Serum Retinol and β-carotene Levels and Risk Factors for Cardiovascular Disease in Morbid Obesity

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Abstract: Objective: To evaluate retinol and β-carotene serum levels and their relationship with risk factors for cardiovascular disease in individuals with morbid obesity, resident in Rio de Janeiro. Methodology: Blood serum concentrations of retinol and β-carotene of 189 morbidly obese individuals were assessed. The metabolic syndrome was identified according to the criteria of the National Cholesterol Education Program (NCEP) and World Health Organization (WHO). Lipid profile, insulin resistance, basal insulin, glycemia, blood pressure, and anthropometry and their correlation with retinol and β-carotene serum levels were evaluated. Results: Metabolic syndrome diagnosis was observed in 49.0% of the sample. Within this percentage the levels of β-carotene were significantly lower when body mass index increased. Serum retinol didn’t show this behavior. Serum retinol inadequacy in patients with metabolic syndrome (61.3%), according to WHO criterion, was higher (15.8%) than when the whole sample was considered (12.7%). When metabolic syndrome was diagnosed by NCEP criterion, β-carotene inadequacy was higher (42.8%) when compared to the total sample (37.5%). There was a significant difference between average β-carotene values of patients with and without metabolic syndrome (p=0.048) according to the classification of the NCEP. Lower values were found in patients with metabolic syndrome. Conclusion: Considering the vitamin A contribution in antioxidant protection, especially when risk factors for cardiovascular disease are present, it is suggested that great attention be given to morbidly obese. This could aid in prevention and treatment of cardiovascular disease, which affects a significant part of the population.

Key words: cardiovascular diseases, morbid obesity, risk factors, vitamin A.
Introduction

Obesity is a growing problem, with alarming rates worldwide; the World Health Organization (WHO) estimates that there are currently over 300 million cases, occurring in both developed or developing nations, affecting adults and children and possibly co-existing in patients suffering from malnutrition. Obesity can be described as a “New World Syndrome”, causing a significant burden to health care services, and is thus considered by developed nations to be the most important nutritional disorder [1].

In Brazil, data published by the Brazilian Institute of Geography and Statistics (the second stage of the Household Budget Survey, from 2002 to 2003, in partnership with the Ministry of Health), reveals how the incidence of excess weight is suffered by 38.8 million Brazilians, accounting for 40.6% of the adult population. Excessive weight tends to increase in men as they age and become wealthier. It appears that the frequency of being overweight greatly exceeds that of being underweight by eight times in the case of the female population, and fifteen times in the male population [2].

An increase in obesity could be found in the population’s wealthiest social classes as well as the poorest since, in addition to being conducive to a sedentary lifestyle, the process of industrialization has reduced the cost of food production, making foods with low vitamin and mineral content more accessible. These foods generally contain large amounts of energy and fat, especially saturated fats [2, 3]. As a consequence, the incidence of deficiencies in micronutrients, even if subclinical, can be noted, characterizing a “hidden hunger” co-existing with an increase in obesity [4].

Vitamin A deficiency (VAD) is one of the most prevalent public health problems in the world, harming the health of those afflicted in several ways, even causing death. In Brazil, this disorder affects a large proportion of pregnant women and children of preschool age [5], with a trend toward the situation worsening due to the nutritional transition that Brazil and several other Latin American countries have been going through over the past twenty years [6], and with studies investigating this nutritional deficiency in other segments of the population being rare.

Vitamin A plays a role in several primary functions of the human body, acting on visual acuity, cell differentiation and proliferation, and immunological activity [7]. Nowadays, more attention is being paid to retinol and carotenoids for their action against free radicals, protecting the body against oxidative stress, thus preventing tissue damage and injuries related to various non-transmissible chronic diseases [8].

