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Original Article

Association of Dietary Patterns and Physical Activity with Excess Body Weight, Atherogenic Markers and Cardiovascular Risk Factors in Adults from Cartagena, Colombia

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ABSTRACT

Background: Overweight and obesity are still global public health problems. The main objective of this study was to evaluate associations between diet quality, dietary patterns, and physical activity with anthropometric indices of body adiposity and cardiovascular risk (CVR), as well as with markers of atherogenesis and Framingham International (FRS-I) and Colombia (FRS-C) CVR scores.

Methods: In a cross-sectional study, native adults from Cartagena were screened between September 2023 and January 2024. They were divided to three groups of normal-weight, overweight, and obesity. In turn, the obesity was classified as type I, II and III. The same sampling unit was divided as non-diabetics, insulin-resistants, type 2 diabetics, type 2 diabetic-hypertensives, nondiabetic hypertensives, and uncontrolled hypertensives. Health professionals performed the anamnesis, anthropometry, nutritional/physical activity assessment, and blood sampling.

Results: Prevalence rate was 99% for self-reported family history of chronic non-communicable diseases (NCDs), 92.7% for poor and regular diet quality, 60.3% for physical inactivity, 50% for atherogenic diet, and 46.3% for alcoholism. Prevalence rate of 50% for high CVR and 33% for very high CVR were 5-years forecasted. In type 2 diabetics and type 2 diabetic hypertensives, the 10-year predicted CVR was estimated as high and very high, respectively, according to the FRS-C scale.

Conclusion: Poor and regular diet quality, atherogenic and Western dietary patterns, physical inactivity, basal levels of glycemia, insulinemia, HOMA-IR, insulin resistance status, adiponectinemia and atherogenic markers were shown to be associated with increased obesity, central obesity, arterial hypertension, and CVR.

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Introduction

The Food and Agriculture Organization (FAO) of the United Nations (UN) recognized that the Latin America and Caribbean region (LAC) experienced an increase in food variety and availability, accompanied by a notable reduction in the number of undernourished individuals since 2010. However, significant challenges related to hunger, malnutrition, and food insecurity persist in this region (1).

At the same time, LAC region not only exhibits the highest global increase in overweight and obesity rates in recent decades; but also records the highest prevalence of both conditions in adults worldwide. In this region, the marked annual growth in the body mass index (BMI) of the general population (2) is related to the increase in the prevalence of physical inactivity (39.1%), which exceeds the global average of 27.5% (3). Additionally, this trend is linked to the excessive commercialization and consumption of high-calorie foods and beverages, as well as shifts in dietary patterns characteristic of regions undergoing nutritional transition (4).

Colombia has experienced one of the most significant increases in overweight and obesity across all age groups over the past decade. The prevalence rates of overweight and obesity among children and adolescents are 23% and 8.8%, respectively. Meanwhile, in adults, the prevalence of overweight, general obesity, and abdominal obesity are 36.2%, 21.3%, and 34.4%, respectively, and obesity is more prevalent in women (29.4%) than in men (12.6%) (5). Likewise, the economic burden and healthcare costs associated with excess weight and comorbidities are substantial for Colombia's healthcare system (6). Therefore, an increase in body adiposity and its comorbidities has been recognized as priority public health problems in Colombia, as established in Law 1355 of 2009 issued by the Colombian Congress, in which such disorders are defined and measures are dictated for their prevention, care, and control.

Similarly, the adult population of Cartagena exhibited high prevalence rates of excess weight, associated risk factors, and related comorbidities. Reported prevalence rates include 41.5% for overweight, 18.5% for general obesity, 71.7% for abdominal obesity, 41.5% for hypertriglyceridemia, 30.9% for hypercholesterolemia, 45.8% for reduced high-density lipoprotein cholesterol (HDL) cholesterol, 31.7% for hyperglycemia, 29.1% for hypertension, 68.4% for alcoholism, 20.6% for smoking (7), 66% for atherogenic diet, 37% for physical inactivity, 34% for elevated low-density lipoprotein cholesterol (LDL) cholesterol, 80% for family history of cardiovascular diseases (CVD) (8), 13.1% for type 2 diabetes (T2DM), and an average cardiovascular risk (CVR) score of 8.7 (9). In fact, the above data reflect a considerable increase compared with previous years (8).

In this context, it is urgent to implement public policies across LAC that promote healthier dietary patterns and food systems, aiming to improve diet quality and reduce morbidity and mortality from non-communicable diseases (NCDs), including excess body weight and cardiometabolic diseases (10). For example, it is well known that adherence to a Mediterranean diet is significantly associated with a lower risk of all-cause mortality and CVD mortality in adults, as demonstrated in the National Health and Nutrition Examination Survey (NHANES) Study (11). Additionally, a good-quality diet can reduce the risk of atherosclerotic cardiovascular disease (ACVD) (12). Accordingly, the main objective of this study was to estimate the diet quality, dietary patterns, physical activity, and blood biochemistry in a sample of adults from Cartagena and to investigate potential associations between them and anthropometric indices of body adiposity and CVR, and with CVR according to the Framingham International (FRS-I) and Colombian (FRS-C) scales.

Materials and Methods

This study received ethical approval from University of Atlantico and complies with the Declaration of Helsinki and resolution 008430/1993 issued by the Ministry of Health and Social Protection of Colombia (MHSP). The international biosafety standards (IBS) and good clinical research practices (GCRP) were strictly followed. Accordingly, proper handling of participant data, appropriate preservation of biological samples, and confidentiality of results were ensured. The general sampling unit (GSU) consisted of 136 individuals of both sexes, aged 18-60 years, who were native and permanent residents of Cartagena (Bolivar, Colombia). The sample size was calculated using F statistics in the ANOVA test in G*Power v3.1 software to ensure a statistical power of 0.89, assuming an alpha value of 5%, reliability of 95%, and effect size ≥0.50. The screening of participants was carried out between September 2023 and January 2024.

The initial criteria for stratification consisted of the cutoff points for BMI defined by the WHO (13), to form three main comparison groups of normal-weight (18.50–24.99 kg/mt²), overweight (25.00–29.99 kg/mt²), and obesity (≥30 kg/mt²). Additionally, the obese group was further categorized into three subtypes according to BMI including type I

(30.00–34.99 kg/mt²), type II (35.00–39.99 kg/mt²), and type III (≥40.00 kg/mt²). Simultaneously, within the same GSU, it was possible to form six additional comparison of subgroups including non-diabetics, insulin-resistant, T2DMs, type 2 diabetic-hypertensives, nondiabetic hypertensives and uncontrolled hypertensives.

Normal-weight adults were randomly selected from the general population, while those who were overweight or obese were included from the MUTUAL-SER-EPS-CVR program at Caminos Interactive Patient System (IPS) facilities, and had never received clinical or nutritional intervention for the management of excess weight or CVR. Participants voluntarily signed the written informed consent and met the WHO anthropometric criteria (13), contemplated in resolution 2465 of 2016 issued by MHSP. Individuals diagnosed with hypertension and dyslipidemia were included regardless of their adherence to pharmacological treatment. However, all participants with T2DM were compliant with pharmacological treatment.

