Elevated Serum Retinol and Low Beta-Carotene but not Alpha-Tocopherol Concentrations Are Associated with Dyslipidemia in Brazilian Adolescents

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Summary The purpose of this study was to investigate the status of retinol, beta-carotene, and alpha-tocopherol serum concentrations in adolescents with dyslipidemia. A case series dyslipidemia study was conducted, with an attached control group, including 104 adolescents of public schools in Recife during the months of March/April 2013. Retinol, beta-carotene and alpha-tocopherol serum concentrations were analysed by high efficiency liquid chromatography. Sociodemographic, anthropometric, clinical and biochemical variables were analysed. Dyslipidemic adolescents had high serum concentrations of both retinol (p=0.007) and beta-carotene/apolipoprotein A-I ratio (p=0.034); they also had low concentrations of beta-carotene/total cholesterol (p<0.0001) and beta-carotene/apolipoprotein B ratios (p=0.033) when compared to the controls. The alpha-tocopherol serum status was not associated with dyslipidemia. Overweight, abdominal obesity, lipid profile markers, and systolic and diastolic blood pressures were more prevalent in dyslipidemic adolescents. The findings show an association between vitamin A and dyslipidemia in adolescents. However, additional investigations of this risk group are necessary to clarify the mechanisms of action of this nutrient in the pathogenesis of this syndrome, aiming at reducing cardiometabolic risks as of earlier ages.

Key Words vitamin A, carotenoids, vitamin E, dyslipidemia, adolescent

The prevalence of dyslipidemia in childhood and adolescence has increased over the years (1). Studies conducted in different Brazilian cities have shown the relevance of dyslipidemia in this age range, and its prevalence varies from 6.0 to 71.4%, depending on the parameter used as reference diagnosis (2–4). The most usual type of dyslipidemia seen in young individuals consists of low serum levels of high-density lipoproteins (HDL), which, separately, are an indicator of a risk factor for the development of atherosclerosis (4).

Dyslipidemia in adolescents is associated with a poor diet including low consumption of in natura food, which is the source of nutrients that protect cardiovascular health, such as antioxidant vitamins (1).

The energy metabolism and the immunological system produce physiologically free radicals that play biologically relevant roles to the human organism (5, 6). Under normal circumstances, the deleterious effects of the free radicals are neutralized by a coordinated antioxidant cell defence system, preventing oxidative stress, in which excessive oxidative reactions might lead to irreversible systemic damages. The chronicity of oxidative stress seems to contribute to a higher cardiometabolic risk, and is associated with the pathogenesis of atherosclerosis (6, 7).

Alpha-tocopherol and beta-carotene stand out as potentially antioxidant vitamin compounds (6). The interest in studying dietary antioxidants is based on their relevance as one of the potential agents for the prevention of lipid peroxidation and atherosclerosis, as these nutrients determine the composition of low-density lipoprotein (LDL) and its susceptibility to oxidation. Diet, therefore, is a pivotal factor in the modulation of oxidative stress and cardiometabolic risk, and the intake of an antioxidant-rich diet is associated with the reduction of this risk (1).

In spite of its importance for health, investigations focusing on the role of antioxidant nutrients in the young population exposed to cardiovascular risks are scanty. Although conceptually it is plausible to suppose that antioxidant liposoluble vitamins have an intimate link with cardiometabolic risk markers, more empirical evidence is still needed for an appropriate understanding of this association. This is why this study aimed at investigating the status of retinol, beta-carotene, and alpha-tocopherol serum concentrations in adolescents with dyslipidemia.

MATERIALS AND METHODS

Study design and population. This investigation derived from project “Dyslipidemia and its association with excessive weight, sedentary lifestyle and oxidative stress in a cohort of school students in Recife, PE”. The outline of the research comprised a case series dyslipidemia study with an attached control group, nested in this cohort, the eligible population of which consisted of adolescents of both genders, from 12 to 19 y of age, from public schools of Recife in March/April, 2013.

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The incidental cases of dyslipidemia and their respective controls were tracked by means of a cross section of the eligible population. Adolescents with low serum concentrations of HDL (<1.2 μmol/L) and increased serum concentrations of triglycerides (TAG) (≥1.5 μmol/L) were considered cases of dyslipidemia—a combination of dyslipidemia found in 12.7% of the recruited adolescents. The adolescents who reported a personal history of pathologies, or the use of medications that might change their lipid profile and/or the regular use of vitamin supplements in the previous three months were excluded.

