ALAN-VE ISSN0004-0622
Depósito Legal: pp 199602DF83

Archivos Latinoamericanos de Nutrición (ALAN) es editado como órgano oficial de la Sociedad Latinoamericana de Nutición (SLAN), para la divulgación de conocimientos en el campo de la alimentación y de la nutrición principalmente en el Hemisferio Américano. En sus páginas se acogen manuscritos en español, inglés, portugués y francés, tanto de miembros como de aquellos que no sean miembros de la Sociedad, y de cualquiera de las siguientes categorías: 1. Trabajos generales (revisiones científicas críticas); 2. Trabajos de investigación (originales); 3. Trabajos de nutrición aplicada (resultados analíticos de programas de intervención y discusión de recomendaciones de aplicación práctica), y 4. Cartas al Editor (comentarios cortos de interés general o relacionados con resultados o conceptos científicos publicados previamente en Archivos).

Archivos Latinoamericanos de Nutrición (ALAN) is the official publication of the Sociedad Latinoamericana de Nutrición (SLAN), for the dissemination of knowledge in the fields of food and nutrition, principally throughout the American Hemisphere. Articles in Spanish, English, Portuguese and French are accepted, both from the Society members and from nonmembers, in the following categories: 1. General articles (critical scientific reviews); 2. Research articles (originals); 3. Papers in applied nutrition (analytical results from intervention programs and discussion of reconmendations of practical application), and 4. Letters to Editor (short comments of general interest or about scientific facts and results previously published in Archives).

ARCHIVOS LATINOAMERICANOS DE NUTRICIÓN está registrado en ASEREME e indizado en la siguientes Bases de Datos: LILACS/CD ROM, Abstract on Higiene and Communicable Diseases, Chemical Abstracts, Current Contents, Dairy Science Abstracts, Field Crops Abstracts, Food Science and Technology Abstracts, Horticultural Science Abstracts, Index Veterinarius, MEDLINE, Nutrition Abstracts and Review, Nutrition Research Newletter, Ornamental Horticulture, Plant Breeding Abstracts, Rice Abstracts, Seed Abstracts, Veterinary Bulletin y Wheat, Barley and Triticale Abstracts, entre otros.

ALAN se edita en Venezuela desde 1992, bajo la responsabilidad del Capítulo Venezolano de la Sociedad Latinoamericana de Nutrición.

La Fundación para la Alimentación y Nutrición “José María Bengoa”, el Centro de Atención Nutricional Infantil Antímano, CANIA y el Instituto Nacional de Nutrición colaboran con esta publicación.

Dirección: Centro Seguros La Paz, piso 4, Oficina E-41C, sector La California, Avenida Francisco de Miranda, Municipio Sucre, Caracas, Venezuela. Teléfono: (0212) 2351824. Apartado 62.778. Chacao, Caracas 1060. Venezuela.
Correo electrónico: info@alanrevista.org
Página web: www.alanrevista.org

Diagramación y montaje: Ana María Reyes. Teléfono: (0412) 3950405
Portada: Chavez & López, Diseño Gráfico. Caracas, Venezuela. Teléfono: (0212) 2855529
Impresión: Gráficas Jaes, C.A. Caracas, Venezuela. Telefóno: (0212) 6316187

Archivos Latinoamericanos de Nutrición

Revista Oficial de la Sociedad Latinoamericana de Nutrición

VOL 70 **DICIEMBRE 2020** **N° 4**

Contenido

Archivos Latinoamericanos de Nutrición

Official Publication of the Latin American Society of Nutrition

VOL 70 **DECEMBER 2020** **N° 4**

Contents

ARCHIVOS LATINOAMERICANOS DE NUTRICIÓN
Revista de la Sociedad Latinoamericana de Nutrición
Doi: 10.37527/2020.70.4.001

Vol. 70 N° 4, 2020
Artículo Original

Nutritional status, diet quality and inflammatory markers in adolescents

Nádia Caroline de Moura Matias[1], Ana Karina Teixeira da Cunha França[1,2], Sueli Ismael Oliveira da Conceição[2], Alcione Miranda dos Santos[1], Janete Daniel de Alencar[1], Cadidja Dayane Sousa do Carmo[1], Cecilia Claudia Costa Ribeiro[1].