Individuals were excluded if they exhibited any of the following conditions; underweight (BMI <18.5 kg/mt²); self-reported weight loss of ≥5 kg due to any cause during the three months prior to the medical history assessment; diagnosis of cancer; pathology of primary origin in the thyroid, adrenal or pituitary gland; sleep disorders; depression; dementia; rare genetic diseases (Law 1392/2010 issued by the Congress of Colombia); pregnancy; lactation; women using hormonal contraceptives; men or women undergoing hormonal therapy for growth disorders; type 1 diabetes; immunosuppression; chronic kidney disease in stages 4 and 5; autoimmune diseases; second-degree relatives (excluding one); partial or permanent physical disability; cognitive impairment or other mental disorders hindering accurate information provision; acute respiratory infection diagnosed or compatible with Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2); respiratory or neurological sequelae associated with SARS-CoV-2; symptoms/signs of acute monkeypox virus infection; history of musculoskeletal surgery with subsequent gait impairment, and; those who did not signed the informed consent.

During consultation, an internist performed the anamnesis, anthropometry (weight, height, abdominal circumference, and hip circumference), and blood pressure measurements for their patients. The participants were weighed and sized in light clothing, barefoot, standing upright with their heads in the Frankfort plane, and arms relaxed to avoid lordosis. A calibrated electronic scale and a stadiometer were used. BMI was calculated using the Quetelet index (14). Abdominal circumference (WC: Waist circumference) was determined by placing a measuring tape above the navel at the approximate midpoint between the lower margin of the last palpable rib and the upper part of the iliac crest, taking measurements at the end of unforced expiration and in a standing position (15). WC was used to classify abdominal obesity (AO) and normal-weight based on cutoff points: ≥91 cm in men and ≥89 cm in women, following the recommendations of Buendia *et al.* (16).

To estimate CVR using WC, the WC categories defined by Han *et al.* were applied (17). For men, the WC cutoff points were ≤93 cm (low-risk), 94-101 cm (intermediate-risk), and ≥102 cm (high-risk). For women, the WC cutoff points were ≤79 cm (low-risk), 80-87 cm (intermediate-risk), and ≥88 cm (high-risk) (18). Hip circumference (HC) was measured at the level of the femoral trochanters, at the point of maximum circumference at the level of the glutes, placing the measuring tape horizontally directly on the skin. During the measurement, each subject remained standing, with the feet together, and the gluteal mass was completely relaxed (19).

The Waist-to-Hip Ratio (WHR) was calculated as the quotient (WC/HC). For the diagnosis of AO and normal-weight by WHR, cutoff points of >1.0 in men and >0.85 in women were used (13). In men, to estimate CVR by WHR the cutoff points were ≤0.95 (very low-risk), 0.96-–0.99 (low-risk), and ≥1.0 (high-risk) (15). In women, to estimate CVR by WHR the cutoff points were ≤0.80 (very low-risk), 0.81–0.84 (low-risk), and ≥0.85 (high-risk) (20). The Waist-to-Height Ratio (WHtR) was calculated as the quotient (WC/height). For the diagnosis of AO and normal-weight by WHtR, cutoff points of ≥0.53 in men and ≥0.55 in women were applied (21). For CVR classification by WHtR in both sexes, the following cutoff points were used: <0.5 (without-risk), ≥0.5 to <0.6 (high-risk), and ≥0.6 (very high-risk) (22).

Blood pressure was measured in a quiet environment and temperature-controlled. Participants rested quietly, refrained from speaking, and placed their forearm on a table. A calibrated mercury sphygmomanometer was used, with the inflatable bladder covering 75-100% of the arm at heart level. Three measurements were taken at 1 min intervals, and the average of the three readings was calculated (23). CVR was assumed as the probability of occurrence of one or more of the following clinical outcomes: acute myocardial infarction, heart failure, angina, ischemic stroke, hemorrhagic stroke, transient ischemic attack, and peripheral arterial disease. CVR was calculated using the Framingham International (FRS-I) (24) and Colombia (FRS-C)

(25) scores, including the variables of sex, age, systolic blood pressure (SBP), treated hypertension, smoking status, T2DM, total cholesterol, and HDL cholesterol. The CVR categories by FRS-I were low (0% to <6%), moderate (≥6% to <20%), and high (≥20%) (24). The CVR categories by FRS-C were low (0% to <15%), moderate (≥15% to ≤20%), high (>20% to <30%), and very high (≥30%) (26). All calculations were first performed manually and then corroborated by the calculator of atherosclerotic CVR 10-year forecasted of the Framingham study.

Initially, a clinical nutrition specialist designed and administered a food frequency questionnaire (FFQ) to record information on nutritional habits, including weekly and daily food consumption during the month prior to anamnesis. The collected data was used to create a database of 167 individual foods and their derivatives. To simplify the analysis, recommendations from the Colombian Institute of Family Welfare (ICBF, for its acronym in Spanish) (27) were followed to create seven main food groups including G1) fruits, vegetables, and green; G2) whole grains and legumes; G3) beef, chicken, eggs, fish, and seafood; G4) milk and dairy products; G5) oils, butter, and margarines; G6) refined sugars and sweets, and; G7) meat sausages.

An initial analysis compared the average weekly and daily dietary intakes across food groups by participant sex, BMI, and obesity type. Subsequently, Principal Component Analysis (PCA) (data not shown) was applied, allowing the identification of three distinct dietary patterns of atherogenic, Western, and Mediterranean. For each participant, the percentage of the dietary pattern of *supra cit.* was calculated, and the average percentage of each of these patterns was analyzed by sex, main groups and subgroups of participants. Finally, data on specific foods, food groups, and identified dietary patterns were used to classify diet quality as good, regular or poor based on definitions from the WHO guidelines for sustainable healthy diets (28). In this way, a diet is considered of good-quality when it is balanced with the total caloric expenditure (TCE); ensures an intake of complex carbohydrates and fiber (55-60% of TCE) and protein (10-15% of TCE); reduces daily total fats, saturated fats and trans fats to <30%, <10%, and <1% of TCE, respectively; promotes the intake of omega 3, 6 and 9 polyunsaturated fatty acids (6-10% of TCE); encourages fruit and vegetable consumption (≥400 g/day); reduce free sugar intake to <10% of TCE; reduce salt intake to <5 g/day; and avoids foods/beverages with added sugars (29). In contrast, a poor-quality diet is hypercaloric and does not meet most of the recommendations cited above, while a regular-quality diet has characteristics intermediate to good and poor quality diets.

