30 years, with a Body Mass Index (BMI) between 18.5 and 24.9 kg/m², were selected by non-probabilistic convenience sampling. Participants were informed of the details of the study and voluntarily gave their consent to participate, both oral and written, based on the ethical principles established in the Declaration of Helsinki9. In addition, the study was previously evaluated and approved by the ethics committee of the National University of the Altiplano, issuing certificate of approval No. 028.

Anthropometric measurements of weight, height, waist and hip circumference were taken to assess cardiovascular and metabolic risk through indices such as the Waist-to-Height Index (CLI), Waist-Hip Index (CLI) and Waist Circumference (WC). In addition, the Fat Mass Percentage (%BM) was evaluated by electrical bioimpedance using a TANITA brand balance with 6 electrodes. It is important to mention that the mechanical instruments used were subjected to calibration processes, and the measurements were carried out by trained and standardized personnel according to the technique of the Ministry of Health (MINSA) of Peru, which presents differences with respect to what is indicated by the ISAK, mainly in the measurement of height and waist circumference.

Blood samples were also taken to obtain the lipid profile (total cholesterol, HDL-c, LDL-c and triglycerides by spectrophotometry, for subsequent interpretation using indicators such as the Total Cholesterol/HDL Index (I ColT/HDL), LDL/HDL Index (ILDL/HDL) and TG/HDL Index (I TG/HDL). It was evaluated whether the diet was in line with the Mediterranean diet using the self-administered questionnaire "Chilean Mediterranean Diet Index - MDI", validated in a previous study conducted by Echeverría et al. This instrument was adapted for the population of Puna and validated by means of a content test with 10 expert judges, obtaining an Aiken V coefficient of 0.998, which indicates its validity. In addition, a pilot test was carried out to evaluate its reliability, obtaining a Cronbach's alpha coefficient of 0.70, which indicates an acceptable internal consistency. [(7)]

The results were transferred to an Excel database, where they were organized, classified and diagnosed according to the category of the indicator. The normality of the data was evaluated using the Shapiro-Wilk test, determining that the data did not follow a normal distribution. Therefore, the relationship between the variables was analyzed using Spearman's Rho statistic in the SPSS program, version 21. In addition, an exploratory analysis was carried out using the statistical technique of Factor Analysis of Multiple Correspondences, using the SPADN software, version 5.

Results

Table 1 shows that of the 228 women with a normal body mass index (BMI) who participated in the study, it was observed that: 77.2% had a percentage of fat mass within the normal range, 66.7% had a low risk of cardiovascular disease, and 76.3% had android obesity. It should be noted that 46.9% had a minimal risk of developing cardiovascular disease.

On the other hand, Table 2 shows the cardiovascular risk according to lipid indices. The results indicate that 81.1% of the participants were at low risk according to the total cholesterol/HDL index, 70.2% were at low risk according to the LDL/HDL index, and 80.3% were at low risk according to the triglyceride/HDL index. Finally, Table 3 shows the participants' adherence to the Mediterranean diet, finding that 78.1% have regular adherence to this diet.

Table 4 shows a negative correlation between lipid indices (I ColT/HDL, I LDL/HDL, I TG/HDL and MDI) and the %MG, CC, ICC and ICT variables. Although this negative trend is observed, statistical significance is only evident in the relationships between LDL/HDL I AND TBI ($P = 0.019$) and between MDI and ICT ($p = 0.034$). The rest of the relationships, although negative, do not reach the established level of significance ($p > 0.05$). These results suggest that, with the exception of the two relationships mentioned, there is no statistically significant association between the lipid indices and the other variables evaluated.

On the other hand, by identifying the association between the categories of all variables (ICT, ICC, CC, I ColT/HDL, I LDL/HDL, I TG/HDL and IDM) by means of factor analysis of multiple correspondences. In the map of correspondences (Figure 1), a strong positive association is observed between the categories "High risk according to ICT", "High risk according to %MG", "Limit of %MG" and "High risk according to CC", as well as between "High risk according to I ColT/HDL" and "High risk according to I LDL/HDL", since they are close to each other. In contrast, the categories "Low risk according to I LDL/HDL" and "Low risk according to I TG/HDL" are far apart from each other, suggesting a weak relationship. In addition, "Healthy diet according to MDI" and "High risk according to WC" are distant from the origin of the axis,

indicating that they are not related to each other.