Summary: Nutritional status, diet quality and inflammatory markers in adolescents. Objective: To evaluate diet quality and relationship between Body Mass Index (BMI), diet quality and inflammatory markers in adolescents of public schools in São Luís-MA. Methodology: A cross-sectional study was conducted with 384 adolescents aged 17 and 18 years. The nutritional status was evaluated through the BMI. The quality of the diet was evaluated through the Revised Diet Quality Index (IQD-R). The inflammatory markers used were C-Reactive Ultrasensitive Protein (hs-CRP), IL-6 (Interleukin-6) and TNF-α (Tumor Necrosis Factor α). Multivariate analysis was performed using a decision tree using the CART (Classification and Regression Trees) algorithm to evaluate the relationship between BMI, diet quality and inflammatory markers. Results: The mean age was 17.3±0.5 years, predominance of females (56.5%) and eutrophic (69.3%). The mean IQD-R score was 55.3±12.7. Adolescents in the lowest tertile of IQD-R (T1) had a higher mean BMI (22.1±4.3 kg/m^2 vs 21.5 ± 3.7kg/m^2). Higher levels of IL-6 were observed in those located on the IQD-R T1 (1,345 mg/L vs 1,205 mg/L). In the same group (T1), adolescents who had higher IL-6 levels also had a higher mean BMI (23.6±5.1kg/m^2 vs 20.8±3.0kg/m^2). The adolescents in the largest tertiles of IQD-R (T2 and T3) and who had higher concentrations of IL-6 and CR-us had also a higher mean BMI (23.8±4.9kg/m^2). Conclusions: The diet quality of adolescents studied needs modifications. BMI averages varied with diet quality and levels of IL-6 and hs-CRP. **Arch Latinoam Nutr 2020; 70(4): 237-246.**

Key words: Nutritional status; revised Diet Quality Index; inflammation; adolescents.

Resumo: Estado nutricional, qualidade da dieta e marcadores inflamatórios em adolescentes. Objetivo: Avaliar a qualidade da dieta e a relação entre Índice de Massa Corporal (IMC), qualidade da dieta e marcadores inflamatórios em adolescentes de escolas públicas de São Luís-MA. Metodologia: Foi realizado um estudo transversal com 384 adolescentes de 17 e 18 anos. O estado nutricional foi avaliado por meio do IMC. A qualidade da dieta foi avaliada por meio do Índice de Qualidade da Dieta Revisado (IQD-R). Os marcadores inflamatórios utilizados foram Proteína C Reativa Ultrassensível (PCR-us), IL-6 (Interleucina-6) e TNF-α (Fator de Necrose Tumoral α). A análise multivariada foi realizada usando uma árvore de decisão usando o algoritmo CART (Classification and Regression Trees) para avaliar a relação entre IMC, qualidade da dieta e marcadores inflamatórios. Resultados: A média de idade foi de 17,3 ± 0,5 anos, predomínio do sexo feminino (56,5%) e eutrófico (69,3%). A pontuação média do IQD-R foi de 55,3 ± 12,7. Os adolescentes no tercil inferior do IQD-R (T1) tiveram uma média de IMC mais alta (22,1 ± 4,3kg/m^2 vs 21,5 ± 3,7kg/m^2). Níveis mais elevados de IL-6 foram observados naqueles localizados no IQD-R T1 (1.345 mg/L vs 1.205 mg/L). No mesmo grupo (T1), os adolescentes que apresentaram níveis mais elevados de IL-6 também apresentaram média de IMC mais elevada (23,6 ± 5,1kg/m^2 vs 20,8 ± 3,0kg/m^2). Os adolescentes nos maiores tercis de IQD-R (T2 e T3) e que apresentaram maiores concentrações de IL-6 e CR-us também apresentaram maior IMC médio (23,8 ± 4,9kg/m^2). Conclusões: A qualidade da dieta dos adolescentes estudados necessita de modificações. As médias do IMC variaram com a qualidade da dieta e os níveis de IL-6 e PCR-us. **Arch Latinoam Nutr 2020; 70(4): 237-246.**

Palabras clave: Estado nutricional, Índice de Qualidade da Dieta revisado, inflamação, adolescentes.