PA was evaluated in accordance with the WHO global recommendations on PA for health (30). Participants were classified into two groups. The first group comprised individuals who self-reported performing PA at least three times per week, meeting a minimum of 150 cumulative minutes of moderate-intensity aerobic PA weekly, or instead, 75 cumulative minutes of vigorous-intensity aerobic PA weekly, or an equivalent combination of moderate and vigorous activity (mixed). The second group included individuals who practiced PA irregularly or sporadically without exceeding 150 minutes of moderate-intensity aerobic PA or 75 minutes of vigorous-intensity aerobic PA weekly, and also participants who did not practice any PA and exhibited sedentary habits. All participants provided information on their average daily sedentary hours, excluding night-time rest.

After anamnesis and anthropometry, compliance with a minimum fasting period of 8 hours was confirmed. Venipuncture was performed using a closed-system technique, adhering to IBS and GCPR. Two whole venous blood samples without anticoagulants were collected. Blood samples were labeled with a unique code assigned to each participant to ensure confidentiality and transported in a refrigerated container at 4°C to a research laboratory at the University, where they were centrifuged at 10.000 rpm for 10 min at 4°C to obtain serum. Fresh serum samples were used to quantify basal levels of glucose, total cholesterol (TC), HDL, LDL and triglycerides (TG) using an enzymatic-colorimetric method, with absorbances measured at 500 nm using a UV-5100B spectrophotometer (M&A Instruments Inc.). C-Reactive Protein (CRP) level was measured using a plate agglutination method (BioSystems®). Very low-density lipoprotein (VLDL) level was calculated using the Friedewall formula (TG/5). For participants with TG level exceeding 400 mg/dL, the Martin-Hopkins formula was applied (31). Basal insulin and adiponectin hormones were quantified by ELISA (Accubind Insulin Test - Monobind Inc. ® and Human Adiponectin ELISA Kit - Invitrogen®).

Initially, the variables were classified as categorical (ordinal or nominal) or scale (discrete or continuous). Normality was assessed using the Kolmogorov-Smirnov test. Descriptive statistics were conducted for each variable in the GSU, stratified by sex, main groups, and comparison subgroups. The descriptive analysis included the mean, confidence intervals of the mean, standard deviation, median, minimum and maximum values, and interquartile range (data not shown). For variables that followed a normal distribution, mean differences were compared by sex, across the normal-weight, overweight and obesity groups, and among obesity subtypes, using unpaired Student's t-tests and one-way ANOVA. In both tests, a *p* value <0.05 was considered statistically significant differences (SSD). The student's t-test was used to compare anthropometric and biochemical variables between the sexes. In ANOVA, Levene's test was applied to assess the homogeneity of variances, followed by Bonferroni and Tukey post-hoc tests to compare differences between anthropometry across normal-weight, overweight, and obesity groups, as well as among obesity subtypes; age, blood pressure and biochemical markers were compared across the *supra cit.,* groups, and nutritional habits by sex; weekly and daily food consumption was examined by food groups and sex, and weekly and daily consumption by BMI categories and obesity type.

For variables that did not follow a normal distribution, the Kruskal-Wallis H test (KWH) was performed for K-independent samples with Bonferroni correction, along with the Mann-Whitney U (MWU) test. In both tests, a *p* value <0.05 was considered as SSD. The KWH test was used to compare medians for anthropometry, age, blood pressure, and blood biochemistry by BMI categories and types of obesity; CVR by FRS-I/FRS-C by sex, BMI, and types of obesity, as well as within subgroups before and after Bonferroni adjustment in Dunn's test. The MWU test was used to compare median differences by sex for age, anthropometry, body composition by BMI, WHR, WHtR, WC, biochemistry, and CVR by WHR, WHtR, and WC.

Simultaneously, the Pearson´s chi-square test was utilized to compare percentage differences between sexes with sociodemographic variables, risk factors, family history of NCDs, percentage distribution for BMI, WHR, WHtR, WC, physical activity, and percentage distribution of CVR by WHR, WHtR, and WC. Further, the percentage differences between dietary quality and dietary patterns were determined by sex, groups and subgroups of participants. Superscript letters were included above each variable to indicate the statistical test performed, and superscript numbers or letters above the *p* values were included to highlight the group pairs compared. Next, all variables that initially did not follow a normal distribution were transformed into logarithms to base 10.

Subsequently, Pearson's correlation (PC) was used to explore the associations between age, weight, height, BMI, WC, HC, WHR, and WHtR, with age, number of children, and BMI (considered as a continuous variable), as well as the associations of biochemical variables among themselves and of these with anthropometry. Similarly, using Multiple Linear Regression (MLR), the associations between categorical (independent) variables, age groups, socioeconomic stratum (SES), sex, education, smoking, alcoholism, normal-weight, overweight and obesity groups, PA, diet quality, and dietary patterns, with anthropometry (continuous dependent variables) were analyzed. Likewise, the relationships between the cutoff points for AO and CVR by WC, WHtR, WHR, and FRS-I/FRS-C scores with TAS, TAD, and biochemical variables were explored. In PC, correlation coefficients (r) were reported, with the significance level (p) indicated as a superscript, whereas in MLR, the adjusted R^2, standardized beta coefficients (SβC), and their respective *p* values were reported.

Concurrently, using the aforementioned tests, the associations between BMI, PA, dietary patterns and quality, with anthropometry, and anthropometric CVR (aCVR) were analyzed. Additionally, the associations between blood biochemistry and their relationships with anthropometry were explored. The relationships between anthropometry, and their associations with AO cutoff points, aCVR, and FRS-I/FRS-C were also examined. Furthermore, the associations between systolic (SBP) and diastolic blood pressure (DBP), as well as biochemical variables, with the categorical variables: essential hypertension (EH), isolated systolic hypertension (ISH), isolated diastolic hypertension (IDH), hypertension categories (HTC), individual hypertension categories (HTC1, HTC2, HTC3), and the overall scores and CVR categories by FRS-I/FRS-C were analyzed.

In parallel, the associations between anthropometry, cutoff points for AO, and aCVR, general scores by FRS-I/FRS-C, categories of aCVR, categories of CVR by FRS-I/FRS-C with PA, sedentary hours per day, dietary patterns and quality, and consumption habits of fried foods and fruits were analyzed. Likewise, the associations between atherogenic markers with SBP, DBP, EH, ISH, IDH, HTC, and individual categories of hypertension were explored. The associations between dietary patterns and quality with food groups and consumption of fried foods and fruits were determined using of the $\chi 2$ test of independence. In the latter, the Cramér V value was reported, and the significance *p* value in superscript. Finally, the associations between biochemical variables and atherogenic markers with dietary patterns and quality, food groups, and the consumption of fried foods and fruits, as well as with CVR by FRS-I/FRS-C were examined. Additionally, the relationships between the entire variable matrix and the family history of NCDs were explored (data not shown). Analyses involving the T2DM group and their comparison pairs were corrected for pharmacological treatment. All analyses were performed using R statistical software.

