# Influence of Prior Nutritional Status on the Development of the Metabolic Syndrome in Adults

*Renata Maria Souza Oliveira, Sylvia do Carmo Castro Franceschini, Gilberto Paixão Rosado, Silvia Eloiza Priore*
*Departamento de Nutrição e Saúde da Universidade Federal de Viçosa (UFV), Viçosa, MG - Brazil*

## Summary

**Background: The increase in the prevalence of excess weight among people of increasingly younger age groups may lead to the early development of cardiovascular risks.**

**Objective: To investigate the prevalence of the metabolic syndrome among young adults and the impact of birth conditions and nutritional status during adolescence on this disorder.**

**Methods: One hundred individuals were evaluated at three different stages of life. By consulting the database of people enlisted in the army reserve military service, data were collected on weight, height, and waist circumference of all draftees of 1996, 1997, and 1999 in order to analyze their nutritional status during adolescence. Using the same database, information was sought at the maternity on their birth conditions and the adult individuals were identified. Anthropometric and biochemical data were obtained from these adults. The Metabolic Syndrome (MS) was classified according to ATP III NCEP. Body fat percentage was assessed with bioelectrical impedance and the statistical analysis was performed using the Sigma Stat 2.0 software.**

**Results: Prevalence of the MS was detected in 13% of the individuals. The birth conditions showed no relationship with the syndrome. In adolescence, those individuals diagnosed with MS had greater values for weight (11 kg; p =<0.001), WC (8 cm; p < 0.001), and BMI (2.5 kg/m²; p= 0.002).**

**Conclusion: A significant part of the risk factors for cardiovascular conditions starts during childhood and adolescence, and is likely to persist throughout life; therefore, primary prevention measures are critical in the context of cardiovascular disease. (Arq Bras Cardiol 2009;92(2):101-106)**

**Key words: Nutritional status; metabolic syndrome; adults.**

## Introduction

Cardiovascular diseases are the most frequent cause of morbidity/mortality in Brazil (300,000 deaths/year), and account for the greatest portion of hospital expenses of the Unified Health System[1,2].

Increased life expectancy contributes to making some factors such as visceral obesity, glucose intolerance, systemic arterial hypertension, hypertriglyceridemia, and low HDL values more frequent, thus justifying the fact that the Metabolic Syndrome is a public health concern[3].

This is a disorder characterized by a set of risk factors for cardiovascular conditions: arterial hypertension, increased triacylglycerols, lowered HDL, and impaired glucose tolerance/type 2 diabetes, usually related to central fat deposition and insulin resistance. It is important to note that the association of this syndrome with cardiovascular diseases has increased all-cause mortality approximately 1.5-fold, and cardiovascular death about 2.5-fold[4].

Prevalence of the metabolic syndrome depends heavily on the criterion used to define it and therefore, study outcomes differ significantly[5].

The increased prevalence of excess body weight among increasingly younger age groups may lead to the premature development of cardiovascular risks[6].

Thus, the aim of this study was to evaluate the prevalence of risk factors for metabolic syndrome among young adult men in Viçosa, state of Minas Gerais, and the potential influence of their conditions at birth and nutritional status in adolescence on the development of the syndrome.

## Methods

One hundred men were evaluated during three stages of their lives: at birth, during adolescence, and adult life.

### Adolescence

Sample selection was made using database registries of reserve army draftees of the municipality of Viçosa. Weight,

**Mailing address: Renata Maria Souza Oliveira •**
Rua Floriano Peixoto, 275/201, Centro - 36570-000 - Viçosa, MG - Brazil
E-mail: renata_vicosa@yahoo.com.br
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height, and waist circumference measurements of all draftees enlisted in 1996, 1997, and 1999 were collected (n = 1,082 full registries) to analyze their nutritional status in adolescence. The BMI was determined according to the Center for Disease Control and Prevention criteria[7]. In order to classify the waist circumference (WC), cutoff values proposed by the WHO[8] were used for adults since the adolescents in this study were at the end of their teen years, i.e., 18 to 19 years old.

### Birth conditions

Based on the names of the draftees' mothers contained in the database, information about the birth conditions were obtained from the only maternity in the city at the time, from 1978 to 1981. Information on birth weight and length was obtained as per the World Health Organization classification[9]. Intrauterine growth was assessed as per Rohrer's ponderal Index (RI) that classifies intrauterine growth immediately after birth according to the weight (kg) and length (cm) at birth[10]. However, of the initial 1,082 individuals enlisted, only 385 had complete evaluations for these two stages of life.