Introduction

Chronic noncommunicable diseases (NCDs) pose health concerns in the 21st century (1). Their main risk factors are hereditary, race, sex, tobacco use, unhealthy diet, obesity, physical inactivity, and harmful alcohol consumption (2). Early exposures to these factors during

[1]Programa de Pós-Graduação em Saúde Coletiva, [2] Curso de Nutrição, Departamento de Ciências Fisiológicas, Universidade Federal do Maranhão.
Autor para la correspondencia: Sueli Ismael Oliveira da Conceição, email: sueli.ismael@gmail.com

childhood or adolescence increase the chances of development of NCDs in the future (1).

Many inflammatory markers have been associated to the pathogenesis of NCDs and used in clinical practice and research. Among these markers are Interleukin-6 (IL-6), Tumor Necrosis Factor α (TNF-α), and C-Reactive Ultrasensitive Protein (hs-CRP) (3). Increased plasmatic levels of these inflammatory markers have been associated with obesity, insulin resistance, dyslipidemia metabolic syndrome, and increased risk of cardiovascular events (4).

Literature suggests that the concentrations of inflammatory markers can be influenced by anthropometric conditions and eating patterns (3). In addition, plasmatic levels of inflammatory markers associated to NCDs could be compromised early in childhood and adolescence (5).

Under this perspective, the need to evaluate eating patterns and global quality of diet in early stages of life is increasing. The Revised Diet Quality Index (IQD-R), an adaptation of the Healthy Eating Index (HEI-1995) developed in the United States, evaluates a combination of different types of food, nutrients, and diet components in relation to the proposed diet recommendations and/or health outcomes (6).

The IQD-R is useful to monitor the eating habits of adolescents and to identify associations with demographic, socioeconomic (7-10), anthropometric factors, and life habits (7,9,11). However, there are few investigations that associated the IQD-R with risk factors for NCDs (12-14) and specially those that associate the index with inflammatory markers in adolescents. Therefore, the present study proposes an evaluation of diet quality and the relationship between Body Mass Index (BMI), diet quality, and inflammatory markers in adolescents of public schools, with the purpose of early identifying the risk factors that may trigger NCDs.

Materials and methods

Cross-sectional study conducted with adolescents, derived from a research titled "Adolescer - Are oral health problems in adolescents associated to risk factors for chronic noncommunicable diseases?", developed by Universidade Federal do Maranhão (UFMA) from January 2014 to June 2016, with the approval of the Research Ethics Committee from UFMA under protocol number 441.226/2013.

The study was conducted in public schools in the urban area of São Luís - MA, located in the Northeastern region of Brazil and with Human Development Index of 0.768 in 2013. In 2012, there were 42,009 students enrolled in 52 public High Schools.

In order to calculate the sample size, the correlation coefficient of 15%, power of test of 80%, and significance level of 5% were used, resulting in, at least, 347 adolescents. Predicting possible losses, the sample was increased by 10%. For the selection of the participants, a cluster sampling was performed in three stages (school, school year, and class), with random sampling and without replacement. Adolescents of both sexes and aged 17 and 18 years were included, with the purpose of verifying health outcomes after the growth spurt phase. Since the present study used secondary data from the aforementioned research and meeting the inclusion and non-inclusion criteria, 384 adolescentes were included in the final sample.

The data collection was performed with semi-structured forms applied with the adolescents. The following sociodemographic data were collected: age, gender, skin color (white and non-white), mother's education in years (≤4, 5-8, 9-12, and >12), and economic class (A/B, C, and D/E, which corresponded at the time to U$2,527, U$590, and U$336 of average family gross income per month, respectively) (15).

The lifestyle covered information about alcohol intake and use of cigarettes in the previous year (yes or no), and practice of physical activity evaluated through the Physical Activity Questionnaire for Adolescents (QAFA) (16). The adolescents that were considered active practiced physical activity ≥300min/week, and the remaining were considered insufficiently active (17).

To characterize the nutritional status of the populationwas used o IMC adopting the criteria proposed by the World Health Organization (18) For such, the body weight (kg) was measured with a digital scale (Tanita®, Japan), along with the height (m) using a portable stadiometer (Alturexata®, Brazil).

