FACTORS ASSOCIATED WITH NORMAL-WEIGHT OBESITY IN ADOLESCENTS

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Ethical Standards Disclosure: This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all the procedures involving human subjects were approved by the Ethics Committee on Human Research of the Federal University of Viçosa (case number 0140/2010). Moreover, this project was presented to the Municipal Department of Education, the Regional Superintendent of Education and principals of schools. All participants, as well as their responsible parents/guardians, were informed about the objectives of the research and written informed consent was obtained from the parents of all adolescents.

Abstract

A new phenotype of obesity has been studied: normal-weight obesity (NWO), which describes individuals with normal-weight by body mass index (BMI) and excess body fat. Despite normal-weight, individuals with NWO have a higher cardiometabolic risk. There is still a gap in the literature on the subject, especially in adolescents, as studies with this population are scarce. Therefore, this study aims to investigate the sociodemographic factors, family history of chronic non-communicable diseases, body perception, lifestyle and food consumption associated with NWO in adolescents. This is a cross-sectional study, conducted with 506 normal-weight adolescents aged 10 to 19 years, of both sexes. Weight and height were obtained and BMI/age was calculated. Body fat analysis was performed using dual-energy X-ray absorptiometry. Sociodemographic data, level of physical activity, food consumption, body self-perception and lifestyle habits were also obtained. Logistic regression with hierarchical approach was used to analyze the associations. The odds of NWO are greater with age (OR=1.14; 95% CI=1.04-1.26), lower in male adolescents (OR=0.21; 95% CI=0.11-0.41) and higher in those with a history of familial dyslipidemia (OR=1.81; 95% CI=1.01-3.28). Adolescents satisfied with their body (OR=0.30; 95%CI 0.16-0.56) and physically active (OR=0.44; 95% CI=0.24-0.81) have a lower odds of NWO, compared to the others. In addition, it was observed that the odds of NWO is greater among adolescents who use sweeteners (sugar substitutes) (OR=3.84; 95% CI=1.70-8.65). The factors associated with NWO were female sex, older age, positive family history of dyslipidemia, lower body satisfaction, lower level of physical activity and greater use of sweeteners.

Keywords: Normal-weight obese. Adiposity. Health behaviors. Lifestyle. Adolescents.

INTRODUCTION

Chronic non-communicable diseases, including cardiovascular diseases, cancer and diabetes mellitus, are the leading cause of morbidity and mortality worldwide [1–3]. Obesity, defined by the World Health Organization (WHO) as excessive fat accumulation, is an important risk factor for these diseases [4]. The number of overweight adolescents is increasing worldwide, and according to the WHO, more than one in six adolescents worldwide were overweight in 2016 [5].

The body mass index (BMI) is a simple index, which considers weight and height, commonly used to classify overweight and obesity [4]. Although it is widely used as a measure that characterizes obesity, BMI does not provide information about the amount of body fat, as it does not differentiate lean tissue from adipose [6]. In this context, a specific phenotype of obesity was defined: normal-weight obesity (NWO) [7], which is used to classify individuals with BMI considered healthy, but with excess body fat [7].

Most studies conducted with NWO are with adults and the presence of the phenotype is associated with a low-grade pro-inflammatory state, insulin resistance, dyslipidemia and increased risk of cardiovascular disease [7–13]. In adolescents, a recent systematic review conducted by our research group [14] points out that, as for adults, NWO is associated with the presence of cardiometabolic risk factors, such as increased waist circumference, dyslipidemia and unfavorable glycid profile.

Although information is available on the potential of NWO to impact cardiometabolic health in adolescence, few studies have examined the factors associated with NWO occurrence, especially in early life [14]. Thus, evidence on how sociodemographic and behavioral characteristics, including food consumption, are associated with this phenotype is scarce [14]. The identification of the factors associated with NWO in adolescents is necessary, since it will provide evidence for the implementation of preventive strategies. This is particularly important when considering that NWO in this age group is often neglected, because they present normal-weight and young age. Therefore, it is intended to help fill the existing gap on the subject with this study that aims to investigate the sociodemographic factors, family history of chronic non-communicable diseases, body perception, lifestyle and food consumption associated with NWO in adolescents.

MATERIALS AND METHODS

This study is an integral part of the "Comparative study between the three phases of adolescence, in relation to excess body fat and cardiovascular risk factors for metabolic syndrome", already detailed in other publications [15,16]. All stages of data collection were carried out at the Health Division of the Federal University of Viçosa, by three previously trained nutritionists. The adolescents were instructed to attend the data collection steps accompanied by their parents/guardians.

Population, design and sampling

A cross-sectional, population-based epidemiological study was conducted with adolescents aged 10 to 19 years, of both sexes, selected from the rural and urban, public and private school population of the municipality of Viçosa, state of Minas Gerais (MG), Brazil, between the years 2010 to 2013. The sample size was calculated using the StatCalc, Epi Info software, version 6.04, from a specific formula for cross-sectional studies, considering the total population of 11,898 adolescents in the municipality of Viçosa/MG [17], expected prevalence of 50.0% [18], acceptable variability of 5% and 95% confidence level, totaling a minimum sample of 372 adolescents. When 20% was added to this for possible losses and control of confounding factors, a minimum total of 447 was required. The adolescents were selected by simple random sampling, using a random device to draw the participants. A total of 506 adolescents with adequate nutritional status (normal-weight) according to BMI/age [19] were included in this study.

The inclusion criteria were: not making regular use of medications that alter blood glycemia, insulinemia, lipid metabolism and/or blood pressure levels, not participating in weight reduction and control program, not making regular use of diuretics/laxatives, not being pregnant or have already been pregnant, not having deformities in the neck, not having been diagnosed with infections, acute inflammations and thyroid diseases.