### Adult life

As adults, individuals were located through addresses obtained from the local reserve army database and/or from the telephone directory, according to their own names or those of their parents.

Figure 1, below, shows the sample selection, stressing that the evaluation in these three stages of life was considered an inclusion criterion for this study.

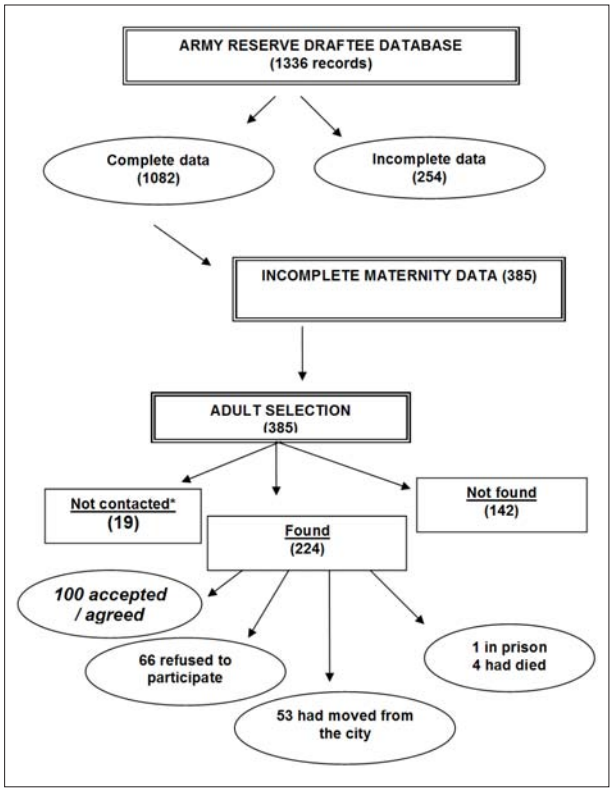


*Figure 1 - Diagram of sample selection. * Not counted due to time available for data collection.*

Anthropometric evaluation in adults included weight and height, from which BMI and its derivatives were calculated, and waist and hip circumference from which the waist-to-hip ratio (WHR) was calculated. BMI, WC, and WHR were classified using WHO cutoff values[8]. The percentage of body fat (% BF), as well as fat mass (FM) and fat-free mass (FFM) in kilograms, were measured by horizontal electrical impedance, and the percentage of total body fat was classified as suggested by Lohman[11]. Tricipital (TSF), bicipital (BSF), subscapular (SCSF), and suprailiac (SISF) skinfolds (mm) were also measured for body fat distribution analysis. Peripheral fat and central fat were calculated as the sum of peripheral (BSF and TSF) and central (SISF and SCSF) skinfolds, respectively.

Blood samples were drawn for lipid profile determination at the *Laboratório de Análises Clínicas* of the *Universidade Federal de Viçosa*. Arterial blood pressure was measured using an automatic device, as per instructions of the manufacturer. MS classification was performed according to NCEP-ATP III[4] criteria, which were developed for clinical use and do not require insulin resistance confirmation, thus facilitating their use.

Diet analysis was performed based on the register of three non-consecutive days of meals taken, and data were analyzed with Diet Pro 4.0[12] software. Individuals were asked if they were engaging in physical activities, and if yes, what kind and with what frequency.

For the statistical analysis, Student's t test and Pearson's correlation (parametric variables) or Mann Whitney test and Spearman's correlation (non-parametric variables) ($p < 0.05$) were used along with the Sigma Stat 2.0 software.

This study was submitted to and approved by the Human Research Ethics Committee of the UFV, and participants were evaluated only after having signed Informed Consent Forms.

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## Results

### Evaluation of nutritional status in adult life

The mean age of the 100 individuals in the study at this stage was 26.2 ± 1.2 years. Evaluation of the nutritional status was performed using BMI, which is one of the indicators most commonly used for evaluating populations[9,13]. Two percent of the individuals were underweight, 65% were normal weight, and 33% had excess weight (overweight or obesity); obesity (BMI ≥ 30 kg/sq m) was detected in 9% of the sample.