Similarly, in Figure 2, a strong positive correlation is observed between the classifications "High risk according to ICT", "High risk according to %MG", "Limit of %MG" and "High risk according to CC", as well as between "Low risk according to ICT" and "Gynecoid according to ICC", due to their proximity. On the other hand, the ratings "Android according to ICC", "Healthy IDM", "Moderate risk according to ICT", "Low risk according to I LDL/HDL", "Low risk I ColT/HDL" and "Low risk according to I TG/HDL" are separated from each other, suggesting a weak relationship. The category "Very high risk according to CC" is far from the origin, indicating that it is not related to other categories.

Finally, in Figure 3, a strong positive association can be seen between the categories "Moderate risk according to ICT", "High risk according to CC", "High risk according to I LDL/HDL", "High risk according to I TG/HDL", "High risk according to %MG" and "High risk according to ICT", due to their proximity. In contrast, the categories "Regular diet according to MDI", "Normal according to %MG", "Normal according to CC", "Low risk according to I TG/HDL" and "Low risk according to I LDL/HDL" are separated from each other, suggesting a weak association. In addition, "Very high risk according to CC" and "Healthy diet according to IDM" are far from the origin, indicating that they are not associated with each other.

	Categories	**Frequency**	**Percentage**
% fat mass	Normal	176	77.2
	Limit	33	14.5
	High risk	19	8.3
Waist circumference	Low risk	152	66.7
	High risk	67	29.4
	Very high risk	9	3.9
Waist/Hip Index	Gynoid	54	23.7
	Android	174	76.3
Index Waist/Size	Minimal risk	107	46.9
	Moderate risk	93	40.8
	High risk	28	12.3
	TOTAL	228	100.0

Board 1 - Fat mass, abdominal circumference, waist-to-hip ratio, and waist-to-height ratio in young adult women

	Categories	**Frequency**	**Percentage**
Índice ColT/HDL			
	Low Risk	185	81.1
	High Risk	43	18.9

Índice LDL/HDL			
	Low risk	160	70.2
	High Risk	68	29.8
Índice TG/HDL			
	Low Risk	183	80.3
	High Risk	45	19.7
TOTAL		228	100.0

Table 2 - Cardiometabolic risk in young adult women

Adherence to the Mediterranean diet	**Frequency**	**Percentage**
Suitcase	43	18.8
Regular	178	78.1
Healthy	7	3.1
TOTAL	228	100.0

Table 3 - Adherence to the Mediterranean diet in young adult women

Correlations		**% fat mass**	**Waist circumference**	**Waist/Hip Index**	**Index Waist/Size**
Índice ColT/HDL	Rho	-0.102	-0.021	-0.022	-0.03
	P	0.124	0.754	0.747	0.654
Índice LDL/HDL	Rho	-0.097	-0.108	-0.088	-0.156
	P	0.144	0.102	0.186	0.019
Índice TG/HDL	Rho	-0.011	-0.035	0.095	-0.063
	P	0.872	0.598	0.154	0.345
DM adhesion	Rho	-0.161	-0.09	-0.019	-0.14
	P	0.015	0.175	0.773	0.034