All participants and their parents/ guardians, in the case of volunteers under the age of 18, signed the Informed Consent Form, according to the Helsinki Declaration. The study was approved by the Ethics Committee in Human Research of the Federal University of Viçosa (Of. Ref. No. 0140/2010).

At the end of the study, all participants were informed about the results of anthropometric, body composition, nutritional and clinical evaluations, and were

oriented about healthy eating. In addition, the volunteers who presented altered nutritional status, as well as those who were interested, received individualized nutritional care according to their needs and at no cost.

Socio-economic and demographic aspects

A questionnaire was applied to assess the profile of adolescents, such as age and sex. In addition, the socioeconomic condition was investigated through the application of a questionnaire that collects a diversity of social and economic themes at the household level, using the same methodology adopted by the *Pesquisa sobre Padrões de Vida (PPV)* - Research on Living Standards [20], which was classified as "adequate" or "precarious and intermediate".

Family history of diseases

Adolescents were asked (accompanied by parents/guardians) about the family history of diseases, based on information regarding family background - parents, siblings, maternal and paternal uncles and grandparents - who have some chronic non-communicable disease or who had died due to some chronic non-communicable disease: obesity, dyslipidemia, arterial hypertension, diabetes and cardiovascular diseases. When at least one of the family members had any of these diseases, a positive family history for the respective disease was considered.

Body perception

Adolescents were asked about self-perception of body image through a question. They had to answer whether they were satisfied with their body or not.

Physical activity

The level of physical activity was evaluated using the international physical activity questionnaire (IPAQ), short version, validated for this population group [21]. The questionnaire consists of seven items that assess the number of days the participant practices vigorous, moderate activities or walking; and the time allocated to these activities. In addition, the questionnaire investigates the time spent sitting at home, in front of the TV, video game, cell phone or other electronic equipment, at school or at work. Sitting time is assessed both on weekdays and on weekends. Based on this information, adolescents are classified as sedentary, irregularly active, active and very active [22]. We chose to group sedentary and irregularly active individuals into

insufficiently active; and those considered active and very active were grouped into physically active.

Food consumption

The dietary analysis was performed through the application of the qualitative Food Frequency Questionnaire (FFQ), in order to know the frequency of consumption of food groups. The FFQ was applied individually and adolescents were instructed to report on the frequency of food consumption in the month prior to the date of application of the questionnaire [23]. The list of foods that made up the FFQ was determined considering the foods that are part of the eating habits of adolescents in the municipality of Viçosa, based on data regarding the application of 24-Hour Recall in adolescents assisted by the *Programa de Atenção à Saúde do Adolescente* (PROASA) - Adolescent Health Care Program -, of Federal University of Viçosa. The FFQ was tested before collection with other adolescents from Viçosa, reproducing the same methodology of this study, in a pilot study. This procedure was performed in order to verify whether the list of foods in the FFQ was adequate for the study group. In this test, foods that were not included were observed, and these were added to the FFQ. Finally, the FFQ in this study consisted of 106 items, divided into 9 food groups (Table 1 - Supplementary Material). For each food item, the participant could answer, in relation to the frequency of weekly consumption, the options: <1 day; 1 day; 2 days; 3 days; 4 days; 5 days; 6 days; 7 days; or never. Information regarding food items was grouped and analyzed according to the 9 food groups: cereals (such as rice, bread, cakes, potatoes and noodles); vegetables (such as lettuce, tomatoes, cauliflower and onions); fruits (such as bananas, apples, papaya and avocado); legumes (such as beans and lentils); meats, sausages and eggs (such as beef and pork, fish, ham, sausages and eggs); milk and derivatives (including cheese, curd and yoghurt); sugars and sweets (such as chocolate, ice cream and soft drinks); oils and fats (as margarine, butter and oil for the preparation of fried foods); industrialized condiments (such as mustard, ketchup, meat broths and other industrialized ready-made seasonings). The frequency of weekly consumption was categorized as < 4 or ≥ 4 times per week [24], and the frequency ≥ 4 was referred to as regular consumption.

In addition, through a questionnaire, the volunteers were asked about their eating habits, including the use of sweeteners (sugar substitutes) (yes or not) and the consumption of breakfast (yes or not) and substitute snack for dinner (yes or not). We

also investigated the number of daily meals, habit of alcohol consumption (yes or not) and whether the participants have ever tried cigarettes (due to the low prevalence of smokers in our sample (n=4), we considered both smokers and those who had tried cigarettes).

Anthropometry and body fat assessment

The participants were barefoot, wearing light clothing, without metallic ornaments and fasting for 12 hours, for the anthropometric and body composition analysis.

Weight and height were measured using standardized international techniques [25], using electronic digital scale (LC 200pp, Marte®, São Paulo, Brazil) and portable stadiometer (Alturexata®, Belo Horizonte, Brazil). Height was measured twice, by two different nutritionists, and a maximum variation of 0.5 cm was admitted between the two measurements, using the mean as the final result. If the measurement exceeded the variation of 0.5 cm, the measurement was repeated.

For total body fat analysis, the equipment Dual Energy X-ray Absorptiometry (DEXA) (Lunar Prodigy Advance DXA System - analysis version: 13.31, GE Healthcare, Madison, WI, USA) was used. The evaluation was performed with each individual in dorsal decubitus, through a series of transverse scans from head to feet, with a duration of full body screening of approximately 10 minutes.

Definition of normal-weight obesity

Normal-weight obesity is defined by the presence of normal-weight, but excess body fat [7]. To evaluate the nutritional status of adolescents and classify them as normal-weight, BMI was used, obtained by dividing the weight by the square of height, analyzed according to sex and age, in agreement to the World Health Organization [19]. Those with Z-score values between ≥-2SD and <+1SD, were classified as normal-weight [19].