Results

Most participants self-reported that at least one or multiple family members, across different degrees of consanguinity and both parental lineages, had been clinically diagnosed with or had died from one or more NCDs. The number and percentage of affected relatives, stratified by the degree of consanguinity, parental lineage, and participant sex, were detailed in Table 1. In the GSU, the highest proportion of participants were non-diabetics (85%), insulin-resistants (36%), obese (36%) and non-diabetic hypertensives (29.4%). In GSU, the weekly frequency of alcohol consumption and smoking was at least once per week. Participants included non-smokers, passive smokers, and active smokers, with the latter consuming 1-35 cigarettes per week. Specifically, 7.4% self-reported actively smoking an average of 22.5 cigarettes per week while simultaneously consuming alcohol at least once a week. Additionally, 12.5% of participants were identified as passive smokers and reported occasional exposure to wood smoke. None of participants reported the use of narcotic or psychotropic substances.

A total of 68% of participants (n=92) had undergone at least one surgical procedure throughout their lifetime. Among women, the most common surgeries involved the reproductive system, including cesarean section, pomeroy tubal ligation, hysterectomies, and breast surgeries (fibroadenomas and one case of breast cancer). Additionally, there was one case of ovarian cancer, both cases of cancer diagnosed, treated, and in complete remission for over six years prior to this study. Among men, the most frequently reported surgeries included arm fracture, hernia, appendectomy, and two cases of gynecomastia. In both sexes, lipoma excision and varicose ulcer treatment have also been reported.

Table 2 shows the sociodemographic characteristics and risk factors for NCDs. The analysis of sociodemographic characteristics and risk factors for NCDs revealed a higher number of children and less physical activity in females, accompanied by a higher proportion of smoking and alcoholism in males. There was a high proportion of poor (57.4%) and regular (35.3%) dietary quality in the GSU (both 92.7%), without SSD between sex (Table 2).

Table 3 illustrates the body composition by BMI, WHtR, WHR, and WC. In the GSU the average BMI was 28.3 kg/mt^2, allowing it to be classified as overweight, while the medians for WC, WHR and WHtR coincided in classifying the majority of participants in AO with prevalences between 47% and 59.5%. In relation, SSD was detected for weight, height, WC, WHR, HC/TG, and TG/HC between sexes, being higher in males. In addition, similar levels of glycemia, SBP, DBP, and TC between sexes, but higher levels for BMI, WC, TG, LDL, VLDL, TG/HDL, LDL/HDL, and TC-HDL in males (Table 3). The classification by BMI, WHtR, and WC allowed the identification of higher proportions of normal-weight in females, but higher proportions of AO by WHtR, WHR, and WC in males.

Table 4 demonstrates the physical activity (PA) of participants. The prevalence of PA was 60.3%, mostly due to female sex. However, the lowest frequency of mixed physical activity and the highest average sedentary hours during the day were found in males. SSD was found for WC, HC, WHR, and WHtR among people with normal-weight, overweight and obesity.

Table 1: Anthropometric and clinical classification of participants by sex.

Group	Total (N=136)	Female (n=72)	Male (n=64)
Normal-weight	45 (33.1%)	29 (21.32%)	16 (11.8%)
Overweight	42 (30.9%)	21 (15.44%)	21 (15.44%)
Total obese	49 (36%)	22 (16.15%)	27 (19.85%)
Type I obesity	28 (20.6%)	13 (9.6%)	15 (11%)
Type II obesity	15 (11.03%)	6 (4.4%)	9 (6.63%)
Type III obesity	6 (4.4%)	3 (2.2%)	3 (2.2%)
Non-diabetics	116 (85%)	61 (44.85%)	55 (40.15%)
Insulin-resistants*	49 (36%)	24 (17.64%)	25 (18.36%)
Type 2 diabetics	20 (14.7%)	11 (8.1%)	9 (6.6%)
Type 2 diabetic-hypertensives	7 (5.15%)	4 (2.9%)	3 (2.25%)
Non-diabetic hypertensives	40 (29.4%)	28 (20.6%)	12 (8.8%)
Uncontrolled hypertensives	15 (11%)	9 (6.6%)	6 (4.4%)

*(IR): Insulin-resistants. Defined as adults of both sexes presenting hyperinsulinemia (≥12 µUI/mL) and a HOMA-IR (Homeostatic Model Assessment for Insulin Resistance (HOMA-IR) index ≥2.5 (32).

Table 2: Sociodemographic characteristics and risk factors for non-comunicable diseases.

Variable	Total (N=136)	Female (n=72)	Male (n=64)	*P* value*
Age (years)†	45	49	40	0.547†
E1 (18-29)	20 (14.7%)	7 (5.1%)	13 (9.6%)	0.157
E2 (30-39)	30 (22%)	23 (17%)	7 (5%)	0.000
E3 (40-49)	27 (19.9%)	10 (7.4%)	17 (12.5%)	0.157
E4 (50-59)	28 (21%)	18 (13.2%)	10 (7.8%)	0.157
E5 (60)	31 (22.8%)	8 (5.8%)	23 (17%)	0.000
SES 1 Low-low	40 (29.3%)	24 (17.6%)	16 (11.7%)	0.157
SES 2 Low	38 (42.7%)	33 (24.3%)	25 (18.4%)	0.157
SES 3 Lower-middle	32 (23.5%)	12 (8,8%)	20 (14.7%)	0.157
SES 4 Middle	4 (3%)	2 (1.5%)	2 (1.5%)	0.231
SES 5 Upper-middle	2 (1.4%)	1 (0.7%)	1 (0.7%)	0.231
PEI	25 (18.4%)	20 (14.7%)	5 (3.7%)	0.000
SEC	41 (30.1%)	27 (19.9%)	14 (10.2%)	0.000
TUE	57 (42%)	17 (12.6%)	40 (29.4%)	0.000
PGE	13 (9.5%)	8 (5.8%)	5 (3.7%)	0.231
Number of children	200 (100%)	136 (68%)	64 (32%)	0.000
Smoking	10 (7.4%)	1 (0.7%)	9 (6.7%)	0.000
Alcohol consumption	63 (46.3%)	22 (16.2%)	41 (30.1%)	0.000
Physical activity: Yes	54 (39.7%)	27 (19.85%)	27 (19.85%)	0.231
Physical activity: No	82 (60.3%)	45 (33.08%)	37 (27.2%)	0.049
Good-diet quality	10 (7.3%)	5 (3.65%)	5 (3.65%)	0.231
Regular-diet quality	48 (35.3%)	26 (19.1%)	22 (16.2%)	0.157
Poor-diet quality	78 (57.4%)	41 (30.2%)	37 (27.2%)	0.157

† MWU. *Chi-square test. E1-E5: Age group in years. SES: Socioeconomic status. PEI: complete or incomplete primary education. SEC: complete or incomplete secondary education. TUE: Technical, Technological, or University education. PGE: Postgraduate education (specialization, master´s or doctoral degree completion). The number of children included both male and female offspring. In all tests, *p* value <0.05 indicate SSD.

Table 3: Body composition by BMI, WHtR, WHR, and WC.