Table 4 - Spearman's Rho correlation of variables

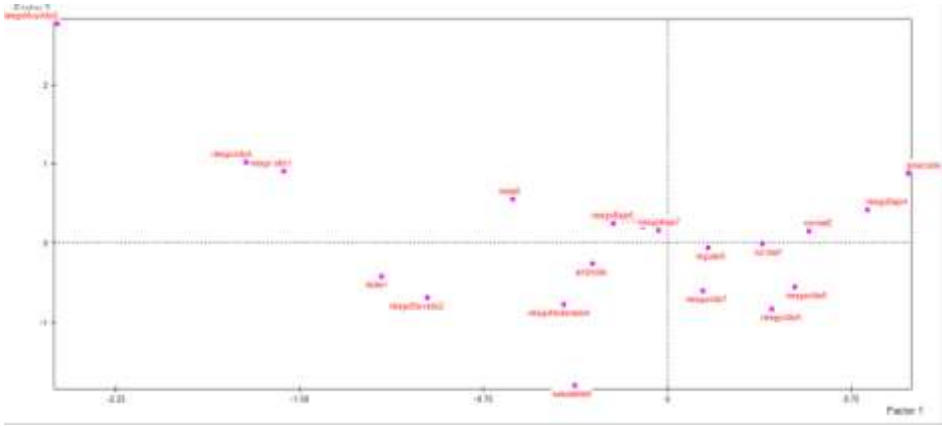

Figure 1. Correspondence factorial plane 1

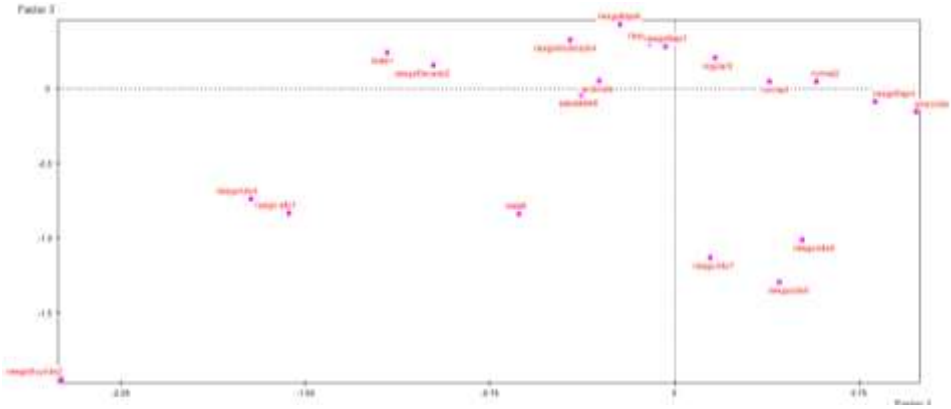

Figure 2. Correspondence factorial plane 2

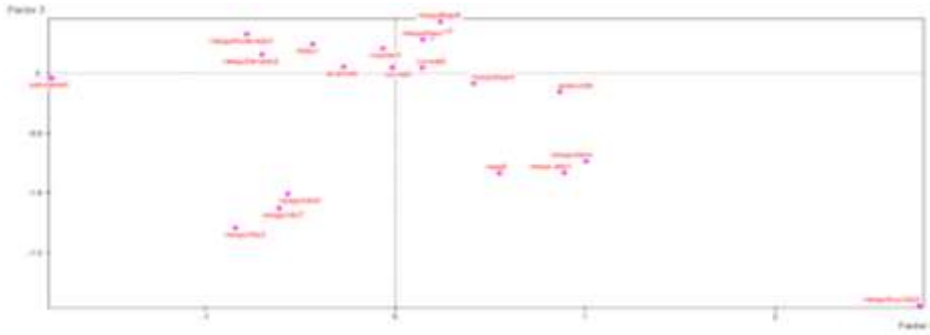

Figure 3. Correspondence Factorial Plane 3

Discussion

Body mass index (BMI) is a widely known indicator used to classify nutritional status, both by nutritionists and other health professionals. Its ease of use and practicality make it very popular. However, BMI does not distinguish between fat mass and muscle mass, nor does it take into account sex and age, which can result in the misclassification of people with a high percentage of fat mass as normal. This phenomenon can hide metabolic abnormalities, which can lead to

biased diagnoses by the practitioner and, consequently, to suboptimal dietary treatments. These results support previous research, such as that of Bautista, who assessed fat percentage in women with normal BMI and found that 8.4% had a fat percentage greater than 33%. Similarly, Ruiz found that 51% of women with normal BMI had a high or very high fat percentage. A similar situation occurred in the present study, where of the 228 participants, the main anthropometric cardiometabolic risk factors with a strong association were % MG, TBI and WC, confirming that having a normal BMI does not exempt them from suffering from fat tissue accumulation, especially at the abdominal level. This accumulation is worrisome, since the excess fat coats organs located in that area, such as the liver, intestines and abdominal muscles, which is associated with the production of proteins that promote chronic low-level inflammation, as well as the activation of proteins that promote the contraction of blood vessels and other proteins that increase glucose levels. and therefore insulin resistance, interrupting metabolic processes. In addition, it was observed that the accumulation of fat in the abdominal area is not proportional to the height of the participants, which increases the probability of having high levels of glucose, cholesterol and triglycerides. (8,9) [(10)] (11)

