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Association between Neck Circumference and Glycemia in Adolescents

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Abstract

Background: The determination of glycemia is an essential element for the diagnosis of diabetes or possible glycemic alterations. The body composition and fat distribution are related to this parameter. The neck circumference (NC) is an anthropometric measure that has been used to evaluate the overweight and accumulation of subcutaneous fat in the upper body, regardless of age. It is also a useful tool to predict insulin resistance and other risk factors. This research aimed to study the relationship between the NC and glycemia in adolescents and, thus, to analyze the applicability of this anthropometric measure in the screening of glycemic alterations in this group. **Methods:** The study population consisted of 600 adolescents aged 10 to 19 years. Data on sex, birth date, NC, fasting blood glucose and stage of sexual maturation was collected. **Results:** The evolution of sexual maturation generated a significant difference in the NC in both sexes, but not affected glycemia. Thus, the association between NC and glycemia was investigated according to this parameter. Among the pre-pubertal adolescents, the NC was significantly higher among those who had glycemia within borderline values, and the opposite occurred among pubertal adolescents. Among post-pubertal adolescents, NC was similar between the two groups. A negative correlation was found in all adolescents, as well as among those who were in the pubertal and post-pubertal stages of sexual maturation. Differently, adolescents in the pre-pubertal stage showed a positive correlation between the NC and the biochemical parameters. **Conclusion:** This study showed that the relationship between the NC and glycemia varies according to the stage of sexual maturation. As this maturation factor is rarely considered in the glycemic alteration screening, the use of the NC in this age group is not safe and requires further investigations.

Keywords

Adolescents, Glycemia, Neck Circumference, Sexual Maturation, Puberty

1. Introduction

The sedentary behavior observed in the majority of adolescents together with an inadequate diet is associated with the development of chronic non-communicable diseases [1]. The changes in the lifestyle increase the risk of metabolic disorders, leading to the development of type 2 diabetes, dyslipidemias, systemic arterial hypertension and metabolic syndrome, which aggravates the risk of developing cardiovascular diseases [2] [3] [4] [5].

The determination of glycemia is an essential element for the diagnosis of diabetes or possible glycemic alterations [6] and body composition. The fat distribution is related to this parameter, which can be used as predictors of modifications in the glycemia [7] [8].

The methods considered the gold standard for evaluating body adiposity are the imaging exams, including computed tomography, magnetic resonance imaging and dual-energy radiologic absorptiometry (DEXA), which have limits for their accomplishment in addition to being expensive. In this scenario, the anthropometric measures for the detection of body composition and fat distribution are valuable because they are easy to obtain, fast, non-invasive, low cost and therefore easier to apply [9].

The neck circumference (NC) is an anthropometric measure that has been used to evaluate the overweight and accumulation of subcutaneous fat in the upper body, regardless of age. It is also a useful tool to predict insulin resistance and other risk factors [10] [11].

The measure of the NC in adolescence can be a valuable indicator of health and can identify insulin resistance, and other components of the metabolic syndrome (Silva *et al.* [12]). Despite this, studies on the NC in this age group are scarce.

Considering what was reported above, this research intended to investigate the relationship between NC and fasting capillary glucose in adolescents and, furthermore, to evaluate the applicability of this anthropometric measure in the screening of glycemic alterations in this age group.

2. Methods

This research has an experimental, observational, transverse and analytical design, carried out with adolescents of both sexes, aged 10 to 19 years, recruited in three public and three private schools in the city of Marília, São Paulo State, Brazil. Before starting this research, we obtained authorization from the school leader, and adolescents received an invitation to participate. After that, we acquired the approval of the parents or guardians who signed the Term of Free and

Informed Consent. Exclusion criteria were pregnant adolescents, the presence of diabetes, patients with thyroid diseases or anomalies in the head and the neck region, the presence of infections or medications that might interfere with the results of the glycemic test.

The data on gender and date of birth were collected from the school enrollment records. The NC was obtained with the adolescent standing at the Frankfurt horizontal plane (the lower margin of the orbital opening and the upper one of the auditory meatus should be in a same horizontal line), and the head elevated to acquire the midpoint between the lower part of the chin and the sternal manubrium. Afterward, the adolescent's head was placed in the Frankfurt position, and an inextensible tape measure was applied perpendicularly around the neck, just above the midpoint previously obtained. When the male adolescent presented evident laryngeal prominence, the measurement was performed just below it. This technique was adapted from that used by Preis *et al.* [13] and Vasques *et al.* [14].

Fasting capillary glycemia was performed using the calibrated and validated glucometer, following a technique recommended by the Brazilian Society of Diabetes and the American Diabetes Association. This biochemical test was performed in the morning after 8-hour fast [15]. The test was performed after the hands were submitted to antisepsis, and a lancet was used to puncture the lateral to get a drop of blood [6]. The adolescents were considered in the normal glycemic state when fasting capillary glycemia was ≤ 99 mg/dL and borderline if ≥ 100 and < 126 mg/dL. A value greater than or equal to the latter suggests a diagnosis of diabetes, but necessitating of complementary tests for confirmation.