In order to quantify the sample, an alpha error of 5% (1.96) and an error beta of 10% (1.28) were considered with one standard deviation (S) for the distribution of serum retinol concentrations of 0.252 μmol/L; and a difference (D) of 0.175 μmol/L to be detected between the cases and controls for serum retinol concentrations. After using the formula \( n = \left[ Z_{a/2} + Z_{b/2} \right]^2 \times 2.5 \) (9), 44 cases was the minimum sample size. In order to fix occasional losses, 15% [100/100–15] were added, resulting in 52 cases of dyslipidemia paired regarding gender and age to a similar number of controls.

**Evaluation techniques and methods.** The researchers conducted the fieldwork, and a trained technical team collected the data. The technical team was experienced in checking clinical and anthropometrical measures, handling biological materials and delivering the questionnaire.

Systolic blood pressures and diastolic blood pressures were checked by the auscultation method. Two right-arm measurements were made per adolescent at 5-min intervals.

As to the biochemical analyses, 5 mL of blood was drawn from each student by venous puncture after a 10- to 12-h fast, and stored in dry vials. The vials were stored in Styrofoam boxes containing reusable ice packs, sealed and transported for processing and analysis in a clinical analysis laboratory. The materials used in the procedures were all disposable and sterile.

Glucose, TAG, total cholesterol and HDL serum levels were determined by means of an enzymatic method. The LDL fraction was calculated with Friedewald's formula [LDL=TC−HDL−TAG/5] (10). The diagnosis of dyslipidemia was performed according to the 1st Brazilian Guideline for the Prevention of Atherosclerosis in Children and Adolescents (10). Serum levels of total cholesterol ≥4.4 μmol/L, LDL ≥3.4 μmol/L and TAG ≥1.5 μmol/L were all classified as increased values. Serum levels of HDL <1.2 μmol/L are deemed lower than the desirable values.

Apolipoproteins B and A-I as well as \( \alpha-1 \)-acid glycoprotein were analysed using kits based on the Immuno-turbidimetric method (RANDOX, London, UK).

For the analysis of retinol, alpha-tocopherol and beta-carotene right after the drawing of the venous blood, the samples were put into tagged test tubes and protected from the incidence of light. After full coagulation, the samples were centrifuged at 3,000 rpm during 10 min for the total separation of the serum, which was then transferred to Eppendorf tubes. Then, the samples were stored in a freezer at a temperature of -20°C, and transported for processing and analysis at the Micronutrient Investigation Centre [Centro de Investigação em Micronutrientes]/Federal University of Paraíba.

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who accumulated \( \geq 300 \) min/wk (21).

**Data analysis algorithm.** The Epi Info program, version 6.04b (WHO/CDC, Atlanta, GA) was used to build the database, and the data were typed in double data entry, and data consistency was verified by the validate module. The statistical analyses were done using the Statistical Package for Social Sciences—SPSS for Windows, version 13.1 (SPSS Inc., Chicago, IL).

The distribution normality of the continuous variables was tested using the Kolmogorov-Smirnov test. BMI, waist circumference, glycemia, total cholesterol, LDL, ApoA-I, ApoB, \( \alpha_1 \)-acid glycoprotein, retinol, and the beta-carotene/total cholesterol and beta-carotene/LDL ratios were normally distributed, and were described as their averages and standard deviations. The variables that were not normally distributed underwent a logarithmic transformation, and their normality was retested. Variables ApoB/ApoA-I, alpha-tocopherol, alpha-tocopherol/LDL, alpha-tocopherol/ApoB, alpha-tocopherol/ApoA-I and beta-carotene/ApoB were normally distributed and were described in the form of geometric means and confidence intervals of 95% (CI95%). The other variables still presenting a non-Gaussian distribution were described in the form medians and interquartile ranges.

Student’s t-test for unpaired data was used to compare the averages of the studied groups when the homoscedasticity criteria and normal distribution were met; otherwise, the Mann-Whitney U test was used. In describing the proportions, the binomial distribution approximated the normal distribution by the CI95%. In the statistical inference tests, proportions were compared by Pearson’s Chi-square test. The significance level adopted for rejecting the null hypothesis was 5.0%.