Classification	n (%)	X^2	Female	Male	*P* value
BMI (N=136)					
Normal-weight	45 (33.1%)	p<0,01	29 (21.3%)	16 (11.8%)	<0.05
Overweight	42 (30%)		21 (15%)	21 (15%)	>0.05
Obesity	49 (36%)		22 (16.1%)	27 (19.9%)	>0.05
Type I obesity	28 (20.6%)		13 (9.5%)	15 (11.1%)	>0.05
Type II obesity	15 (11%)		6 (4.4%)	9 (6.6%)	>0.05
Type III obesity	6 (4.4%)		3 (2.2%)	3 (2.2%)	>0.05
WHtR (N=136)					
Normal-weight	62 (45.6%)	p<0,01	34 (25%)	28 (20.6%)	<0.05
Abdominal obesity	74 (54.4%)		22 (16.2%)	52 (38.2%)	<0.05
WHR (N=136)					
Normal-weight	72 (53%)	p<0,01	30 (22%)	42 (31%)	<0.05
Abdominal obesity	64 (47%)		20 (14.7%)	44 (32.3%)	<0.05
WC (N=136)					
Normal-weight	55 (40.4%)	p<0,01	35 (25.7%)	20 (14.7%)	<0.05
Abdominal obesity	81 (59.5%)		37 (27.1%)	44 (32.4%)	<0.05

BMI: Body Mass Index. WHtR: Waist-to-Height Ratio. WHR: Waist-to-Hip Ratio. WC: Waist Circumference. X^2 test comparing the percentage distribution of each classification (BMI, WHtR, WHR, and WC). The *p*-value in the last column corresponds to MWU test. In both tests, *p* value <0.05 indicate SSD.

Table 5 presents blood biochemistry findings by sex. Similar levels of glycemia, SBP, DBP, and TC between sexes, but higher levels for BMI, WC, TG, LDL, VLDL, TG/HDL, LDL/HDL, and TC-HDL in males (Table 5). SSD was found for WC, HC, and WHtR by obesity type.

In relation to anthropometric CVR as 5-years forecasted, WHtR was classified in 33% for very high risk; WHtR, WHR, and WC were estimated between 44.9% and 50% as high risk with SSD and

Table 4: Physical activity (PA).

Classification	Total (n=136)	Female (n=72)	Male (n=64)	*P* value
PA: Yes	54 (39.7%)	27 (19.85%)	27 (19.85%)	0.231
Vigorous PA (75 min/week)	20 (14.7%)	9 (6.6%)	11 (8.1%)	0.537
Moderate PA (150 min/week)	27 (19.85%)	12 (8.8%)	15 (11.05%)	0.428
Mixed PA	7 (5.14%)	6 (4.4%)	1 (0.74%)	0.041
Average sedentary hours per day*	4.41	3.74	5,09	0.049
PA: No	82 (60.3%)	45 (33.08%)	37 (27.2%)	0.049
None PA	37 (27.2%)	21 (15.44%)	16 (11.76%)	0.348
Irregular or sporadic PA	45 (33.08%)	24 (17.64%)	21 (15.44%)	0.348
Average sedentary hours per day*	5.84	4.48	7.48	0.049

Mixed PA: combination of moderate and vigorous PA. *Not including night-time sleep hours. Chi-square test, *p*-values <0.05 indicate SSD.

Table 5: Blood biochemistry by sex.

Variable	Total (n=136)	Female (n=72)	Male (n=64)	*P* value
Glycemia (mg/dL) [a]	98.37	99.17	95.43	0.560
Insulin (µU/mL) [b]	9.22	9.41	9.41	0.404
HOMA-IR [b]	2.36	2.38	2.35	0.378
Adiponectin (µg/mL) [a]	23.98	23.94	24.03	0.910
C-reactive protein (mg/dL) [a]	4.27	4.83	3.65	0.556
Triglycerides, TG (mg/dL) [b]	126.48	117.12	136.75	0.002
TC (mg/dL)[b]	202.5	201.87	203.54	0.291
HDL (mg/dL) [b]	34.36	34.10	35.00	0.988
LDL (mg/dL) [a]	124.70	117.55	133.46	0.046
VLDL (mg/dL) [b]	25.30	23.42	27.35	0.002
TC/HDL [a]	5.85	5.65	6.07	0.237
TG/HDL [b]	3.56	3.16	4.04	0.015
LDL/HDL [b]	3.24	2.85	3.72	0.049
(TC-HDL) [b]	166.68	161.97	172.84	0.028
(TC-HDL)/HDL [a]	4.8	4.65	5.07	0.237

[a] Unpaired Student's t-test. [b] MWU test. In both tests, p-values <0,05 indicate SSD. HOMA-IR: Homeostatic Model Assessment for Insulin Resistance. TC: Total cholesterol, LDL: Low-density lipoprotein cholesterol, VLDL: Very low-density lipoprotein cholesterol, HDL: High-density lipoprotein cholesterol, TG: Triglyceride.

between sexes; and WC in 21.3% for intermediate risk without SSD and between sexes. In contrast, WHR and WC were estimated between 26.5% and 33.8% as low risk, while WHR and WHtR were estimated as very low risk in 28% and 17%, respectively, while both without SSD and between sexes. On the other hand, the 10-year forecasted CVR was defined by IFS/CFS for the GSU and by sex showing median percentages that were classified as low risk in 84.55% of participants by IFS and 88.23% of participants by CFS; as moderate risk in 3.67% of participants by IFS and 5.88% of participants by CFS; as high risk in 7.35% of participants by IFS and 2.94% of participants by CFS; and at very high risk in 4.41% of participants by IFS and 2.94% of participants by CFS, all without DES between sex. Likewise, both scores classified the CVR as low in the normal weight, overweight, and obese groups without DES. In contrast, DES was detected for both scores among the three types of obesity, although CVR was also estimated to be low in each of them. However, a trend toward marginal increases in CVR for both Framingham scores was observed with increasing BMI.

Additionally, Framingham scores classified all subgroups as low to moderate CVR, although there was a trend of increasing risk from ND (non-diabetics)<IR (insulin-resistants)<HND (non-diabetic hypertensives)<UH (uncontrolled hypertensives)<T2DM (type 2 diabetics)<HDT2 (type 2 diabetic hypertensives), until classifying these last two groups into high and very high CVR respectively due to CFS. In accordance, SSD were detected for CVR by both scores before and after Bonferroni adjustment in the KWH test and Dunn´s post-hoc test for most of subgroups, except between T2DM and HDT2. The largest differences for CVR were found between ND with T2DM, HDT2, HND, and UH.