The stage of sexual maturation was determined by the method of self-evaluation, according to the criteria defined by Tanner [16]. In both sexes, this staging is done based on the pubic hairs (characteristics, quantity, and distribution) plus the evaluation of the development of the breasts in girls and the development of genitals in boys (evaluated according to size, characteristics, and shape) [17]. In this method, five figures are presented to adolescent, according to the sex, each corresponding to a phase of pubertal development, when they are asked to indicate which of the figures corresponds to the current developmental condition. Although it is a subjective evaluation and with some limitations, it is the most suitable for population [18].

As we intended to maximize the reliability of this method, we used a well-prepared graphic material with an adequate guide to the adolescent to provide confidentiality, and privacy. The adolescent was informed and clarified about the method before the procedures (recommendations by Faria *et al.* [19]). For the classification of sexual maturation, stage 1 corresponds to pre-pubertal growth and development, while stages 2 to 4 correspond to the progression from puberty to full maturation (Stage 5) [16].

The statistical treatment of the quantitative data was performed with the support of the BioEstat 5.0 program. Data are presented in frequency tables or descriptive statistics data (mean ± standard deviation, median, minimum and

maximum). Appropriate tests were used to evaluate the association between the studied variables, depending on the variance of the data to be analyzed. The probability of significance considered was 5% ($p \leq 0.05$).

This research had the approval of the Research Ethics Committee of the University of Marilia-UNIMAR (São Paulo, Brazil), under Protocol number 2,083,551, on May 25, 2017.

3. Results

A total of 600 adolescents participated in the study, 64% of them were girls. The mean age of participants was 14.67 ± 2.09 years (10 to 19 years), with no significant difference ($p = 0.2817$) as well as in fasting capillary glycemia. The NC measure was significantly higher among boys (<0.0001) (Table 1).

The data were analyzed according to the stage of sexual maturation (Table 2). The evolution of sexual maturation generated a significant difference in the NC in both sexes, but did not affect fasting capillary glycemia.

Considering that NC measurement differed significantly between stages of sexual maturation, the association between this parameter and glycemic levels in this group of adolescents was investigated (Table 3).

Among pre-pubertal adolescents, the NC was significantly higher among those with fasting capillary glycemia within borderline values (≥100 and <126 mg/dL) and the opposite occurred among adolescents in the pubertal stage. Among post-pubertal adolescents, the NC was very similar between the two groups.

The degree of relationship between NC and fasting capillary glycemia was analyzed using the Pearson correlation coefficient. We found a negative, small and weak correlation in all the adolescents, as well as among those who were in the pubertal and post-pubertal stage of sexual maturation (Table 4). Differently, adolescents in the pre-pubertal stage presented a weak but positive correlation between NC and the analyzed biochemical variable.

4. Discussion

Our study showed a negative relationship between NC and glycemia according to the stage of sexual maturation in some groups and a positive relationship in

Table 1. General data of the adolescents.

Data	Total n = 600	Girls n = 384	Boys n = 216	p-value
	mean ± standard deviation (median)			
Age (years)	14.67 ± 2.09 (15.00)	14.63 ± 2.05[a‡] (15.00)	14.73 ± 2.16[a] (15.00)	0.2817*
NC (cm)	32.22 ± 3.09 (32.00)	31.11 ± 2.48[a] (31.00)	34.18 ± 3.10[b] (34.00)	<0.0001**
Glycemia (mg/dL)	88.50 ± 8.3 (88.00)	88.40 ± 8.1[a] (88.00)	88.70 ± 8.6[a] (88.00)	0.3645*

*Independence t-test. **Mann-Whitney Test. NC: Neck circumference. ‡Different letters indicate a significant difference between the pubertal stages at a level of 5%.

Table 2. Data of the adolescents according to the stage of sexual maturation.

Data	Stage of sexual maturation			p-value
	Pre-pubertal (n = 11)	Pubertal (n = 473)	Post-pubertal (n = 116)	
	mean ± standard deviation (median)			
NC (cm)	29.54 ± 2.16[a‡] (29.00)	31.94 ± 2.96[b] (31.00)	33.61 ± 3.23[c] (33.00)	0.0000*
Glycemia (mg/dL)	89.60 ± 7.41 (90.00)	88.60 ± 7.98 (89.00)	88.13 ± 9.49 (87.00)	0.5235**

*Anova 1 criterion and Tukey. **Kruskal-Wallis. NC: Neck circumference (cm). ‡Different letters indicate a significant difference between the pubertal stages at a level of 5%.