As to percentage of body fat, 39% of the individuals were above the cutoff value defined by Lohman[11]; among these, 14 (35.8%) were eutrophic, confirming the low sensitivity of BMI in identifying body fat.

Waist circumference (WC) and hip circumference (HC) values were found to be greater in 21% and 2% of the sample, respectively. The waist-to-hip (WHR) ratio was increased in only one of the participants.

### Prevalence of metabolic syndrome components

In this sample, there was only one individual with a fasting glycemia value equal to or greater than 110 mg/dL. However, a significant prevalence was observed for all other components of the syndrome: abdominal circumference >102 cm (21%), triglycerides ≥150 mg/dl (12%), HDL < 40 mg/dL (57%), and arterial blood pressure ≥ 130 mmHg or ≥85 mmHg (58%).

As to arterial pressure, 58% of the individuals had values equal to or greater than 130 mmHg or 85 mmHg. Prevalence of hypertension (≥140 mmHg, ≥ 90 mmHg) was observed in 28% of the sample, and the mean systolic and diastolic arterial pressure values were 130.6 ± 13.2 mmHg and 77.6 ± 10.2 mmHg, respectively.

Nevertheless, the combination of three of these factors, which characterizes the metabolic syndrome, was observed in 13% of the study individuals, especially reduced HDL, hypertriglyceridemia, and arterial hypertension.

### Comparison of the variables evaluated in adult life among individuals "with" and "without" the Metabolic Syndrome

Table 1 displays the statistically significant comparison results of mean and median values of anthropometric, body, and biochemical composition variables of individuals with and without the metabolic syndrome.

As can be seen, individuals classified as having the metabolic syndrome showed greater and more statistically significant values for all anthropometric variables evaluated, as well as for body fat and peripheral fat percentages. As to biochemical analysis, significant results were found for HDL, VLDL, triglycerides, cholesterol/HDL ratio, and LDL/HDL ratio.

Considering the major role of exercise in controlling and fighting MS components, we sought to assess the level of physical activity among individuals diagnosed with MS and found out that seven of them (53.8%) were not engaged in any kind of activity.

The analysis of food intake was also conducted to assess its relationship with the presence of the metabolic syndrome, and only the vitamin C intake was statistically different among the groups, being above average among individuals without the syndrome.

### Influence of the prior nutritional status in determining the Metabolic Syndrome in adult life

Table 2 displays mean, standard deviation, median, minimum, and maximum values of the variables evaluated at birth and in adolescence.

The potential relationship between birth conditions and nutritional status in adolescence was investigated in this study as a determining factor for the development of the metabolic syndrome in adults (Table 3).

It was noted that individuals who developed MS as adults had a higher median weight at birth than the others. However, this difference was not statistically significant.

Body proportionality at birth, assessed as per Rohrer's Index, and the median length were identical for both groups.

Table 1 - Comparison of the mean or median values of anthropometric variables of body composition and in adult life of individuals with or without a diagnosis of Metabolic Syndrome

| | With Metabolic Syndrome (n = 13) | W/o Metabolic Syndrome (n = 87) | p |
|---|---|---|---|
| Weight (kg) | 94.4 | 71.1 | <0.001* |
| Height** | 179.2 | 174.9 | 0.016* |
| BMI (kg/sqm) | 27.7 | 23.4 | <0.001* |
| Fat (kg) | 27.9 | 16.6 | <0.001* |
| FFM (kg)** | 66.3 ± 9.1 | 55.1± 7.4 | <0.001* |
| FBMI (kg/m$^2$) | 8.4 | 5.4 | <0.001* |
| FFBMI (kg/m$^2$)** | 20.5 ± 2.0 | 17.9 ± 2.0 | <0.001* |
| SCSF (mm) | 27.0 | 20.0 | 0.002* |
| SISF (mm) | 27.0 | 17.0 | <0.001* |
| % fat** | 30.3 ± 4.5 | 23.4 ± 5.1 | <0.001* |
| Central fat (SISF + SCSF) | 57.0 | 36.0 | <0.001* |
| WC (cm)** | 100.0 ± 11.7 | 82.8 ± 8.4 | <0.001* |
| HC (cm) | 110.0 | 101.0 | <0.001* |
| WHR | 0.87 | 0.82 | <0.001* |
| HDL** | 27.8 ± 4.9 | 40.3 ± 8.7 | <0.001* |
| VLDL | 42.2 | 15.2 | <0.001* |
| TG | 233.0 | 76.0 | <0.001* |
| Chol/HDL | 7.1 | 4.5 | <0.001* |
| LDL/HDL | 4.4 | 3.1 | <0.001* |