Body composition analysis was performed by DEXA and to classify the body fat percentage, values equal to or greater than 25% and 30% in males and females sex, respectively, were considered high [26].

Thus, the 506 adolescents with normal BMI/age in this study were divided into two groups:

A) With normal-weight obesity: represents adolescents with normal-weight, according to BMI/age [19], and with excess body fat (body fat values equal to or greater than 25% and 30% in males and females, respectively [26]).

B) Without normal-weight obesity: represents adolescents with normal-weight, according to BMI/age [19], and without excess body fat (body fat values <25% and <30% in males and females, respectively [26]).

Statistical analysis

The database was prepared with double typing, in Microsoft Office Excel 2007. Statistical analysis were performed using STATA software, version 14. The consistency and distribution of quantitative variables were evaluated by histograms, asymmetry coefficient and kurtosis, as well as by Shapiro Wilk normality test. According to the normality and homogeneity of the variances, quantitative variables were analyzed by Student's t-test or Mann-Whitney test. Statistical differences in categorical variables were analyzed by Pearson's chi-square test or Fisher's exact test. Categorical variables were expressed as absolute and (relative) frequency, and quantitative variables as mean and standard deviation (SD) or median and interquartile range (IR).

To evaluate the factors associated with NWO, a hierarchical approach was used, [27] based on a theoretical model on the relationships between the variables studied, which were grouped into four blocks. In the first, sociodemographic characteristics were included: sex, age and socioeconomic status, as well as family history of diseases. In the second block, body satisfaction and, in the third block, variables related to lifestyle. In the fourth block, the food consumption variables assessed by the FFQ were inserted (Figure 1 - Supplementary Material).

From the established theoretical model, simple and multiple binary logistic regression models were estimated. For the multiple analysis, in each block, an internal analysis was performed. This intra-block analysis consisted in the estimation of a logistic regression model considering NWO as an outcome variable and the other variables of the block as explanatory. All the variables of a block were used as adjustments in the following blocks and, thus, began to compose the group of variables of the next block. This procedure was repeated until the final block (block 4). The Hosmer-Lemeshow test was used to evaluate the quality of the models in each block.

The association measure used was the odds ratio (OR) with confidence interval (CI) of 95%. The significance level adopted in all analysis was 5%.

RESULTS

Among the 506 adolescents with normal-weight by BMI/age, 54.5% were female and the median age was equal to 14.2 (IR=3.02) years. It was observed that 93.9% of adolescents had a family member with one or more chronic diseases (obesity, diabetes, dyslipidemia, hypertension or cardiovascular disease). In addition, unhealthy habits such as alcohol intake (27.5%), have tried cigarettes at least once in life (10.3%), not having breakfast (27.5%) and insufficient levels of physical activity (26.5%) were observed in a considerable proportion of adolescents (Table 1). Analysis of the population stratified by sex indicated that girls had a higher frequency of family members with diabetes (female: 56.1% vs. male: 46.9%; $p<0.05$) and were more dissatisfied with their own body (female: 56.9% vs. male: 33.9%; $p<0.05$). A higher percentage of girls did not eat breakfast (female: 32.6% vs. male: 21.3%; $p<0.05$) and replaced dinner with snacks (female: 28.6% vs. male: 16.5%; $p<0.05$) was also observed. On the other hand, regular consumption of vegetables (female: 73.6% vs. male: 64.3%; $p<0.05$) was higher among female participants. Consumption of legumes (female: 86.6% vs. male: 93.5%; $p<0.05$) was more frequent among males. A borderline significance was also observed for physical activity level, in which boys were more physically active (female: 69.9% vs. male: 77.8%; $p=0.045$) (Table 1).

The prevalence of NWO phenotype in the studied group was 13.8% (n=70) (95% CI = 10.8-17.0). It is observed (Table 2) that the frequency of female adolescents among those with NWO is 82.9%, while 50.0% of adolescents who do not have NWO are female ($p<0.05$). In addition, adolescents with NWO are older (with NWO: 15.93 [4.48] years vs. without NWO: 13.95 [6.06] years; $p<0.05$), have a higher frequency of family members with dyslipidemia (with NWO: 68.6% vs. without NWO: 52.3%; $p<0.05$), are less satisfied with their body (with NWO: 22.9% vs. without NWO: 58.5%; $p<0.05$) and are more physically inactive (with NWO: 37.1% vs. without NWO: 24.8%; $p<0.05$). Adolescents with NWO were also observed to consume fewer meals per day (with NWO: 4.17 [0.96] meals vs. without NWO: 4.45 [0.97] meals; $p<0.05$), use more sweeteners (with NWO: 17.1% vs. without NWO: 9.2%; $p<0.05$), and have a higher frequency of having tried cigarettes (with NWO: 24.3% vs. without NWO: 7.3%; $p<0.05$) (Table 2).

In the logistic regression analyses, in the crude model (Table 3) it is observed that with each increase in the consumption of one meal per day, the odds of having NWO reduces by 25% (OR=0.75; 95%CI 0.58-0.97). However, after adjustments for lifestyle variables, family history of disease, and sociodemographic variables, this association disappeared. Similar to the number of meals per day, it is noted, in the crude model, that the odds of having NWO among adolescents who have ever tried cigarettes is 2.05 times the odds compared to those who have never tried (OR=2.05; 95%CI 1.02-4.13) (Table 3). Moreover, in the crude model, the phenotype was associated with sex, age, family history of dyslipidemia, body satisfaction, level of physical activity and use of sweeteners, which maintained significant associations in the analysis of factors associated with the phenotype (adjusted model) (Table 3).