β-carotene alone is an important element in defending against the oxidative attack of low-density lipoprotein cholesterol (LDL-C), and has been associated with high-density lipoprotein cholesterol (HDL-C) increase, both in vitro and in vivo. On the other hand, retinol inhibits transcription of the inducible nitric oxide synthase gene (iNOS), an enzyme that enables oxygen to stimulate the production of other free radicals, especially the nitric oxide variety. Carotenoids also act as suppressors of iNOS expression, reducing production of reactive oxygen species [9].

In recent times, the relationship between low serum retinol and/or carotenoid concentrations and some cardiovascular disease (CVD) risk factors has been demonstrated, which is extremely relevant due to the importance of antioxidants in maintaining cardiovascular health [10].

In relation to metabolic syndrome (MS), there have been few studies designed for assessment of the vitamin A nutritional status in individuals with the syndrome and, in the case of morbidly obese individuals with MS, no work has been done to investigate deficiency in this vitamin. Ford et al. [11] found reduced vitamin C, E, and carotenoid levels, as well as lower dietary intake of fruits and vegetables, among individuals suffering from MS. Moreover, carotenoid levels decreased according to the increase in the number of components of MS.

The purpose of this study was to investigate retinol and β-carotene serum levels and their relationship to CVD risk factors in morbid obesity. Among these factors we highlight: lipid profile, blood pressure, glyceremia, baseline insulin, insulin resistance, body mass index (BMI), waist circumference (WC), waist/hip ratio (WHR), and the association of these factors, characterized by MS.

Material and methods

The study investigated 189 individuals with BMI ≥ 40 kg/m², of both sexes without color or class distinction, being treated at the private Carlos Saboya Surgical Clinic in Rio de Janeiro, between February and September of 2006. The clinic performs on average 250 Roux-en-Y gastric bypass (RYGB) operations each year. Around 76% of the patients indicated for surgery were enrolled in this study.

Patients were included in the project by way of formal authorization by signing a consent form after the researcher explained the project’s objectives and procedures. Excluded from the study were individu-
als with malabsorption syndromes, acute and chronic infections, pregnant and nursing mothers, bearers of associated endocrinopathies, as well as individuals who had undergone bariatric surgery or who were using vitamin A supplements at the time the study was carried out.

Weight was determined using a platform scale (Welmy) with a maximum capacity of 150 kg. Height was measured using a portable stadiometer (Seca®), graduated in tenths of a centimeter, attached to a flat surface. BMI was calculated from weight and height [12].

The cut-off points used were those recommended by the WHO (1998) for classifying healthy, overweight, and obese individuals. Moreover, the sample group was classified into BMI interval classes of 5 kg/m², resulting in five groups:
- group 1: individuals between 40 and 44.9 kg/m²;
- group 2: those between 45 and 49.9 kg/m²;
- group 3: those between 50 and 54.9 kg/m²;
- group 4: those between 55 and 59.9 kg/m²; and
- group 5: those between 60 to 64.9 kg/m².

Waist (WC) and hip (HC) circumference were obtained using an inextensible measuring tape. Waist/hip ratio (WHR) was calculated. The WHR cut-off point used was greater than 1.0 for men and 0.85 for women [12].

Blood pressure was taken according to the Brazilian Guidelines for Systemic Arterial Hypertension (SAH) V [13]. Three measurements were taken with a minimum interval of one minute between them, with the average of the last two measurements considered to be the individual’s blood pressure. Individuals with systolic blood pressure greater than or equal to 140 mmHg and diastolic blood pressure greater than or equal to 90 mmHg were considered to have SAH.

To assess the nutritional state of vitamin A, a 5-mL blood sample was collected for laboratory analysis of serum retinol, after an overnight fast of no less than 8 hours. Retinol and carotenoid serum levels were evaluated using high-performance liquid chromatography (HPLC) at the UFRJ Biochemistry Institute laboratory. In this study, serum retinol levels > 1.05 μmol/L were considered to be sufficient and a cut-off point of ≤ 1.05 μmol/L was used to indicate VAD. The cut-off point used to indicate insufficient serum β-carotene was ≤ 40 μg/dL, as suggested by Sauberlich et al. [14].