In line with the proposed objectives, the search for associations allowed us to detect a strong positive correlation between age up to 49 years with all anthropometric indices, but after 50 years, the majority of indices decreased significantly, although the above-mentioned correlation remained. Weight decreased slightly with increasing SES, while height was low in people from the first two SES. BMI, WC, HC, and WHR increased proportionally from SES 1 to 3 but decreased in SES 4 and 5. WHtR remained low in people with a short height from SES 1 and 2 but increased markedly from SES 3 to 5. The sex variable showed strong positive associations with all anthropometric indices, being particularly higher in males, except for WC, WHR, and WHtR, which were higher in females. Likewise, education, smoking, and alcoholism exhibited strong positive associations with anthropometry. However, smoking, and alcoholism decreased with increasing age.

Analogously, strong inverse associations were found between glycemia with insulin and adiponectin as well as between insulin and HOMA-IR with adiponectin. In contrast, moderate to strong positive associations were detected between glycemia, insulin, and HOMA-IR with TC and TG. In addition, TC was positive and strongly associated with LDL, LDL/HDL, TC/HDL, TC-HDL, and (TC-HDL)/HDL. Further, there was a positive and moderate correlation between TG with adiponectin, and between TG/PC with insulin and HOMA-IR, and an inverse correlation between TG/PC with adiponectin highlighting the positive and moderate associations of most atherogenic markers with each other.

In this context, the number of children increased with age, but decreased with weight gain, and exhibited a moderate to strong positive association with the rest of the anthropometry. On the other hand, SBP and DBP were directly correlated with age, weight, BMI, WC, HC, WHR, and WHtR, but were inversely correlated with height. Likewise, glycemia, insulin, HOMA-IR, and IR status showed a moderate to strong positive association with anthropometry, except between glycemia and WHR. Adiponectin level was inversely and moderately associated with anthropometry, except for height. At the same time, CRP level was positively and slightly associated with anthropometry, except with BMI. The lipid profile and its atherogenic markers were positively and moderately associated with anthropometry, except for HDL, which showed a moderate to strong inverse association with age and anthropometry, except for height.

Similarly, most biochemical parameters were positive and slightly associated with the cutoff points for AO defined by WC, WHtR, and WHR. However, there were strong positive associations between glycemia, insulinemia, HOMA-IR, lipid profile, and atherogenic markers with aCVR and CVR based on Framingham. In contrast, a slight negative association was detected between adiponectinemia and the cutoff points for AO and aCVR and CVR based on Framingham, except with WHR. HDL level was inversely and strongly associated with AO, aCVR, and CVR based on Framingham. The TG/HC index showed a slight positive association with the cutoff points for AO but a strong positive association with aCVR, and CVR as defined by Framingham.

Additionally, although most biochemical parameters were positively and strongly associated with aCVR categories, they highlight the influence of high levels of glycemia, insulinemia, and HOMA-IR on the increase of aCVR by WC, and WHtR. In contrast, the decrease in insulinemia, HOMA-IR, LDL, and atherogenic markers were associated with a marked decrease in aCVR defined by WC, WHtR and WHR, whereas their increase was associated with a marked increase in aCVR. In contrast, a decrease in adiponectinemia level from slight to moderate was associated with an increase in aCVR by WC and WHtR. Notably, increases in TG/HC, and HC/TG were positively and strongly associated with increases in aCVR. Similarly, most biochemical parameters, including atherogenic markers and TG/HC were positively and strongly associated with increases of CVR categories described by Framingham. Furthermore, decreases in adiponectinemia and HDL levels from slight to moderate were associated with increases of CVR categories explained by Framingham.

Equally important, SBP, DBP, essential hypertension (EH), isolated systolic hypertension (ISH), isolated diastolic hypertension (IDH), hypertension categories (HTC), individual hypertension categories (HTC1, HTC2, HTC3), and CVR as defined by Framingham were positively and strongly associated with increases in weight, BMI, glycemia, insulinemia, HOMA-IR, lipid profile, atherogenic markers and TG/HC. In contrast, adiponectinemia and HDL showed moderate to strong inverse associations with the above variables, whereas HC/TG was slightly and inversely associated with TAS, TAD, and EH.

Similarly to practice PA, at least three times per week at moderate to vigorous intensity and accumulating between 75 and 150 minutes per week and to have a routine exercise, it significantly reduced the majority of anthropometric indices except height, as well as decreasing the cutoff points for AO, aCVR, and aCVR categories by WC, WHtR, and WHR. Further, it reduced the CVR by Framingham, and its risk categories, SBP, DBP, and many biochemical parameters, including atherogenic markers, and TG/HC. In contrast, not practicing PA, and the increase in sedentary hours during the day were associated positively and strongly with anthropometry, AO, aCVR, and CVR based on Framingham, including the risk categories.

Similarly, a good-quality diet, Mediterranean dietary pattern, and fruit consumption were associated with reductions in all indices of body adiposity, AO, aCVR, and CVR by Framingham, including the risk categories. In contrast, poor- and regular-quality diets, atherogenic and Western dietary patterns, and fried food (FF) consumption showed a moderate to marked positive associations with anthropometry, AO, aCVR, and CVR by Framingham, including the risk categories, whereas the Mediterranean diet and fruit consumption moderately to markedly decreased the Framingham risk categories.

Finally, a good-quality diet was positively and strongly associated with the Mediterranean dietary pattern, food groups of G1, G2, G3, and fruit consumption. In contrast, poor- and regular-quality diets were positively and strongly associated with Western and atherogenic dietary patterns, food groups of G4 to G7, and FF intake. In agreement, good-quality diet, Mediterranean dietary pattern, food groups of G1, G2, and G3, and fruit consumption demonstrated moderate to marked inverse associations with biochemical parameters, including atherogenic markers and TG/HC, except for adiponectinemia and HDL, which increased proportionally with the increase of good-dietary quality. However, poor- and regular-quality diets, Western and atherogenic dietary patterns, as well as food groups of G4 to G7, and FF intake showed a moderate to marked positive associations with biochemical parameters, except adiponectinemia and HDL.

There is a high probability that in the native population of Cartagena, the group of NCDs, including overweight and obesity ones to be transmitted mainly through the maternal line and significantly affect both sexes up to the third degree of consanguinity. In this study, basal levels of glycemia, insulinemia, HOMA-IR, lipid profile, and atherogenic markers significantly modified the severity of arterial hypertension, aCVR, and CVR by Framingham. Therefore, in Colombia it is necessary to integrate the simultaneous basal measurement of the *supra cit,* biochemical parameters in primary care, to increase the diagnostic sensitivity of insulin resistance, prediabetes, T2DM and CVR, especially in people with excess weight and hypertension.

It is also worth noting that although the adiponectinemia averages were within normal ranges between sexes and all groups, individual adiponectinemia level was inversely associated with increased BMI, central obesity, hyperglycemia, hyperinsulinemia, HOMA-IR, IR, aCVR, and CVR by Framingham. The adiponectinemia level increased slightly with increasing obesity severity, and moderately with hypertriglyceridemia. Similarly, an increase in adiponectinemia was observed in DT2, and HDT2 groups. This indicates that adiponectin would not only be involved in the control of body adiposity but would also participates in the control of several metabolic and signaling mechanisms altered in T2DM, arterial hypertension, hypertriglyceridemia, and CVR.