In this sense, in the adjusted model, when investigating the factors associated with NWO phenotype (Table 3), it is noted that the odds of having NWO in male participants is 79% lower (OR=0.21; 95% CI 0.11-0.41) compared to female participants; and that the odds of the NWO phenotype is greater in adolescents with a positive family history of dyslipidemia (OR=1.81; 95% CI 1.01-3.28). In addition, the one-year increase in age is associated with a 14% increase (OR=1.14; 95% CI 1.04-1.26) in the odds of having NWO. In block 2, an inverse association was observed with body satisfaction, that is, the odds of having NWO among adolescents satisfied with their body was 70% lower compared to those dissatisfied (OR=0.30; 95% CI 0.16-0.56). At block 3, it was observed that the odds of having NWO in physically active individuals is 56% lower compared to insufficiently active individuals (OR=0.44; 95% CI 0.24-0.81). In addition, it was found that the odds of having NWO in adolescents who use sweeteners (sugar substitutes) is higher, compared to those who do not (OR=3.84; 95% CI 1.70-8.65) (Table 3). The different factors associated with NWO are represented in Figure 2 in the supplementary material.

Furthermore, as a secondary analysis, we investigated whether the factors associated with the NWO phenotype differed between sexes by means of a stratified analysis. For this, we used the same hierarchical approach as the adjusted model with the total sample. It was observed, for males, that the odds of the NWO phenotype is higher among adolescents with family history of dyslipidemia (OR=4.76; 95% CI 1.07-20.94), who used sweeteners (OR=16.33; 95% CI 1.64-62.38) and among those who had already tried cigarettes (OR=14.12; 95% CI 1.06-88.70). In addition, an inverse

association of the phenotype was observed with body satisfaction (OR=0.19; 95% CI 0.05-0.75) and use of processed condiments (OR=0.03; 95% CI 0.01-0.60). For female adolescents, it was observed a positive association of the NWO phenotype with age (OR=1.23; 95% CI 1.10-1.37) and use of sweeteners (OR=3.42; 95% CI 1.32-8.80), and an inverse association of the phenotype with body satisfaction (OR=0.37; 95% CI 0.18-0.77) and practice of physical activity (OR=0.48; 95% CI 0.24-0.96) (data not shown).

DISCUSSION

The prevalence of NWO in adolescents is not uncommon and can vary from 6.8% to 55.6% [14], depending on the population, age group and diagnostic criteria used. The presence of this phenotype is associated with increased cardiometabolic risk, which can persist until adulthood [28,29]. Thus, understanding the factors associated with NWO becomes important for the development of prevention and control strategies. According to our knowledge, this is the first study that investigated, through hierarchical analysis, the factors associated with NWO in a representative sample of adolescents of both sexes. We observed a prevalence of NWO in 13.8% among the participants and that the factors associated with the phenotype were sex, age, family history of dyslipidemia, body satisfaction, level of physical activity and use of sweeteners. Therefore, our study brings relevant contributions on the topic, especially considering that studies with adolescents with NWO are scarce.

In accordance with the findings of other studies [7,9,30], there was a predominance of NWO in females. In addition, also in accordance with what we observed, there is a positive association of the phenotype with age [31,32], which can be explained because of the fact that body fat increases over the years [33–36]. We also found higher odds of having NWO in adolescents who had a family history of dyslipidemia. The family history of diseases, such as dyslipidemias, can help in the tracking of various cardiometabolic changes [37,38], since it is based on heredity, eating habits and shared lifestyle [39]. In this way, the investigation of family history for chronic diseases can be useful in assessing the cardiometabolic risk of adolescents.

In addition, we found that the odds of having NWO was lower among those who are satisfied with their body, compared to those who are not satisfied. In a cross-sectional study with male adolescents, Fortes et al. (2015) observed that participants who were not satisfied with the body had a higher percentage of body fat than those

who were satisfied [40]. In another study conducted with university students, it was observed that body adiposity, evaluated by the sum of the thickness of five skin folds, was associated with dissatisfaction with body image (OR=2.56; 95% CI 1.36-4.80) [41]. Hence, our findings corroborate those of other authors, highlighting that body dissatisfaction may be associated with excess body fat, even among normal-weight individuals, as found in this study.

High body adiposity, regardless of BMI, is a factor associated with increased risk for cardiovascular disease, cardiometabolic dysregulation, coronary artery disease and cardiovascular mortality [42]. Cardiometabolic disorders are one of the leading causes of death worldwide [43,44] and excess fat exerts an important influence for the evolution of these disorders. The conventionally described risk factors for excess body adiposity include unhealthy eating patterns and physical inactivity, that are also partly responsible for the increase in obesity [45,46]. In this sense, it is valid to consider that several chronic diseases manifested in adulthood originate from modifiable lifestyle factors practiced in childhood and adolescence [45] and the adoption of good life habits are important for the prevention and control of these diseases.

In this sense, the results of other studies indicated an association of the NWO phenotype with modifiable lifestyle factors, such as low levels of physical activity in adolescents and adults [11,14,47]. In line with these studies, we found lower odds of having NWO among adolescents who are physically active. Regular physical activity has been associated with several benefits, such as lowering cholesterol, blood pressure and obesity [48,49]. In addition, physical inactivity is an important risk factor for cardiovascular diseases [50] and the increase in the adoption of sedentary behaviors in adolescents, such as watching TV, playing video games and using the computer, is a cause for concern, since it has contributed to reduce the promotion of a physically active lifestyle [51]. In this context, encouraging the practice of physical activity is of great importance, given the beneficial role that exercising plays in health, including in adolescence.