**Ethical Aspects.** This study was conducted according to the guidelines laid down in the Declaration of Hel-

### Table 1. Sociodemographic, anthropometric and lifestyle characteristics of adolescents with and without dyslipidemia in public schools. Recife, 2013.

| Variables | Categories | Cases\(^a\) | Controls | \( p \)^b |
|-----------|------------|-------------|----------|---------|
| Gender    | Male       | 30 (57.7)   | 21 (40.4) | 0.078   |
|           | Female     | 22 (42.3)   | 31 (59.6) |         |
|           | Total      | 52 (100.0)  | 52 (100.0)|         |
| Age       | 12 to 15 y | 36 (69.2)   | 36 (69.2) | 1.000   |
|           | 16 to 19 y | 16 (30.8)   | 16 (30.8) |         |
|           | Total      | 52 (100.0)  | 52 (100.0)|         |
| Father’s  | Until elementary school | 17 (41.5)   | 20 (62.5) | 0.074   |
| Schooling | High school/Higher education | 24 (58.5)   | 12 (37.5) |         |
|           | Total      | 41 (100.0)  | 32 (100.0)|         |
| Mother’s  | Until elementary school | 19 (43.2)   | 28 (66.7) | 0.029   |
| Schooling | High school/Higher education | 25 (56.8)   | 14 (33.3) |         |
|           | Total      | 44 (100.0)  | 42 (100.0)|         |
| Social Class | B1 or B2 (\( \geq 23 \) points) | 12 (26.1)   | 9 (20.0)  | 0.491   |
|           | C1, C2 or D (\( \leq 22 \) points) | 34 (73.9)   | 36 (80.0) |         |
|           | Total      | 46 (100.0)  | 45 (100.0)|         |
| Body Mass | Not overweight | 22 (42.3)   | 45 (86.5) | \(<0.0001\) |
| Indexd   | Overweight/Obesity | 30 (57.7)   | 7 (13.5)  | 6.0–26.4 |
|           | Total      | 52 (100.0)  | 52 (100.0)|         |
| Waist     | Without abdominal obesity | 25 (48.1)   | 50 (96.2) | 0.0001\(^i\) |
| Circumference | With abdominal obesity | 27 (51.9)   | 2 (3.8)   | 0.7–14.3 |
|           | Total      | 52 (100.0)  | 52 (100.0)|         |
| Waist     | Without abdominal obesity | 28 (53.8)   | 50 (96.2) | 0.0001\(^i\) |
| Circumference | With abdominal obesity | 24 (46.2)   | 2 (3.8)   | 0.7–14.3 |
| Heightf   | Total      | 52 (100.0)  | 52 (100.0)|         |
| Physical  | Underactive | 36 (69.2)   | 31 (59.6) | 0.306   |
| Activityg | Active     | 16 (30.8)   | 21 (40.4) |         |
|           | Total      | 52 (100.0)  | 52 (100.0)|         |

\(^a\) High-density lipoprotein \(<1.2 \) \( \mu \)mol/L and triglycerides \( \geq 1.5 \) \( \mu \)mol/L.

\(^b\) Confidence interval 95%.

\(^c\) Brazilian Association of Research Companies, 2012 (19).

\(^d\) WHO, 2007 (17).

\(^e\) Abdominal obesity \( \geq \) percentile 80 (16).

\(^f\) Abdominal obesity \( \geq 0.5 \) (18).

\(^g\) Underactive \( \leq 300 \) min/wk and Active \( \geq 300 \) min/wk (21).

\(^h\) Pearson’s Chi-square test.

\(^i\) Fisher’s exact test.
sinki and all procedures involving human subjects were approved by the Committee of Ethics in Research with Human Beings of Lauro Wanderley University Hospital at the Federal University of Paraíba (Comitê de Ética em Pesquisa em Seres Humanos do Hospital Universitário Lauro Wanderley da Universidade Federal da Paraíba) (Record CEP/HULW No. 723/10). Written informed consent was obtained from all subjects.

RESULTS

Variables gender, age, fathers’ education level, and social class were similar in both groups (Table 1). Approximately 67% (CI95%: 50.3–80.0) of the adolescents’ mothers in the control group did not complete their secondary education. Overweight and abdominal obesity were more prevalent in dyslipidemic adolescents. The average total cholesterol, LDL, ApoB and ApoB/A-I ratio, as well as the percentile distribution of systolic and diastolic blood pressure figures, were higher in adolescents with dyslipidemia, when compared to those seen in the control group. Only the average concentrations of ApoA-I were lower in adolescents with dyslipidemia, when compared to the control group (Table 2).