The following laboratory tests were performed using the esterase/oxidase colorimetric method at a private laboratory in Rio de Janeiro, Brazil, to assess lipid profile: cholesterol, triglycerides, HDL-C, and LDL-C. The National Cholesterol Education Program (NCEP) criteria [15] for classifying risk of developing CVD accordingly were adopted. For the purpose of statistical analysis, low-risk/normal-risk values were considered appropriate while border high-risk/very-high-risk values were considered inadequate.

Insulin resistance (IR) was determined by the Homeostasis Model Assessment Index method (HOMA) [16]. Formula removed.

MS was identified by way of diagnostic criteria recommended by the NCEP [15] and the WHO [17], the most commonly used criteria as they cover several different variables for diagnosis. The NCEP criteria are the easiest to apply in clinical practice while the WHO criteria identify more serious illnesses.

According to the NCEP [15], MS diagnosis is performed when three or more of the following risk factors are present: abdominal circumference > 102 cm in men or > 88 cm in women; triglycerides ≥ 150 mg/dL, and HDL-C < 40 mg/dL in men or < 50 mg/dL in women; blood pressure ≥ 130/85 mmHg; and fasting glucose ≥ 110 mg/dL.

According to recommendations from the American Diabetes Association [18], the cut-off point proposed for impaired fasting glucose diagnosis was altered from 110 mg/dL to 100 mg/dL.

For MS diagnosis, the WHO [17] has proposed that individuals with type 2 diabetes (DM II) or glucose intolerance should present at least two of the following components: blood pressure > 140/90 mmHg; hypertriacylglyceridemia > 150 mg/dL or HDL-C levels < 35 mg/dL for men and < 40 mg/dL for women; central obesity as measured by waist-hip ratio > 0.90 for men and > 0.85 for women or BMI > 30 kg/m²; and microalbuminuria > 20 μg/minute or albumin/creatinine relation > 30 mg/g. Individuals who did not show any change in glucose tolerance must have IR documented by way of a euglycemic clamp, HOMA-IR [16] or by high basal insulinemia, in addition to the two criteria aforementioned.

Statistical analysis was performed using the SPSS statistical package for Windows version 8.0. The level of significance adopted was 5%.

Results

The sample group was made up of 189 individuals, of which 101 (53.4%) were female and 88 (46.6%) were male. The mean age was 36.5 ± 11.7 years, with 38.92 ± 2.05 for men and 35.5 ± 1.14 for women. There was no significant difference between the male and female average age (p = 0.141).
Considering the sample as a whole, regardless of MS diagnosis, the main risk factor observed in the group was excessive LDL-C, with 69.8% of the sample presenting high LDL-C levels. Moreover, 39.3% had hypertriglyceridemia, 33.6% had insufficient HDL-c levels, and 46.9% had hypercholesterolemia. Insulin resistance and elevated blood glucose were diagnosed in 58.5% and 29.7% of the sample group, respectively. SAH occurrence was 48.6%.

In classifying dyslipidemia according to risk of CVD, 11.7%, 17.9%, 12.2%, and 33.6% of the individuals showed, respectively, cholesterol, triglycerides, LDL-C, and HDL-C levels in the high-risk range for developing the disease.

According to the age range classification proposed by the Institute of Medicine (IOM) [7], dividing the age into 3 groups, 19–30 years (group 1), 31–50 years (group 2), and 51–70 years (group 3), significantly higher weight, BMI, and WC averages were observed in the younger age groups, compared with the median age. There was no significant difference between groups 1 and 3, and 2 and 3 (Table I).

MS diagnosis was observed in 62.1% female and 37.9% male, according to WHO criteria [17]. The MS diagnosis, according to NCEP [15], was positive in 61.4% female and 38.6% male.