The adoption of practices aimed at weight reduction is common in adolescence, highlighting the use of sugar substitute products, such as sweeteners. In a cross-sectional study with 118 female normal-weight adolescents, the use of sweeteners was the factor most associated with excess adiposity in the established risk model [52]. In accordance with these findings, we observed in this study that adolescents with NWO

consume more sweeteners than normal-weight individuals without excess body fat. Considering the cross-sectional design of this study, it is important to consider that this result can be explained by reverse causality. This is because the practice of using sweeteners among individuals with NWO, combined with the high frequency of body dissatisfaction also observed in this group, can be a way to reduce energy consumption in order to reduce weight and body fat. In addition, it should be highlighted the possibility of this restriction of energy consumption, through the use of sweeteners, be compensated by the increase in the intake of other foods, such as fast-food, which could cause greater deposition of body fat [53].

Different methods and instruments are used for dietary analysis, which is challenging, given the complexity of qualitatively and quantitatively assessing food intake [54]. In this study, we did not find any association of food consumption due to FFQ with NWO. The simplicity in the administration of FFQ and its cost-effectiveness are great advantages [55], in addition to the ease of coding and processing [56]. However, the performance of the FFQ in the accurate assessment of food intake varies between populations and environments. Differences can be due to a variety of reasons: the number and variety of food items used; ordering of questions; and whether the questionnaires were self-applicable or interview-guided [57,58]. In addition, a FFQ can be non-quantitative, asking only the frequency of food consumed [59], which was the case of the one used in this study. It is also important to consider that in this study we did not adjust the models by total energy intake, as we did not obtain this information from the qualitative FFQ. This may justify, in part, the absence of association of food items evaluated by the qualitative FFQ with the NWO phenotype.

This research presented other limitations that deserve to be highlighted. A questionnaire was used by the interviewers, with a single question, to evaluate body self-perception, without using a validated method. In addition, the cross-sectional design makes it impossible to ensure the temporality of the observed associations between the factors and NWO, besides the possibility of the reverse causality bias already mentioned. Despite these limitations, this population-based study contributes to filling important gaps on the subject in the adolescent public, and has as positive points the methodological robustness in data collection, use of validated methods, such as DEXA, in addition to the large set of covariates that allowed a more thorough evaluation of the factors associated with the phenotype.

CONCLUSION

The odds of having NWO increases with age, is lower in male adolescents, and higher in those with family history of dyslipidemia. Adolescents satisfied with their body and physically active have lower odds of having NWO. In addition, those with NWO have higher odds of using sweeteners. Given this, the importance of adopting a healthy lifestyle in adolescence to minimize the present and future health risks related to excess fat observed in those with NWO is emphasized.

Furthermore, it is highlighted that further studies are needed to investigate the eating habits of individuals with NWO, as well as longitudinal studies that can establish causal relationships between this phenotype and its risk factors.

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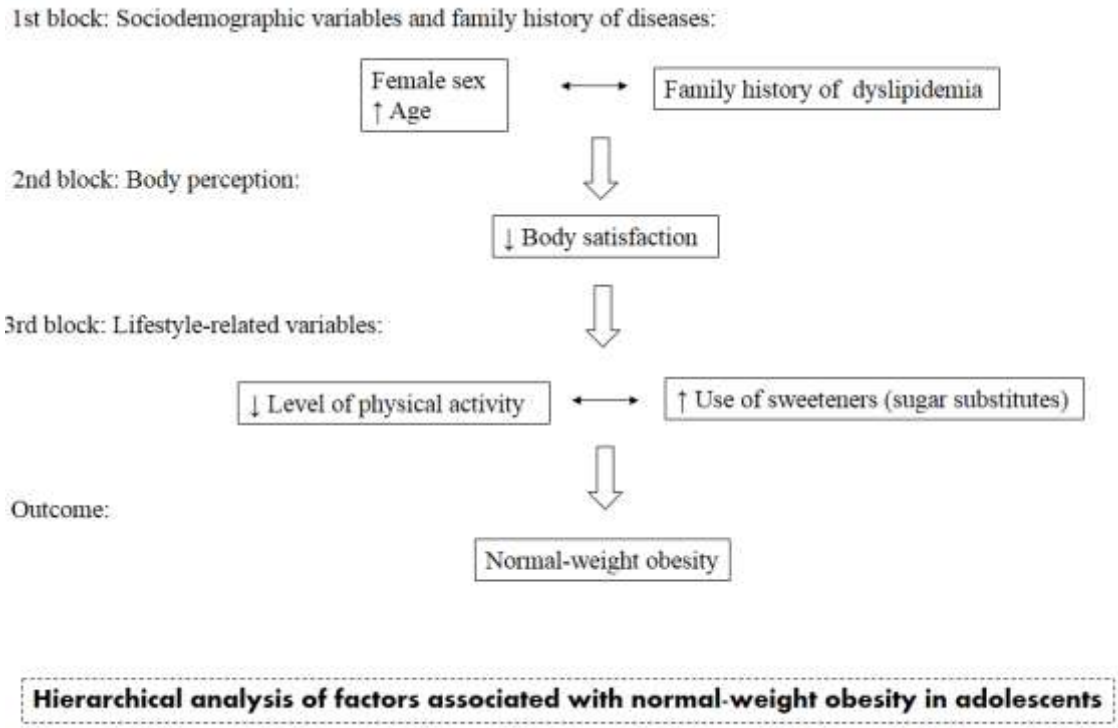

Figure 1

Table 1. Characterization of adolescents in total sample and according to the sex