*FFM - fat-free mass; WC - waist circumference; % fat - percentage of body fat; FM - fat mass; FBMI - fat-free body mass index; BSF - bicipital skinfold; TSF - tricipital skinfold; SCSF - subscapular skinfold; SISF - supra-iliac skinfold; TG - triglyceride; HC - hip circumference; WHR - waist/hip ratio; Chol/HDL - cholesterol/HDL ratio; LDL/HDL - LDL/HDL ratio. ** Variables with a normal distribution; * Statistically significant results. Student's t test - parametric variables; Mann-Whitney test - non-parametric variables.*

Analysis of the role of the nutritional status in adolescence has shown important findings, since during their adolescent years individuals who were diagnosed with MS had greater and more statistically significant weights, WCs, and BMIs.

Excess weight in adolescence was observed in 38.4% of the sample, and the BMI at that stage correlated positively with the weight and BMI of individuals in adult life ($r = 0.634$, $p = < 0.001$; $r = 0.678$, $p = < 0.001$, respectively). This reinforces the hypothesis that excess weight (risk of being or actually being overweight) and fat accumulation in adolescence can be extended into adult life.

## Discussion

The prevalence of obesity observed in the adult population is higher than the percentages reported by other authors for individuals in similar age groups, such as 2.6% and 7.8% in the studies of Coelho et al[14] and Rabelo et al[5], respectively, and close to the figure presented by the Ministry of Health, which

Table 2 - Mean, standard deviation, median, and minimum and maximum values of anthropometric variables investigated at birth and in adolescence

| Variables | Md (min-max) | Interquartile Intervals | |
|---|---|---|---|
| | | P 25 | P 75 |
| At birth | | | |
| Weight (g) ** | 3450 (1930 - 4400) | 3025 | 3650 |
| Length (cm) | 50 (45 - 55) | 49 | 51 |
| RI (g/cm³) ** | 2.71 (1.74 - 3.52) | 2.5 | 2.83 |
| In adolescence | | | |
| Weight (kg) | 61.5 (45.0 - 110.0) | 57.5 | 68.5 |
| Height (cm) ** | 172.5 (158.0 - 189.0) | 168.0 | 177.0 |
| BMI (Kg/cm²) | 20.8 (16.6 - 36.3) | 19.4 | 22.4 |
| WC (cm) | 75.0 (62.0 - 114.0) | 71.0 | 81.0 |

*RI - Rohrer's Index of growth; WC - waist circumference; Mean ± standard deviation ($\overline{X}$ ± SD). Median (Md). Minimum value - min; Maximum value - max. ** Variables with a normal distribution.*

Table 3 - Means or medians of variables at birth and in adolescence of individuals with and without a diagnosis of Metabolic Syndrome

| | With Metabolic Syndrome (n = 13) | W/O Metabolic Syndrome (n = 87) | p |
|---|---|---|---|
| At birth | | | |
| Weight (g)** | 3480.7 ± 282.5 | 3359.8 ± 447.5 | 0.464 |
| Length (cm) | 50.0 | 50.0 | 0.415 |
| RI (g/cm³)** | 2.64 ± 0.27 | 2.66 ± 0.26 | 0.799 |
| In adolescence | | | |
| Weight (kg) | 71.0 | 60.0 | <0.001* |
| BMI (kg/m²) | 22.7 | 20.2 | 0.002* |
| WC (cm) | 83.0 | 75.0 | <0.001* |
| Height (cm) ** | 175.4 ± 7.7 | 172.1 ± 5.8 | 0.071 |

*** Variables with a normal distribution. * Statistically significant results. Student's t test - parametric variables. Mann-Whitney - non-parametric variables. WC - waist circumference. RI - Rohrer index.*

shows a 8% obesity in the Brazilian population[15].

There are no local studies defining the exact prevalence of the metabolic syndrome among Brazilians; however, studies conducted with different populations such as Mexicans, North-Americans, and Asians report a high prevalence depending on the criterion used and the characteristics of the population studied. In these populations, the rates for men range from 12.4% to 28.5%[4].