The three most frequent CVD risk factors in the group classified, according to WHO criteria, were hypertriglyceridemia, low HDL-C levels, and SAH, observed in 37.9%, 37.2%, and 54% of the individuals, respectively. Table II shows the prevalence of these three main factors, by sex and age.

Risk factors were more prevalent in males: 78%, 48.5%, and 54.5% of these individuals had SAH, hypertriglyceridemia, and insufficient HDL, respectively. In females, the prevalence of these risk factors was 38.9%, 31.5%, and 26.4%, respectively. Greater prevalence of these factors was noted as age increased, especially in terms of SAH, which was present in 92.9% of the individuals in the 51- to 70-year-old age range.

As for vitamin A nutritional status, the individuals studied presented average values of 1.66 μmol/L (± 0.65 μmol/L) in serum retinol and 53.8 g/dL (± 32.7 g/dL) in β-carotene serum. Distribution of the sample group, according to serum retinol levels, showed that 12.7% of the patients were below the < 1.05 μmol/L cut-off point, presenting insufficient levels of vitamin A. Among patients with insufficient serum retinol levels, 10.4% were in the ≥ 0.70 μmol/L and < 1.05 μmol/L categories, suggesting marginal deficiency, and 2.3% were in the > 0.35 μmol/L and < 0.70 μmol/L categories, suggesting moderate deficiency. Thirty-seven-point-five% of the patients had insufficient levels of serum β-carotene (≤ 40 g/dL).

There was a positive correlation in serum retinol and β-carotene levels (r = 0.272, p = 0.001). Comparing the β-carotene averages, according to the degree of serum retinol insufficiency, a gradual decline could be noted as the severity of VAD increased (Table II).

The serum retinol and β-carotene averages in patients without MS were 1.61 ± 0.71 μmol/L and 49.9 ± 31.7 μg/dL, respectively, while the averages of patients with MS diagnosed by the WHO [17] were 1.68 ± 0.62 μmol/L and 56.1 ± 31.1 μg/dL. There was no significant difference between the serum retinol and β-carotene averages in patients with and without MS diagnosed using WHO [17] criteria (p = 0.520, p = 0.184).

Considering the NCEP [15] MS diagnosis criteria, the serum retinol and β-carotene averages of patients without MS were 1.66 ± 0.65 μmol/L and 59.8 ± 34.0 μg/dL, respectively, while the averages of patients with MS diagnosed by the WHO [17] were 1.68 ± 0.65 μmol/L and 48.7 ± 29.5 μg/dL. A significant difference was found in average β-carotene levels between patients with and without MS (p=0.048), but no significant difference was noted in average serum retinol levels (p = 0.820).

Patients diagnosed with MS by the WHO criteria [17] had greater percentages of retinol insufficiency, while those diagnosed by the NCEP criteria [15] had a greater percentage of β-carotene insufficiency (Table III).

A positive correlation was found between levels of serum retinol and triglycerides in patients with MS, diagnosed using both WHO (r = 0.205, p = 0.05) and NCEP (r = 0.280, p = 0.022) criteria. A negative cor-

**Table I: Mean and standard deviation of the anthropometric variables, according to age.**

<table>
<thead>
<tr>
<th>Anthropometric Variables</th>
<th>19–30 age</th>
<th>31–50 age</th>
<th>51–70 age</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>130.0 ± 16.9&lt;sup&gt;a&lt;/sup&gt;</td>
<td>115.0 ± 15.7&lt;sup&gt;b&lt;/sup&gt;</td>
<td>118.9 ± 16.3&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.008</td>
</tr>
<tr>
<td>BMI</td>
<td>46.0 ± 5.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>42.6 ± 2.7&lt;sup&gt;b&lt;/sup&gt;</td>
<td>43.2 ± 2.8&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.035</td>
</tr>
<tr>
<td>WC</td>
<td>125.1 ± 8.4&lt;sup&gt;a&lt;/sup&gt;</td>
<td>118.6 ± 10.9&lt;sup&gt;b&lt;/sup&gt;</td>
<td>118.1 ± 8.9&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.041</td>
</tr>
</tbody>
</table>