A good-quality diet, the Mediterranean dietary pattern, weekly fruit consumption, and weekly moderate-to-vigorous aerobic PA are associated with significant reductions in body adiposity and cardiovascular risk factors. In this regard, baseline adiponectin and HDL cholesterol levels increased directly with increasing good quality diet. Therefore, it is highly likely that the beneficial effects of good quality diet on reducing excess body weight and cardiovascular risk factors to be mediated in part by increased synthesis of the hormone adiponectin and its protective effects on both conditions. The high prevalences of poor- and regular-diet quality, represented by atherogenic and Western dietary patterns, as well as the high proportions of physical inactivity reported here, are strongly linked as risk factors that promote the development, maintenance, and severity of body adiposity, its cardio-metabolical comorbidities, the risk of atherogenesis, and the CVR in adults from Cartagena. In contrast, a good-quality diet, the Mediterranean dietary pattern, fruit consumption, and PA could reduce the increasing of body adiposity, the risk of cardiometabolic complications, and the CVR in this population.

In type II obese patients, an upward trend in atherogenic diet intake was observed that was directly associated with BMI. Similarly, throughout the UMG, CVR according to Framingham International and Colombian scores was directly associated with BMI. Increased weekly consumption of refined sugars and sweets, and a parallel decrease in weekly consumption of fruits, vegetables, and fiber, are associated with significant increases in BMI. Additionally, weekly intake of fried foods is significantly associated with increased CVR categories by Framingham International (FRS-I) and Colombian (FRS-C) scales, while the Mediterranean diet and fruit consumption moderately to markedly reduced CVR categories according to FRS-I and FRS-C.

Across the GSU, WHtR exhibited the greatest forecasting capacity for CVR to 5-years with increasing BMI, especially in the overweight and obese groups, followed by WHR, and WC. On the other hand, the FRS-I/FRS-C scores allowed the identification of SSD in the CVR 10-years forecasted, proportionally to increasing of obesity severity. Likewise, among the subgroups, Framingham Colombia contributed to identifying high and very high CVR in T2DM hypertensives and T2DM. Finally, the TG/HC index was positively and strongly associated with SBP, DBP, EH, ISH, IDH, HTC, individual categories of hypertension, and with the increase of the aCVR 5-years forecasted, and the CVR by Framingham 10-years forecasted. To our knowledge, our study is the first to report the clinical utility of the TG/HC index as a strong predictor of 5- and 10-year CVR, indicating that it could serve as a cost-effective and useful tool for the treatment, follow-up, and clinical prognosis of adults with excess body adiposity and, in general, for the monitoring of special subgroups of patients with elevated CVR or with established cardiovascular diseases.

Having an exercise routine and practicing aerobic PA at least three times a week at moderate to vigorous intensity is associated with a significant reduction in SBP, DBP, with a reduction in most biochemical parameters, including atherogenic indices and the TG/HC index, with a significant reduction in body adiposity, OA and aCVR, with a reduction in CVR categories by WC, WHtR and WHR, as well as with a significant reduction in CVR according to FRS-I and FRS-C and the risk categories. In contrast, not practicing PA and the increase in sedentary hours during the day are positively and strongly associated with all indices of body adiposity, OA and CVR, with an increase in aCVR categories and CVR categories according to FRS-I and FRS-C.

Discussion

In the GSU, the highest proportion of participants were non-diabetics (85%), insulin-resistants (36%), obese (36%) and non-diabetic hypertensives (29.4%). Insulin resistance (IR) is defined as the simultaneous presence of hyperinsulinemia ≥12 μUI/mL and HOMA-IR ≥2.5 (32). Notably, the prevalence of IR has been detected in adults with excess body weight who previously did not have this diagnosis. This last finding is related to the fact that, in Colombia, screening for IR is not mandatory as a risk criterion for pre-diabetes, T2DM, or CVR. Therefore, the Finnish Diabetes Risk Score (FINDRISK) algorithm (33), adopted by the MHSP in primary care within the integral care route for the promotion and maintenance of health, does not include IR detection. In accordance with previous results, it is suggested to the leaders of the Colombian MHSP and managers of the MAITE model recognize the importance of IR screening as an essential co-adjuvant tool in the integral evaluation process of pre-diabetes, T2DM, and CVR, since this could improve the sensitivity of early detection of people with this group of disorders and prevent their complications.

Our analysis of sociodemographic characteristics and risk factors for NCDs revealed a higher number of children and less physical activity in females, accompanied by a higher proportion of smoking and alcoholism in males. Accordingly, the prevalence of physical inactivity was 60.3%, mostly due to female sex. However, the lowest frequency of mixed physical activity and the highest average sedentary hours during the day were found in males. In contrast, lower proportions of alcoholism and smoking were identified, but at the same time, greater physical inactivity, as reported by Alayón *et al.* (8). In particular, there was a high proportion of poor (57.4%) and regular (35.3%) dietary quality in the GSU (both 92.7%), without SSD between sex.

Equally important, family history revealed a high proportion of participants who self-reporting family involvement by NCDs. In this way, it highlights the high commitment of affectation of the first, second and even third degree of consanguinity, always predominating the maternal line.

Similarly, the number of affected relatives in the maternal line was higher for the first and second degree of consanguinity, as well as by the female sex of the participant. Likewise, the third degree of consanguinity also had a higher number of affected in the maternal line without SSD, according to the sex of the participants. In this context, it is important to highlight the high and simultaneous involvement of the paternal and maternal lines for the first and second degrees of consanguinity for both sexes of the participant, especially also for the second degree of consanguinity and female sex of the participant. These findings of *supra cit.* seem to indicate that in the Cartagena population, the majority of NCDs, including overweight and obesity, had a hereditary transmission pattern strongly linked to the maternal line, with significant involvement from the first to third degree of consanguinity. Therefore, it is necessary to conduct longitudinal studies on genetic epidemiology in Cartagena to corroborate these results and verify our hypothesis.

On the other hand, in the GSU the average BMI was 28.3 kg/mt^2, allowing it to be classified as overweight, while the medians for WC, WHR and WHtR coincided in classifying the majority of participants in AO with prevalences between 47% and 59.5%. In this relation, SSD was detected for weight, height, WC, WHR, HC/TG, and TG/HC between sexes, being higher in males. In addition, similar levels of glycemia, SBP, DBP, and TC between sexes, but higher levels for BMI, WC, TG, LDL, VLDL, TG/HDL, LDL/HDL, and TC-HDL in males, even higher than those reported by Manzur *et al.* (34). The above and following findings confirm the persistent and high prevalence of overweight, obesity, AO, and their associated metabolic disorders in the adult population of Cartagena over the last two decades.