The average retinol and the median of the beta-carotene/ApoA-I ratio were higher in dyslipidemic adolescents. Beta-carotene/total cholesterol and beta-carotene/ApoB ratios were lower in dyslipidemic adolescents. However, alpha-tocopherol serum concentrations were not associated with dyslipidemia (Table 3).

DISCUSSION

The results found in our series of public school adolescents in the city of Recife build evidence showing dyslipidemia as an existing risk factor as of an earlier age. Similar reports have been described by Pereira et al. (3), who found a prevalence of dyslipidemia of approximately 64% in adolescents in the city of Recife. Low HDL concentrations were the most frequent finding (56.0%). Changes in the family diet patterns have become usual in the most recent decades. The “obesogenic” environment has had a comprehensive impact on the adolescent market, resulting in a more challenging choice of healthy diets. In the young population, obesity and its comorbidities are related to unhealthy lifestyles, including inappropriate consumption of fat, cholesterol, salt and fibre, as well as sedentary lifestyles (22). In both groups, insufficient practice of regular physical exercise was found in our sample, pointing at a risky lifestyle for cardiovascular disease (CVD).

In our results, overweight and abdominal obesity were significantly more prevalent in dyslipidemic adolescents, showing an association between these morbidities. Among adolescents of the State of Bahia, dyslipidemia was also significantly associated with overweight (odds ratio = 3.14; CI95%: 1.93–5.12) (2).

The average total cholesterol, LDL, ApoB and Apo A-I ratio, as well as the percentile distributions of the systolic and diastolic blood pressure figures, were found significantly higher in the group of dyslipidemic adolescents in our study. Multiple cardiovascular risk factors were found in these individuals and, considering the adverse impact of this atherogenic profile over the years, a prompt intervention in this young risk group is highly needed.

Table 2. Clinical and biochemical characteristics of adolescents with and without dyslipidemia in public schools, Recife, 2013.

| Variables                              | Cases (n=52) | Controls (n=52) | p* |
|----------------------------------------|--------------|----------------|----|
| Systolic blood pressure (mmHg)         | 120.0 (20.0) | 110.0 (10.0)   | <0.0001 |
| Diastolic blood pressure (mmHg)        | 75.0 (10.0)  | 70.0 (10.0)    | <0.0001 |
| Glucose (μmol/L)                       | 4.7 (0.5)    | 4.6 (0.5)      | 0.147 |
| Total cholesterol (μmol/L)             | 4.7 (1.0)    | 3.9 (0.3)      | <0.0001 |
| Low-density lipoprotein (μmol/L)       | 2.7 (0.9)    | 2.2 (0.3)      | <0.0001 |
| Apolipoprotein A-1 (g/L)               | 2.3 (0.7)    | 2.6 (0.7)      | 0.022 |
| Apolipoprotein B (g/L)                 | 2.2 (0.6)    | 1.9 (0.3)      | 0.007 |
| ApoB/A-I (g/L)                         | 0.87         | 0.74           | <0.0001 |
| alfa 1 -acid glycoprotein (g/L)        | 0.8 (0.2)    | 0.7 (0.2)      | 0.151 |

*High-density lipoprotein <1.2 μmol/L and triglycerides ≥1.5 μmol/L.
Standard deviation.
Median.
Interquartile range.
Geometric mean.
Confidence interval 95%.
Student’s t-test for unpaired data.
Mann-Whitney U test.

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Likewise in adults, excessive adiposity in childhood (23) and adolescence (24) is associated with an inflammatory process and oxidative stress, and both are well-established cardiometabolic risk factors. In a cohort study of female adolescents, higher serum concentrations of lipoperoxidation markers were found pari passu to an increase in the obesity measures. There was still a positive correlation with variables total cholesterol, LDL, Apo B and non-HDL cholesterol. These results lay emphasis on the oxidative stress markers as an important link between dyslipidemia and metabolic damages resulting from the progression of vascular dysfunctions (25).

Reports in the literature of the role of vitamin A on lipid metabolism (26) and on the physiopathology and progression of atherosclerosis emphasize the protective effects of this vitamin against cardiovascular diseases, which include its antioxidant activity (27, 28).