BMI = Body mass index; WC= Waist-circumference; Statistical Test: Kruskal-Wallis (post hoc Tukey)

* Different letters indicate significant difference (p < 0.05)
A significant negative correlation was found between HC (WC?) extent and β-carotene levels in patients with MS, according to NCEP criteria (r = –0.265, p = 0.029). There was a significant negative correlation between WC and β-carotene levels in patients considered to have MS according to WHO criteria (r = –0.211, p = 0.05).

In patients without MS, negative correlations between glycemia and retinol levels (r = –0.259, p = 0.028) and between triglycerides and β-carotene levels (r = –0.252, p = 0.031) were found. The other CVD risk factors and other components used for diagnosing MS showed no correlation with retinol and β-carotene levels.

When comparing average values of anthropometric and biochemical variables for groups with sufficient and insufficient serum retinol and β-carotene levels, it was noted that in individuals without MS, the average LDL-C was significantly greater in those presenting insufficient serum retinol (133.6 ± 41.4 mg/dL) than in those with sufficient retinol (111.8 ± 26.9 mg/dL; p < 0.03). In individuals with MS, according to WHO criteria, significantly greater average LDL-C (29.4 ± 13.1 mg/dL) was noted in patients with insufficient serum retinol, when compared with (non-MS?) individuals with insufficient retinol (19.7 ± 5.1 mg/dL; p = 0.009). In individuals with MS, according to NCEP criteria, no difference was found between the groups studied.

In individuals with MS, according to WHO guidelines, a reduction was observed in β-carotene levels as BMI subclasses increased, with a significant difference between averages from the subclass 40–44.9 kg/m² (60.4 ± 31.1 μg/dL), and 60–64.9 kg/m² (17.6 ± 7.0 μg/dL; p = 0.006).

There was no significant difference between serum retinol (p = 0.649) and β-carotene (p = 0.445) averages as the number of factors involved in diagnosing MS increased.

### Discussion

Morbid obesity is the disease with the highest mortality rate in the world. In Latin America, it is likely that 200,000 people die annually due to associations between comorbidities [19]. In the 1990s, cardiovascular disease was responsible for 26% of deaths in this region [20].

In this study, the average age of individuals evaluated as morbidly obese was 36.5 ± 11.7 years of age, with no statistically significant difference between men and women, showing greater prevalence of morbid obesity in the population’s younger age groups. Bray et al. [21] report that the rate of mortality from morbid obesity is 12 times greater among men from 25 to 40 years of age compared to normal weight individuals. This makes morbid obesity the second leading cause of preventable death in the world, second only to automobile accidents.

### Table II: Mean β-carotene means in different Vitamin A nutritional statuses

<table>
<thead>
<tr>
<th>Vitamin A Nutritional status</th>
<th>β-carotene (μg/dL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insufficient Retinol (≤ 1.05 μmol/L)</td>
<td>56.2 ± 32.3</td>
</tr>
<tr>
<td>Marginal VAD (&lt; 1.05 ≥ 0.7 μmol/L)</td>
<td>48.0 ± 40.6</td>
</tr>
<tr>
<td>Moderate VAD (&lt; 0.7 ≥ 0.35 μmol/L)</td>
<td>42.7 ± 46.3</td>
</tr>
</tbody>
</table>