	Total sample (n=506)	**Male (n=230)**	**Female (n=276)**	**p-value**
Sex				
Female	276 (54.5%)	-	-	-
Male	230 (45.5%)	-	-	
Age (years)	14.23 (3.02)	14.30 (3.14)	14.67 (2.91)	0.163[a]
Socioeconomic condition				
Adequate	273 (54.0%)	123 (53.5%)	150 (54.3%)	0.845[b]
Precarious and intermediate	233 (46.0%)	107 (46.5%)	126 (45.7%)	
FH of obesity	235 (46.4%)	107 (46.5%)	128 (46.4%)	0.978[b]
FH of diabetes	263 (52.0%)	108 (46.9%)	155 (56.1%)	**0.035**[b]
FH of dyslipidemia	276 (54.5%)	116 (50.4%)	160 (58.0%)	0.082[b]
FH of hypertension	400 (79.1%)	180 (78.3%)	220 (79.7%)	0.722[b]
FH of cardiovascular disease	232 (45.8%)	96 (41.7%)	136 (49.3%)	0.078[b]
Body perception				
Not satisfied	235 (46.4%)	78 (33.9%)	157 (56.9%)	**<0.001**[b]
Satisfied	271 (53.6%)	152 (66.1%)	119 (43.1%)	
Level of physical activity				
Insufficiently active	134 (26.5%)	51 (22.2%)	83 (30.1%)	**0.045**[b]
Physically active	372 (73.5%)	179 (77.8%)	193 (69.9%)	
No have breakfast	139 (27.5%)	49 (21.3%)	90 (32.6%)	**0.005**[b]
Consume a substitute snack for dinner	117 (23.1%)	38 (16.5%)	79 (28.6%)	**0.001**[b]
Number of meals per day	4.41 (0.98)	4.48 (0.97)	4.35 (0.98)	0.123[a]
Use of sweeteners (sugar substitutes)	49 (9.7%)	21 (9.1%)	28 (10.1%)	0.713[b]
Alcohol intake	139 (27.5%)	64 (27.8%)	75 (27.2%)	0.870[b]
Tried cigarette	52 (10.3%)	29 (12.6%)	23 (8.3%)	0.115[b]
Food consumption by FFQ:				
Milk and derivatives				
Does not consume ≥4x/week	120 (23.7%)	53 (23.0%)	67 (24.3%)	0.746[b]
Consumes ≥4x/week	386 (76.3%)	177 (77.0%)	209 (75.7%)	

Meat, sausages and eggs				
Does not consume ≥4x/week	78 (15.4%)	34 (14.8%)	44 (15.9%)	0.719[b]
Consumes ≥4x/week	428 (84.6%)	196 (85.2%)	232 (84.1%)	
Fruits				
Does not consume ≥4x/week	192 (37.9%)	90 (39.1%)	102 (37.0%)	0.616[b]
Consumes ≥4x/week	314 (62.1%)	140 (60.9%)	174 (63.0%)	
Vegetables				
Does not consume ≥4x/week	155 (30.6%)	82 (35.7%)	73 (26.4%)	**0.025**[b]
Consumes ≥4x/week	351 (69.4%)	148 (64.3%)	203 (73.6%)	
Legumes				
Does not consume ≥4x/week	52 (10.3%)	15 (6.5%)	37 (13.4%)	**0.011**[b]
Consumes ≥4x/week	454 (89.7%)	215 (93.5%)	239 (86.6%)	
Sugar and sweets				
Does not consume ≥4x/week	12 (2.4%)	5 (2.2%)	7 (2.5%)	0.790[b]
Consumes ≥4x/week	494 (97.6%)	225 (97.8%)	269 (97.5%)	
Oils and fats				
Does not consume ≥4x/week	62 (12.3%)	32 (11.6%)	32 (11.6%)	0.621[b]
Consumes ≥4x/week	444 (87.7%)	200 (87.0%)	244 (88.4%)	
Condiment				
Does not consume ≥4x/week	271 (53.6%)	127 (55.2%)	144 (52.2%)	0.494[b]
Consumes ≥4x/week	235 (46.4%)	103 (44.8%)	132 (47.8%)	
Cereals				
Does not consume ≥4x/week	0	0	0	-
Consumes ≥4x/week	506 (100%)	230 (100.0%)	276 (100.0%)	

FH: family history. FFQ: Food Frequency Questionnaire.

The results were expressed as absolute and (relative) frequency for categorical variables. Quantitative variables were expressed as mean and (standard deviation) when analyzed by Student's t test or as median and (interquartile range) when analyzed by Mann-Whitney test.

[a] Student's t test

[b] Pearson's chi-square

Table 2. Characterization of adolescents according to the absence or presence of normal-weight obesity (NWO)

	Total sample (n=506)			Male sex (n=230)			Female sex (n=276)		
	without NWO (n=436)	with NWO (n=70)	p-value	without NWO (n=218)	with NWO (n=12)	p-value	without NWO (n=218)	with NWO (n=58)	p-value
Sex									
Female	218 (50.0%)	58 (82.9%)	**<0.001**[a]	-	-	-	-	-	-
Male	218 (50.0%)	12 (17.1%)		-	-	-	-	-	-
Age (years)	13.95 (6.06)	15.93 (4.48)	**0.003**[b]	14.33 (3.17)	13.59 (2.63)	0.428[c]	14.13 (5.62)	16.36 (3.39)	**<0.001**[b]
Socioeconomic condition									
Adequate	230 (52.8%)	43 (61.4%)	0.176[a]	118 (54.1%)	5 (41.7%)	0.399[a]	112 (51.4%)	38 (65.5%)	0.055[a]
Precarious and intermediate	206 (47.2%)	27 (38.6%)		100 (45.9%)	7 (58.3%)		106 (48.6%)	20 (34.5%)	
FH of obesity	201 (46.0%)	34 (48.6%)	0.684[a]	100 (45.9%)	7 (58.3%)	0.789[a]	100 (45.9%)	28 (48.3%)	0.744[a]
FH of diabetes	223 (51.1%)	40 (57.1%)	0.343[a]	99 (45.4%)	9 (75.0%)	0.154[a]	123 (56.4%)	32 (55.2%)	0.865[a]