Table 3. Measurement of the neck circumference (cm) of the adolescents according to the glycemia (normal (≤99 mg/dL) or borderline (≥100 and <126 mg/dL)), and the stage of sexual maturation.

Stage of sexual maturation	Glycemia				p-value
	Normal (n = 548)		Borderline (n = 52)		
	mean ± standard deviation (median)				
Pre-pubertal	n = 9	29.22 ± 2.27 (29)	n = 2	31 (31)	0.0237*
Pubertal	n = 434	32.04 ± 3.0 (32)	n = 39	30.82 ± 2.26 (31)	0.0111**
Post-pubertal	n = 105	33.6 ± 3.34 (33)	n = 11	33.63 ± 2.01 (34)	0.4896*

*Independence t-test. **Mann-Whitney Test.

Table 4. Pearson correlation coefficient between NC and glycemia of the adolescents.

	r (Pearson)	p-value
Total (n = 600)	−0.0596[a]	0.1467
Pre-pubertal (n = 11)	0.1424[b]	0.6762
Pubertal (n = 473)	−0.0144[a]	0.7555
Post-pubertal (n = 116)	−0.1806[c]	0.0522

[a]Negative. [b]Weak positive. [c]Weak negative.

others. The NC measurement requires a simple, reliable and economical technique [20] which presents advantages about waist circumference measurement because it is not affected by postprandial abdominal distension and respiratory movements, besides represents a more socially acceptable measure mainly among overweight and obese individuals. Several authors have observed that increased NC is associated with cardiometabolic risks, as well as abdominal visceral fat [8] [12] [21] [22] [23] [24]. Studies on NC in adolescents were more focused on the use of this anthropometric measure as a marker of adiposity and weight changes. In this age group, few studies analyzed NC in relation to glycemic changes, especially considering sexual maturation, an essential factor in this stage.

Silva *et al.* [12] carried out a transversal study with 388 Brazilian adolescents, of both sexes (10 to 19 years) and similarly to our findings, they observed a positive correlation between NC and glycemia among pre-pubertal and negative in pubertal adolescents in both sexes.

Similarly, the study of Kelishadi *et al.* [25] with 4200 children and adolescents from Iran (7 to 18 years), showed a positive correlation between NC and glycemia among the girls and negative among boys. These authors did not consider the sexual maturation stage in their study.

Also, Dantas *et al.* [26], based on the results of a study conducted with 406 Brazilian students aged 20.8 ± 2.85 years, observed considerable variability in the prevalence of cardiovascular disease risk based on anthropometric parameters, including NC.

However divergent results are presented in literature. In the study conducted in Turkey by Kurtoglu *et al.* [27] with 588 children and adolescents aged 5 to 18 years, NC was positively correlated with glycemia and HOMA1-IR, in both sexes, both in the pre-pubertal and pubertal stage.

Based on a study with 1542 children and adolescents (5 to 18 years) from Germany, Junge *et al.* [10] consider NC comparable to other anthropometric data for the evaluation of glycemic homeostasis but postulate that it is not superior to them, and should only be used as an additional tool.

Androutsos *et al.* [28] assessed 324 Greek children and adolescents, from 9 to 13 years, and found a positive correlation between NC and fasting glycemia. Gonçalves *et al.* [29], in a study performed with 260 Brazilian adolescents aged 10 to 14 years also found a positive correlation between NC and HOMA1-IR. A positive correlation was also found between NC and fasting glycemia and HOMA1-IR in the study by Gomez-Arbelaez *et al.* [30] in a study performed with 669 Colombian children and adolescents, aged 8 to 14 years. Castro-Piñero *et al.* [11] found a positive correlation between the measurement of NC with insulin resistance through HOMA1-IR in 2198 Spanish children and adolescents. Ejtahed *et al.* [31] found that elevated NC increased the risk score for metabolic syndrome among the 3843 Iranian children and adolescents, including the occurrence of a positive correlation between this measure and fasting glycemia. Nevertheless, these studies did not consider the stage of sexual maturation in the analyses.

NC is a simple parameter, reliable and measured with a low-cost procedure that can be implemented in primary care by any health worker, either to prevent diseases or to identify them, reaching large and different populations. However, the literature, as well as our study, shows the need to develop additional studies with adolescents regarding the use of this anthropometric parameter for the screening of glycemic alterations and taking into account the sexual maturation stage.

5. Conclusions

This study showed that the relationship between NC and fasting capillary glyce-

mia varies according to the stage of sexual maturation of the adolescent. As this maturation factor is rarely considered in the glycemic alteration screening, the use of NC in this age range seems to be not safe, and further studies are necessary.

Thus, it is evident for the need to consider the sexual maturation in the screening of glycemic alteration when the NC in a parameter is to be considered. Furthermore, we suggest the NC as an additional tool to investigate risk of cardiovascular diseases in adolescents.

Conflict of Interests

Authors declare no conflict of interests.

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