VAD = Vitamin A deficiency

### Table III: Sufficient serum retinol and β-carotene levels according to MS diagnosis

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Retinol</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sufficient (&gt; 1.05 μmol/L)</td>
<td>84.2%</td>
<td>88.9%</td>
</tr>
<tr>
<td>Insufficient (≤ 1.05 μmol/L)</td>
<td>15.8%</td>
<td>11.0%</td>
</tr>
<tr>
<td>β-carotene</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sufficient (&gt; 40 μg/dL)</td>
<td>67.5%</td>
<td>57.2%</td>
</tr>
<tr>
<td>Insufficient (≤ 40 μg/dL)</td>
<td>32.5%</td>
<td>42.8%</td>
</tr>
</tbody>
</table>

MS – WHO= Metabolic syndrome according to WHO, 1998
MS – NCEP= Metabolic syndrome according to NCEP, 2002
Higher weight, BMI, and WC averages were found in younger age groups. Crerand et al. [22], compared historical data regarding the weight of women with class III obesity with the weights of women with class I and II obesity. The authors found that women with morbid obesity had a longer history of obesity, starting at adolescence, and presented greater body weight throughout life than those with class I and II obesity.

According to Syme et al. [23], among adolescent subjects with high levels of intra-abdominal fat (IAF), MS was found in 13.8% of males and 8.3% of females. In both males and females, subjects with high vs. low IAF had higher levels of fasting insulin, triglycerides, and HOMA indices, and lower levels of HDL cholesterol. The values for insulin, HOMA index, and triglycerides were higher by 20% to 30% and those of HDL cholesterol were lower by 7%.

So, metabolic alterations can be observed at an early age. Therefore, longer periods of obesity can lead to greater risk of developing chronic diseases, among them CVD, due to prolonged exposure to risk factors.

The main CVD risk factors found in this study were high levels of LDL-C and glycemia, presence of SAH, and hypercholesterolemia. Lanas et al. [20] found that abdominal obesity is the most prevalent risk factor for acute myocardial infarction in Latin America. Obesity is among the ten main risk factors in the development of the most prevalent and fatal diseases, associated with 40% of all deaths. The other ten subsequent factors relate to more than 10% of deaths. It is important to note that the risk factors reported in 3rd, 7th, and 14th place (hypertension, high cholesterol, and sedentary lifestyle) have strong associations with obesity [24].

The proportion of MS cases was greater when using the WHO criteria [17]. Women presented a higher prevalence of MS than men in both criteria. Other studies have compared the use of two criteria for MS diagnosis, some of them showing a higher percentage of MS cases when WHO criteria [25, 26] were applied.

There are substantial differences between the two criteria. The WHO’s main focus is to detect cases of insulin resistance and its association with co-morbidities, while the NCEP’s definition prioritizes abdominal obesity and does not take insulin resistance into consideration. Moreover, the WHO uses microalbuminuria, based on its ability to predict CVD, while the NCEP does not include this marker because of the difficulty of using it in practice [27].

As there are many definitions of MS in use, it is hard to compare MS prevalence and impact in different populations. Mattar et al. [28] found MS prevalent in 70% of morbidly obese individuals, using the NCEP criteria for evaluation. On the other hand, Mendez et al. [29] showed MS to be prevalent in 44% of seriously obese individuals by using the WHO criteria.

This study found 12.7% of the sample group to have insufficient serum retinol levels, while 37.5% of the sample group presented insufficient β-carotene. Literature shows [10] that in adults, individuals with lower serum β-carotene levels are at significantly greater risk of CVD.

In Brazil, there are no population studies showing the prevalence of VAD in individuals with diseases similar to this study profile (morbidly obese). However, one can conclude that the VAD found in this study, although lower than those described for traditional risk groups in Brazil [30], is high enough to justify greater attention to this segment of the population.

Insufficient vitamin A nutritional status reduces carotenoid conversion in retinol, demonstrating that there is a relationship between retinol and carotenoid nutritional status [31]. In this study, it was found that individuals with sufficient serum retinol levels had higher serum β-carotene levels, suggesting that a smaller portion of β-carotene had been converted into retinol, corroborating the findings of Mecocci et al. [31]. These findings emphasize the importance of maintaining serum carotenoid levels, given the various functions they perform in the fight against oxidative stress.