FH of dyslipidemia	228 (52.3%)	48 (68.6%)	**0.011**[a]	105 (48.2%)	11 (91.7%)	**0.018**[a]	122 (56.0%)	38 (65.5%)	0.190[a]
FH of hypertension	344 (79.0%)	56 (80.0%)	0.846[a]	170 (77.9%)	10 (83.3%)	0.725[d]	173 (79.4%)	47 (81.0%)	0.778[a]
FH of cardiovascular disease	196 (44.9%)	36 (51.4%)	0.302[a]	89 (40.8%)	7 (58.3%)	0.560[d]	106 (48.6%)	30 (51.7%)	0.675[a]
Body perception									
Not satisfied	181 (41.5%)	54 (77.1%)	**<0.001**[a]	70 (32.1%)	8 (66.7%)	**0.024**[d]	111 (50.9%)	46 (79.3%)	**<0.001**[a]
Satisfied	255 (58.5%)	16 (22.9%)		148 (67.9%)	4 (33.3%)		107 (49.1%)	12 (20.7%)	
Level of physical activity									
Insufficiently active	108 (24.8%)	26 (37.1%)	**0.029**[a]	47 (21.6%)	4 (33.3%)	0.308[d]	61 (28.0%)	22 (37.9%)	0.142[a]
Physically active	328 (75.2%)	44 (62.9%)		171 (78.4%)	8 (66.7%)		157 (72.0%)	36 (62.1%)	
No have breakfast	114 (26.1%)	25 (35.7%)	0.096[a]	43 (19.7%)	6 (50.0%)	**0.023**[d]	71 (32.6%)	19 (32.8%)	0.978[a]
Consume a substitute snack for dinner	95 (21.8%)	22 (31.4%)	0.076[a]	37 (17.0%)	1 (8.3%)	0.696[d]	58 (26.6%)	21 (36.2%)	0.151[a]

Number of meals per day	4.45 (0.97)	4.17 (0.96)	**0.028**[c]	4.51 (0.96)	4 (1.04)	0.077[c]	4.39 (0.99)	4.21 (0.95)	0.219[c]
Use of sweeteners (sugar substitutes)	32 (7.3%)	17 (24.3%)	**<0.001**[a]	18 (8.3%)	3 (25.0%)	0.085[d]	14 (6.4%)	14 (24.1%)	**<0.001**[a]
Alcohol intake	115 (26.4%)	24 (34.3%)	0.169[a]	61 (28.0%)	3 (25.0%)	1.000[d]	54 (24.8%)	21 (36.2%)	0.082[a]
Tried cigarette	40 (9.2%)	12 (17.1%)	**0.042**[a]	26 (11.9%)	3 (25.0%)	0.181[d]	14 (6.4%)	9 (15.5%)	**0.034**[d]
Food consumption by FFQ:									
Milk and derivatives									
Does not consume ≥4x/week	106 (24.3%)	14 (20.0%)	0.431[a]	51 (23.4%)	2 (16.7%)	0.738[d]	55 (25.2%)	12 (20.7%)	0.474[a]
Consumes ≥4x/week	330 (75.7%)	56 (80.0%)		167 (76.6%)	10 (83.3%)		163 (74.8%)	46 (79.3%)	
Meat, sausages and eggs									
Does not consume ≥4x/week	70 (16.1%)	8 (11.4%)	0.320[a]	32 (14.7%)	2 (16.7%)	0.693[d]	38 (17.4%)	6 (10.3%)	0.190[a]
Consumes ≥4x/week	366 (83.9%)	62 (88.6%)		186 (85.3%)	10 (83.3%)		180 (82.6%)	52 (89.7%)	
Fruits									
Does not consume ≥4x/week	168 (38.5%)	24 (34.3%)	0.497[a]	85 (39.0%)	5 (41.7%)	1.000[d]	83 (38.1%)	19 (32.8%)	0.456[a]

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Consumes ≥4x/week	268 (61.5%)	46 (65.7%)		133 (61.0%)	7 (58.3%)		135 (61.9%)	39 (67.2%)	
Vegetables									
Does not consume ≥4x/week	131 (30.0%)	24 (34.3%)	0.475[a]	77 (35.3%)	5 (41.7%)	0.759[d]	54 (24.8%)	19 (32.8%)	0.220[a]
Consumes ≥4x/week	305 (70.0%)	46 (65.7%)		141 (64.7%)	7 (58.3%)		164 (75.2%)	39 (67.2%)	
Legumes									
Does not consume ≥4x/week	41 (9.4%)	11 (15.7%)	0.107[a]	14 (6.4%)	1 (8.3%)	0.564[d]	27 (12.4%)	10 (17.2%)	0.335[a]
Consumes ≥4x/week	395 (90.6%)	59 (84.3%)		204 (93.6%)	11 (91.7%)		191 (87.6%)	48 (82.8%)	
Sugar and sweets									
Does not consume ≥4x/week	10 (2.3%)	2 (2.9%)	0.676[d]	4 (1.8%)	1 (8.3%)	0.237[d]	6 (2.8%)	1 (1.7%)	1.000[d]
Consumes ≥4x/week	426 (97.7%)	68 (97.1%)		214 (98.2%)	11 (91.7%)		212 (97.2%)	57 (98.3%)	
Oils and fats									
Does not consume ≥4x/week	57 (13.1%)	5 (7.1%)	0.160[a]	29 (13.3%)	1 (8.3%)	1.000[d]	28 (12.8%)	4 (6.9%)	0.209[a]
Consumes ≥4x/week	379 (85.4%)	65 (92.9%)		189 (86.7%)	11 (91.7%)		190 (87.2%)	54 (93.1%)	