In our study, vitamin A serum concentrations behave differently, and may express the consumption or the metabolic mobilization of this nutrient. The average retinol, and the median beta-carotene/ApoA-I, ratio were significantly higher in dyslipidemic adolescents, while beta-carotene/total cholesterol and beta-carotene/ApoB ratios were significantly lower in these individuals.

Regarding retinolemia, despite the differences between the age ranges, our results are similar to those found in the elderly population in the State of Pernambuco (29), where a significant increase of retinolemia was found in the elderly with stage 1 hypertension, when compared to those with optimal or normal blood pressure. It has been suggested that this association would be due to further mobilization of the hepatic reserves of vitamin A for the circulating plasma, providing greater availability for the target-tissues, as well as an antioxidant cell defence response to the oxidative stress generated by the hypertensive process. It is possible that a higher level of retinolemia, identified in the dyslipidemic adolescents of our study, is also an organic response against the oxidative damage promoted by an unfavourable lipid profile.

The association between the status of vitamin A and chronic diseases was also identified in a study with obese children and adolescents of the State of São Paulo, in which the values of retinol were directly associated with TAG and HDL serum concentrations, and inversely associated with postprandial glycemia. After a multivariate analysis, only postprandial glycemia became a predictive and independent variable of retinolemia (30).

A study with adolescents of Rio de Janeiro (23) underlines the significant and negative correlation
between BMI and carotenoid serum levels, assigned to the metabolic consumption of antioxidant nutrients in individuals exposed to an increase in the oxidative processes due to overweight. Among Mexican children, an inverse association was found between the carotenoid serum concentrations and the alpha/tocopherol ratio with adiposity, suggesting that physiological alterations do justify this association, including the possibility that this result is a consequence of antioxidant defence mechanisms (31).

A study on children and adolescents in the North of Switzerland found that the intake of vitamins C, E and beta-carotene is a significant negative predictor of leptin, the circulating concentrations of which were significantly higher as adiposity increased (32).

Regarding the Young Adult Longitudinal Trends in Antioxidants (YALITA) Study (33), total and individual concentrations of carotenoids, but not lycopene, were inversely associated with endothelial dysfunction, oxidative stress and inflammation markers, even after the adjustments made to the multiple regression analysis, and this corroborates the relation between carotenoids and risk factors for CVD (34).

In our study with adolescents, no differences were found in the average serum concentrations of alphatocopherol as a function of dyslipidemia, even after the adjustments by means of the lipid profile. These findings are different from the study with Italian children, in which the significantly lower vitamin-E circulating concentrations were found in the obese individuals. Moreover, the concentrations of malonaldehydes—an important marker of lipoperoxidation—were directly related to BMI and waist circumference, and inversely related to serum vitamin E. Therefore, in obese children, an altered oxidant state produces higher intake of antioxidant vitamins. Detecting an oxidative imbalance during childhood is quite alarming, as hormonal changes, typical in puberty, may worsen this imbalance in adolescence (35).

Lower lipid levels change the plasma levels of fatsoluble vitamins even in young populations. A study with hypercholesterolemic children and adolescents found that total cholesterol, low-density lipoprotein cholesterol, very low-density lipoprotein cholesterol, and triglycerides decreased significantly after supplementation with plant sterol esters, fish oil, and vitamins B12, B6, and folic acid. However, in parallel with this improvement in lipid profile, only the plasma levels of alpha-tocopherol decreased after adjusting the studied fatsoluble vitamins (alpha-tocopherol, gamma-tocopherol, retinol, and beta-carotene) for LDL-cholesterol (36).

The first phase of oxidative stress begins with a higher production of reactive species, characterized by an increase in the production of hydroperoxides. The second phase begins when free radicals react with their main targets, including antioxidants, which prevent damage. In this phase, vitamin E is essential for preventing or interrupting the spread of lipid peroxidation, which would be the final step in oxidative stress. This step is preceded by biochemical processes that lead to the formation of different molecules (37).

However, plasma levels of vitamin E may not be the best predictor of the cell status of this vitamin, as demonstrated by a study with hypercholesterolemic children (38). The said study suggested that other markers, such as erythrocyte vitamin E, in addition to vitamin E adjusted for lipid levels, could be better for assessing the vitamin E status of young populations.

Still, according to a study in obese children (39), the plasma levels of beta-carotene after adjustment for lipid levels were low in hyperlipidemic children while retinol levels were high. Hence, the kinetic differences between fat-soluble vitamins in children also stood out in that study.