Although no difference between retinol and β-carotene levels and components of MS was found, patients with MS displayed significantly lower levels of β-carotene (according to NCEP criteria). In patients with MS, according to WHO criteria, as the individuals’ BMI increased, significantly lower β-carotene levels were found. Moreover, insufficiency of serum retinol in these patients (15.8%) was higher than when the sample was considered as a whole (12.7%).

Few studies have been designed to assess vitamin A nutritional status in individuals with MS. Ford et al. [11] found reduced levels of vitamin C, E, and carotenoids, as well as lower dietary intake of fruits and vegetables among individuals with MS. Furthermore, the authors noted that carotenoid levels decreased with as the number of components of MS increased, which was not observed in this study.

According to Bozbaş et al. [32] patients with metabolic syndrome (MS) aggregate atherosclerotic risk factors. It is general consensus in the literature that all components of MS lead mainly to increased cardiovascular risk [33], and many studies show the relationship between serum retinol and carotenoid levels, due to the role of free radicals in disease patho-
genesis [34]. The literature suggests risk of CVD decreased with increased consumption of β-carotene, by increasing serum HDL-C levels, or by inhibiting smooth-muscle-cell proliferation in the arteries’ intimal layer [4].

Hypertension is associated with oxidative stress in that, as individuals’ blood pressure levels increase, there is an increase in free radical production and a reduction in some important antioxidants, which could have reduced oxidative damage and possibly blood pressure [35].

Studies on hypertensive individuals have found low serum retinol levels, and have reported an inverse association between serum levels of this nutrient and individuals’ blood pressure [10]. This study found no relationship between vitamin A and β-carotene levels and blood pressure.

In patients without MS, a negative correlation between glycemia and retinol levels was found. In these individuals, average LDL-C was significantly higher among those with insufficient retinol. Silva et al. [36] found that insufficient carotenoid levels remained in individuals with type 2 diabetes, and no association with serum retinol levels was found. Literature shows [34] that the hyperglycemia tends to reduce levels of serum antioxidants, such as β-carotene, and increase lipid peroxide levels. Additionally, ingestion of antioxidants reduces lipid peroxidation levels.

In this study, a reduction in β-carotene levels as BMI increased was also observed, with significant difference between the averages of the different interval classes. Overweight and obese individuals appear to be at greater risk of presenting reduced serum retinol or carotenoid levels. Studies have shown serum carotenoids to be lower in obese individuals when compared to healthy ones, with no significant difference in intake of dietary sources for these nutrients [37]. Literature also shows [38] a negative correlation between retinol and β-carotene, and BMI.

In regard to retinol and β-carotene levels and obesity, a negative correlation was observed between β-carotene and WC and HC, according to the WHO and NCEP criteria, respectively. Moreover, in patients with MS, according to the WHO criteria, a reduction in β-carotene levels as BMI interval classes increased was found. Neuhouser et al. [10] observed lower carotenoids levels in obese subjects in relation to non-obese, and studies [38, 39] with adults have reported lower β-carotene levels in individuals with higher BMI values. This finding may be due to greater metabolic use of carotenoids in fighting oxidative stress, since these individuals are more exposed to increased free radical production.

Conclusion

Despite no difference in retinol and β-carotene having been observed in individuals with CVD risk factors alone, greater prevalence of VAD was found in individuals suffering from MS, regardless of the diagnostic criteria used.

Based on the aspects discussed, one can conjecture that the VAD may have great impact on the prevalence of CVD, as well as in its progression and complications. Therefore, fighting vitamin A deficiency may contribute significantly to the prevention and treatment of these diseases. It is recommended that greater attention be paid to this segment of the population in terms of encouraging greater intake of dietary carotenoids and retinol, as foods rich in these nutrients are also sources of other nutrients with antioxidant functions that are key in maintaining cardiovascular health.

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