This leads us to the results of the biochemical markers of the study sample, in which strong associations were evidenced with the ColT/HDL Index, LDL/HDL Index and TG/HDL Index mainly, which is consistent with the anthropometric indicators (% MG, ICT and WC). Being at high risk according to these biochemical indicators means that there is proportionally more total cholesterol relative to HDL cholesterol, as well as more LDL cholesterol relative to HDL and more triglycerides relative to HDL-c. This is synonymous with an activation of the metabolic pathways of lipids, promoting the formation of triglycerides that are stored in adipocytes. In addition, it promotes the formation of low-density lipoproteins, such as LDL-c, which transports cholesterol to cells, while HDL-c transports cholesterol from the arteries to the liver. However, LDL-c cholesterol is considered a fat that contributes negatively to the 10-year cardiometabolic risk. Therefore, hypercholesterolemia is recognized as one of the main risk factors for the development of cardiometabolic diseases. Several studies support this claim, pointing out that elevated levels of total cholesterol and LDL-c, along with low levels of HDL-c and elevated triglyceride (TG) values, in young individuals, increase the risk of atherosclerosis. In the present study, it was observed that 18.9% of the participants had a ColT/HDL Index in the high-risk range. These results are consistent with the findings of another study conducted in Venezuela, where a similar percentage of the population with high cholesterol (14.8%) was reported. Similarly, when comparing our results with a study conducted in Lima, elevated total cholesterol levels were found in 2.1% of the participants. [(12)] [(13)] [(13)] [(14)]

Although diet is an important factor in the elevation of triglycerides and LDL-c, the results suggest a weak association between adherence to the Mediterranean diet and the biochemical and anthropometric indicators evaluated. Although the Mediterranean diet, according to the IDM, is considered healthy, its impact on participants appears to be limited.

It is essential to highlight that the Body Mass Index (BMI) is not always enough to identify people at risk of developing cardiometabolic alterations. Individuals who appear to be healthy according to BMI may actually be at high risk of mortality. For example, those with a body fat percentage greater than 33% are up to seven times more likely to suffer from metabolic syndrome, a key risk factor for various chronic diseases. In this study, although many participants had a normal BMI, a significant percentage showed indicators of high or very high risk when assessing waist circumference, waist-to-hip ratio, and waist-to-height ratio. These results are consistent with

previous research at the national and international levels. For example, in a study conducted in Peru, Vianey reported that 4.3% of women with normal BMI had a high waist circumference. Similarly, in a Venezuelan university population, 12.2% of normal-weight individuals had abdominal obesity. These findings underscore the importance of supplementing BMI with other anthropometric measures, such as waist circumference, for a more accurate assessment of nutritional status and cardiovascular risk. Early detection of abdominal obesity in young people is crucial to prevent and reduce morbidity and mortality due to chronic and cardiometabolic diseases in the long term. (15) (8) (16) (6) (17)

Scientific Contribution

Among the eight risk factors studied (ICT, ICC, CC, ColT/HDL Index, LDL/HDL Index, TG/HDL Index and MDI) in young university students with a BMI within normal parameters, the percentage of fat mass, waist-to-height ratio and waist circumference were identified as the main cardiometabolic risk factors. These are anthropometric risk factors with a strong association, while the ColT/HDL Index, LDL/HDL Index and TG/HDL Index are biochemical cardiometabolic risk factors that also have a strong degree of association. In contrast to the diet factor, whose association was weak. Therefore, it is suggested that other indices be used in addition to BMI, to timely detect various risk factors that generate morbidity and mortality in the medium and long term.

Conflict Of Interest

The authors declare that they have no conflict of interest.

Authors' Contribution

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Annex

Abbreviations
BMI: Body Mass Index
CC: Waist Circumference
ICT: Waist Size Index
BCI: Waist-hip ratio
%MG: Percentage of fat mass
I ColT/HDL: Índice Colesterol Total/HDL
ILDL/HDL: Índice LDL/HDL
I TG/HDL: Triglycerides/HDL index
MDI: Chilean Mediterranean Diet Index
NDE: Cardiometabolic diseases
MCRF: Cardiometabolic Risk Factors

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