Antioxidant defenses act in coordination; that is, the deficiency of one component may affect the efficiency of other components (7). Thus, the multiplicity of metabolic interactions that coordinates the behavior of fatsoluble vitamins in response to changes in the lipid profile requires further investigation.

It is worth noting that the small sample size of our study might not have favoured the finding of changes in the behaviour of alpha-tocopherol as it relates especially to dyslipidemia, considering the chronic development pattern of the lipid disorders that might have limited the possibility of comparing these variables more specifically, such as in the cross sectional approach of this investigation. It is also possible that the young age group of our sample also develops antioxidant compensation mechanisms to balance a greater need to use and/or mobilize nutrients in the presence of an initial oxidative stress, such as dyslipidemia, for example, so that the differences in the serum concentrations of the antioxidant vitamins could be detected only at later stages of life.

Because of the extremely low number of overweight adolescents without dyslipidemia in our sample, adjusting the concentrations of the vitamins studied based on their body mass was not feasible, as the statistical results could be masked by a random error, and this was a limitation to be considered in this investigation.

It is reasonable to underline that the action of the dietary antioxidants of biological importance in vivo depends on several factors, such as the level of oxidative stress to which the organism is exposed, the composition, the quantity and the bioavailability of antioxidants and pro-oxidants usually ingested, which may act in an additive and/or synergistic way (5).

Fruits and vegetables contain vitamins, carotenoids, flavonoids, fiber, and other yet unknown bioactive substances that act together and synergistically to provide these food groups with high antioxidant capacity and multiple anti-inflammatory actions, limiting or preventing oxidative stress (40, 41).

In healthy adolescents, a varied diet of fruits and vegetables was associated with low levels of oxidative stress and inflammation markers, suggesting that such kinds of food may act at an early stage on these markers, and that a similar pattern of consumption brings even stronger benefits with the evolution of age, resulting in lower cardiovascular risk (42). A study conducted with
female obese adolescents found that the consumption of nutrients and antioxidant substances had a positive impact on the lipid profile, without, however, changing the anthropometric parameters (43).

Therefore, it is valid to emphasize the appropriate contribution of fruits and vegetables and, consequently, antioxidants in adolescence, favouring homeostasis influenced by the growth, and by hormonal alterations during this stage of life, which is more susceptible to lipid peroxidation (44).

Other limitations to be considered in this study should be described. First, as in any cross-sectional study, it is not possible to ensure causal relations between the variables, as residual confounding factors might have affected the reported associations. In this sense, prospective studies are highly recommended.

Attention should equally be paid to the fact that the definition of dyslipidemia implies the adoption of biomarkers (isolated or in combination) that may not be the most valid parameters for the identification of the dyslipidemic syndrome. On the other hand, the diagnostic discrimination points used to identify the states of normality/abnormality are, in the best case, consensual, and thus subject to a classification bias.

In addition, it is important to reinforce that investigating the action of antioxidant compounds analysed from isolated nutrients, rather than considering dietary patterns, is a relevant methodological limitation, as the interaction of the nutrients is not considered, which may act synergistically in the protection against oxidative damages. Thereby, it is possible to incur in interpretation errors about the results referring to the antioxidant potential of the studied compounds (6). The characteristics of the methodology currently available did not allow collecting information about the food intake of the study population; only their blood levels of fat-soluble vitamins were measured. However, measuring the presence/intensity of oxidative stress requires investigating a whole set of other specific markers, including markers of lipid peroxidation and antioxidant enzymes, as described by the literature on adults (41, 45), adolescents and children (24, 46), which contributed to a better understanding of the results. Therefore, the mechanisms responsible for the association of the studied vitamins and dyslipidemia in adolescents, in this model, justify further investigation.

The findings show an association of vitamin A with dyslipidemia in young individuals. All in all, caution is necessary when analysing this association, as the mechanisms modulating the effects of this nutrient in the organism are not precisely clear.

Considering that the atherosclerotic plaque buildup starts early in life, and that appropriate antioxidant consumption is associated with less adverse effects in adulthood, this paper contributes to a better understanding about the behaviour of liposoluble vitamins in dyslipidemic adolescents. It is also worth mentioning that population diagnoses on the association of cardiometabolic risk factors and antioxidant nutrients are highly valid, as they foster the development of strategies for promoting healthy dietary habits—built since childhood and adolescence—that tend to remain over a lifetime, and this relates to a lower prevalence of chronic non-communicable diseases.

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