Condiment									
Does not consume ≥4x/week	230 (52.8%)	41 (58.6%)	0.365[a]	117 (53.7%)	10 (83.3%)	**0.044**[a]	113 (51.8%)	31 (53.4%)	0.827[a]
Consumes ≥4x/week	206 (47.2%)	29 (41.4%)		101 (46.3%)	2 (16.7%)		105 (48.2%)	27 (46.6%)	
Cereals									
Does not consume ≥4x/week	0	0	-	-	-	-	-	-	-
Consumes ≥4x/week	436 (100.0%)	70 (100.0%)		218 (100.0)	12 (100.0%)		218 (100.0%)	58 (100.0%)	

NWO: normal-weight obesity. FH: family history. FFQ: Food Frequency Questionnaire.

The results were expressed as absolute and (relative) frequency for categorical variables. Quantitative variables were expressed as mean and (standard deviation) when analyzed by Student's t test or as median and (interquartile range) when analyzed by Mann-Whitney test.

[a] Pearson's chi-square

[b] Mann-Whitney

[c] Student's t test

[d] Fisher's exact test

Table 3. Crude and adjusted odds ratios (OR) and 95% confidence intervals (95% CI) for factors associated with normal-weight obesity (n=506)

	Crude Model OR (95% CI)	**Adjusted model OR (95% CI)[a]**
1st block: Sociodemographic variables and family history of diseases		
Male sex[b]	0.21 (0.11-0.40)*	0.21 (0.11-0.41)*
Age	1.15 (1.05-1.25)*	1.14 (1.04-1.26)*
Precarious or intermediate socioeconomic conditions[c]	0.70 (0.42-1.18)	0.84 (0.49-1.45)
Family history of obesity	1.06 (0.65-1.74)	1.08 (0.63-1.85)
Family history of diabetes	1.22 (0.74-1.99)	0.86 (0.49-1.52)
Family history of dyslipidemia	1.84 (1.10-3.08)*	1.81 (1.01-3.28)*
Family history of hypertension	1.01 (0.55-1.86)	1.01 (0.51-1.99)
Family history of cardiovascular diseases	1.24 (0.76-2.02)	1.03 (0.60-1.77)
2nd block: Body perception		
Body satisfaction (satisfied)	0.21 (0.12-0.38)*	0.30 (0.16-0.56)*
3rd block: Lifestyle-related variables		
Physically active[d]	0.56 (0.33-0.95)*	0.44 (0.24-0.81)*
Have breakfast[e]	0.64 (0.37-1.09)	1.13 (0.56-2.30)
Consume a substitute snack for dinner[e]	1.65 (0.95-2.86)	0.81 (0.40-1.64)
Number of meals per day	0.75 (0.58-0.97)*	0.83 (0.59-1.17)
Use of sweeteners (sugar substitutes)[e]	4.04 (2.10-7.77)*	3.84 (1.70-8.65)*
Alcohol intake[e]	1.46 (0.85-2.49)	0.75 (0.34-1.67)
Tried cigarette[e]	2.05 (1.02-4.13)*	1.90 (0.75-4.84)
4th block: Food consumption by FFQ[f]		
Regular consumption (≥4 times/week) of food groups:		
Milk and derivatives	1.29 (0.69-2.40)	1.39 (0.66-2.91)
Meat, sausages and eggs	1.48 (0.68-3.23)	1.80 (0.70-4.65)
Fruits	1.20 (0.71-2.04)	1.20 (0.62-2.32)

Vegetables	0.82 (0.48-1.40)	0.84 (0.44-1.59)
Legumes	0.56 (0.27-1.14)	0.62 (0.26-1.46)
Sugars and sweets	0.80 (0.17-3.72)	0.33 (0.05-2.32)
Oils and fats	1.96 (0.76-5.06)	2.31 (0.73-7.34)
Condiment	0.79 (0.47-1.32)	0.64 (0.35-1.18)
Cereals	NA[g]	NA[g]

FFQ: Food Frequency Questionnaire. * Statistical significance

[a] This model represents the analysis of the factors associated with the NWO phenotype using a hierarchical approach. First block: adjustment made for the variables of this block; Second block: adjustment made for the variables of this block and for the variables of the previous blocks (First block); Third block: adjustment made for the variables of this block and for the variables of the previous blocks (First and second block); Fourth block: adjustment made for the variables of this block and for the variables of the previous blocks (First, second and third block).

[b] The results express the odds of the phenotype in the male sex, compared to the female sex.

[c] The results express the odds of the phenotype in adolescents with precarious or intermediate socioeconomic condition, compared to the adequate one.

[d] The results express the odds of the phenotype in physically active adolescents, compared to insufficiently active adolescents.

[e] Variables categorized as yes or no. The results express the consumption of breakfast and substitute snack for dinner, use of sweeteners, alcohol intake and those who have tried a cigarette (yes), in relation to those who do not consume breakfast and substitute snack for dinner, do not use sweeteners, do not consume alcohol and who have never tried a cigarette (no).

[f] The food groups were categorized as consumption ≥ 4 times per week and < 4 times per week. The results express regular consumption (≥ 4 times/week), compared to non-regular (<4 times/week).

[g] NA: not assessed, as all participants consume cereals ≥ 4 times a week.