However, the high prevalence of risk factors for the metabolic syndrome among young individuals has been mentioned by other authors[5,16] and is reinforced by the findings of this study, drawing attention to the need to establish prevention programs.

The prevalence of increased WC is noteworthy, since studies have reported the association of abdominal fat and metabolic disorders and cardiovascular risks, abnormalities detected in the lipid profile, arterial hypertension, insulin resistance, and diabetes[13,17,18].

The prevalence of high triglyceride levels observed in this study is similar to the findings of other studies; however, the prevalence of reduced HDL values was higher than that reported by other authors.

Coelho et al[14] evaluated the lipid profile and the risk factors for cardiovascular diseases of medical students and reported the following findings: abnormal levels of cholesterol, LDL, and TG detected in 11.8%, 9.8%, and 8.5 % of the students, respectively, and reduced levels of HDL in 12.4 % of them. Likewise, Rabelo et al,[5] conducted a study on risk factors for atherosclerotic disease in young adults at a private university in São Paulo and observed that 9.1% and 16.3% of their sample had increased levels of total cholesterol and triglycerides, respectively; 7.6% had hypertriglyceridemia and 6.8% had reduced levels of HDL.

The prevalence of arterial blood pressure in our study was higher than that reported by Giroto et al[19] (7%), and Rabelo et al[5], who studied the prevalence of risk factors for atherosclerotic disease in students between 19 and 25 years of age and recorded 15.8% of arterial hypertension.

Comparative findings about the mean values of anthropometric, biochemical, and body composition variables of groups with and without the metabolic syndrome can be explained by the recognized association between excess weight and body fat and metabolic alterations, such as arterial hypertension and dyslipidemias, which are used to diagnose the syndrome.

The analysis of physical activity in this study confirmed findings in literature about the association between physical inactivity and the presence of cardiovascular risk factors, such as arterial hypertension, insulin resistance, diabetes, dyslipidemia, and obesity[20].

As to food intake, the difficulty in evaluating the association between eating patterns and the development of diseases has been described in literature. According to Flegal[21], the complexity involved in considering diet as an exposure variable is a methodological setback, since this is a totally random and fluctuating event.

Knowing the role food intake has on the nutritional status and biochemical profile, and considering the results obtained showing that there is no difference between the groups with and without the metabolic syndrome, perhaps the dietary instrument used for evaluating diet-disease relationship did not actually correspond to the eating patterns of the individuals evaluated.

Considering the evidence described in literature about the influence of birth conditions on the determination of an individual's future nutritional status[22,23], it is of utmost importance to investigate this relationship. However, the findings of this study do not allow a conclusion to be drawn about the impact, if any, of the nutritional status at birth on the metabolic syndrome. We highlight, however, that further investigations are needed with larger samples of individuals born with macrosomy and with delayed intrauterine growth in order to obtain results that are more reliable.

On the other hand, the findings of this study point to the role of the nutritional status in adolescence in determining an individual's future nutritional status. This relationship has been described in literature[24].

Cardiovascular abnormalities, until recently considered typical middle-age disorders, may take decades before clinical manifestations of myocardial infarction, cerebrovascular accident, and peripheral vascular diseases[25].

Most risk factors begin or are acquired during childhood and adolescence, and are likely to persist throughout life[5].

Metabolic disorders, such as dyslipidemia, diabetes, and arterial hypertension associated with body fat distribution observed in obese adults start to manifest themselves during the adolescent years of obese individuals[26].

Initial alterations of each one of these factors may occur with different associations that even when manifested as slight signs, determine an unfavorable cardiovascular profile for these youngsters.

## Conclusion

The results of this study point to the prevalence of the metabolic syndrome among young adults, who were not previously seen as a group at risk of developing this condition. Moreover, the nutritional status of these individuals as adults has been affected by their previous nutritional conditions. Although further studies are needed to define the long-term consequences of birth conditions, the nutritional status during adolescence behaved as a risk factor for the nutritional status and the development of chronic-degenerative diseases during adult life. Therefore, it is important to attend to the health status of this group, in order to warrant them a healthier life now and in the future.

### Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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### Study Association

This article is part of the dissertation of master submitted by Renata Maria Souza Oliveira, from *Universidade Federal de Viçosa*.

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