In parallel, the classification by BMI, WHtR, and WC allowed the identification of higher proportions of normal-weight in females, but higher proportions of AO by WHtR, WHR, and WC in males. SSD was found for WC, HC, WHR, and WHtR among people with normal-weight, overweight and obesity, as well as for WC, HC, and WHtR by obesity type. Furthermore, in subgroups, higher means and medians were identified for weight and BMI in the IR and DT2, and for SBP/DBP in HDT2 and UH. Likewise, the highest medians were represented by WC in IR (101 cm) and DT2 (97.5 cm), HC in IR (109 cm) and DT2 (100.5 cm), and WHtR in IR (0.61) and HDT2 (0.60), showing SSD between themselves and with the rest of the subgroups (data not shown).

Likewise, SSD was detected for glycemia, insulin, HOMA-IR, CRP, TC, TG, VLDL, TC/HDL, TG/HDL, TC-HDL, and (TC-HDL)/HDL in normal-weight and obese individuals, with the obese group showing the highest values. Also, SSD was noticed for insulin and HOMA-IR among normal-weight and overweight groups, and among overweight and obese. In addition, a significant increasing trend was observed in the levels of glycemia, insulin, HOMA-IR, CRP, lipid profile, their atherogenic markers with increasing BMI. In particular, although the adiponectinemia averages were within normal ranges in all groups, a marginal increasing trend was observed in their levels, as well as in TC, TG, LDL and atherogenic markers with increasing severity of obesity without SSD, except for TC-HDL, which showed SSD among type II and III obesity.

Similarly, among subgroups, higher means and medians were observed for adiponectin in DT2, and HDT2 women, TG in IR, DT2, HDT2, and UH, TC in IR, and DT2 men, LDL in ND, IR, and UH men. Likewise, the highest levels of VLDL, TC/HDL, TC-HDL and (TC-HDL)/HDL were found in IR and DT2 men (data not shown). From the self-reported nutritional habits, it can be appreciated that the male sex had a greater compliance with meal times, and that both sexes consume equally between 3 and 4 meals per day. From the analysis of weekly consumption by food groups, it was possible to identify a higher consumption of foods from groups G6 (refined sugars and sweets), G1 (fruits, vegetables), G5 (oils, butter and margarines) and G3 (beef, chicken, eggs, fish and seafood) in both sexes, although lower weekly frequency (WF) for the *supra cit.* food groups, that reported for all ages in Colombia. However, the daily intake of meat sausages, refined sugars and sweets was higher in the male sex, coinciding with that reported before (35).

Additionally, an increase and SSD were observed between the WF of food intake from G6 (refined sugars and sweets), but at the same time, a reduction and SSD for WF of food intake from G1 (fruits, vegetables, and greens), with the increase of BMI. In addition, there was SSD between G1, G3, G5 and G6 with the rest of the food groups within each BMI category (data not shown). In addition, the WF of intake by food groups according to obesity type also revealed a higher consumption of foods and SSD in the order of G6>G1>G5 >G3, except for G2, and G4. However, the daily intake frequency for all food groups was similar within each BMI category, and obesity type (data not shown).

In this context, the highest prevalence of dietary quality was recorded in the UMG for poor and regular quality (92.65%), followed by poor quality (57.35%), regular quality (35.3%), and the lowest for good quality (7.35%). The groups with a prevalence of poor dietary quality exceeding or equal to 70% were type II obese (87%), type 2 diabetic hypertensives (71.42%), and type 2 diabetics (70%). The highest proportion of regular diet quality was represented by type III obese (50%), normal weight (42.22%), overweight (38.1%), and non-diabetic (37.93%) patients. In contrast, the proportions of good diet quality were led by non-diabetic hypertensives (12.5%), normal weight (11.11%), and type 2 diabetics (10%). The analysis of dietary quality in the UMG highlights the urgent need to provide nutritional interventions to all participant groups, especially to those with the highest proportions of poor and regular dietary qualities.

In agreement, it was possible to identify in all groups that the atherogenic diet was predominated (50%), followed by Mediterranean (26%), and Western (24%) diets, without SSD between sexes. Similarly, a tendency of increasing of atherogenic diet intake with increasing BMI was observed, while in subgroups, the atherogenic diet predominated in insulin-resistants, the Western diet in type 2 diabetics, and the Mediterranean diet in non-diabetic hypertensives. The high proportion of atherogenic diet present in the GSU in the main groups and subgroups, reflects the high intake of hypercaloric foods, including refined sugars and sweets, saturated and trans fats from oils, butter, margarines, and fried foods (FF), accompanied by low consumption of fiber, whole grains, and legumes. The high proportion of atherogenic diet recorded here, although lower, maintains a strong relationship with that reported by Alayón *et al.* (8).

In this context, it is recognized that the Western and atherogenic dietary patterns were associated with increased central adiposity, insulin-resistance and increased atherogenic lipids (36), and subsequently promoted the formation of atheromatous plaques, the recruitment of proinflammatory cells, and the activation of foam macrophages in the intima of many arteries, thereby amplifying the inflammatory and coagulation cascade (37), increasing the size and degree of the atheromatous lesion, and increasing the CVR, morbidity, and mortality due to CVD (38). Additionally, visceral adipose tissue releases significant amounts of triglycerides, diacylglycerides, trans fats, and ceramides, which are then captured by hepatocytes, cardiomyocytes, endothelial cells and pancreatic beta cells, increasing oxidative stress, mitochondrial dysfunction/death, and demarcating the status of chronic systemic inflammation between low to moderate degree observed in overweight and obesity (39), which in turn leads to glucose intolerance, hyperglycemia, peripheral insulin resistance, compensatory hyperinsulinemia, T2DM, atherosclerosis, arterial hypertension and increased CVR (40).

Conclusion

Poor and regular diet quality, atherogenic and Western dietary patterns, physical inactivity, basal levels of glycemia, insulinemia, HOMA-IR, insulin resistance status, adiponectinemia and atherogenic markers were shown to be associated with increased obesity, central obesity, arterial hypertension, and CVR.

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Authors' Contribution

DJVP is the principal and correspondence author, because he formulated the idea and proposal of research, planned the design, and led the execution of the study, supervised all the phases of the study, developed instruments for clinical, nutritional, and PA assessment, databases, carried out statistical analysis, approved the scientific literature to include, and contributed to the critical writing of the manuscript. CLVZ is the co-author because she permanently advised the main author and co-authors on issues of epidemiology, public health, research methodology, nutritional biochemistry, and was responsible for unifying the criteria of the main author and co-authors, and correcting the writing. EEVD and MPMR are co-authors because they contributed to the screening of participants; clinical and nutritional assessment; anthropometry; blood sampling; data recording; and interpretation of clinical, nutritional, and PA results. JAHS and DAHP are co-authors because they verified the information in clinical histories and nutritional/PA instruments, corroborated the anthropometric measurements, consolidated the databases, carried out some statistical analysis, and contributed to the writing and translation of the manuscript to the English language. It is necessary to mention that supplementary files for our findings were submitted to IJNS and are available based on request.

Conflicts of Interest

None declared.

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