A 24-hour food record (24hR) was applied to evaluate the food consumption in two nonconsecutive days. The data from the 24hR were converted in energy and nutrients through the software Virtual Nutri Plus®. For the evaluation of the adolescents' diet quality, the study used the IQD-R adapted for Brazil from the American HEI, based on the Dietary Guidelines for the Brazilian Population in the year of 2006. The IQD-R includes 12 components based on the energetic density (portion/418kJ or 1000 kcal) or percentage contribution of calories in the diet (6).

The specific scores of each component of the IQD-R range from 0 (minimum) to 5, 10 or 20 (maximum). The minimum score corresponds to the non-consumption of the components that are considered healthy or to the consumption above the proposed limit of components that are considered unhealthy; the maximum score of each element is established from the reference intake value, when consumption is equal/inferior to the unhealthy components or equal/superior to the healthy components. The scores for the intermediate intake values are attributed proportionally. The total score of the IQD-R ranges from 0 to 100 points (6).

The IQD-R was used as a continuous numerical variable and categorized in tertiles. For the characterization of the adolescents' diet quality, a classification proposed by Bowman et al. was adopted: scores <51 - "inadequate diet"; 51 to 80 - "diet that needs modification"; >80 - "healthy diet" (19).

The biochemical evaluation consisted of the measurement of the inflammatory markers (TNF-α, CRP-us, and IL-6) determined by the technology Magpix-Milliplex. Since there are no established reference values for this population, the levels of inflammatory markers were used as continuous numerical variables.

The data were analyzed with the software STATA®14.0. The categorical variables were presented as frequencies and percentages and the numerical, as measures of central tendency and dispersion. The Kolmogorov-Smirnov test was used to verify normality.

The Kruskal-Wallis test was performed to compare consumption of the IQD-R components in tertiles. Spearman's correlation was conducted between the IQD-R variables, BMI, and inflammatory markers (CRP-us, IL-6, and TNF-α), being classified as weak when r:≤0.29, moderate when r: 0.50-0.69, and strong when r: 0.70-0.89 (20). The level of significance adopted was 5%.

In order to identify the relationship between BMI, diet quality, and inflammatory status of the adolescents, the study adopted the Decision Tree (DT), which established the relationship between independent variables and the response variable. The DT is obtained through successive binary divisions in the data set in order to make the subgroups increasingly more homogeneous in regards to the response variable (21).

To create the DT, the BMIwas considered a dependent variable. The independent variables included gender, physical activity, IQD-R, and inflammatory markers (CRP, IL-6 e TNF-α). The DT was created based on the nonparametric classification method CART (Classification and Regression Tree) to originate a BMI average classification of the adolescents according to the tertiles of diet quality and the individual inflammatory markers. The statistics software SPSS® was used to generate the DT.

Results

There was a predominance of female (56.5%), 17 years old (65.4%), non-white adolescents (84.1%), from class C (64.2%), and whose mothers had ≥9 years of education (46.1%). Regarding the lifestyle of the participants, 51.6% were insufficiently active and, in the previous year, 54.2% reported not having consumed alcohol and 88.5% not smoking (Table 1).

Excess weight was identified in 14.1% of the participants (9.7% overweight and 4.5% obese). The average value (p25-p75) of the CRP-us was 0.11 mg/L (0.00-0.28), of the IL-6 1.18 ml/L (0.76-2.05), and of the TNF-α 2.81 mg/L (1.68-4.11) (Table 1).

Table 1. Demographic, socioeconomic, lifestyle, and clinical-nutritional characterization of adolescents. São Luís - MA, Brazil, 2014-2016.

Variables	n	%
Gender		
Masculine	167	43.5
Feminine	217	56.5
Age		
17 years old	251	65.4
18 years old	133	34.6
Skin color		
White	60	15.6
Non-white	323	84.1
Not informed	1	0.3
Mother Education		
≤ 4 years	71	18.5
5 to 8 years	88	22.9
9 to 12 years	155	40.4
>12 years	22	5.7
Not informed	48	12.5
Brazilian Economic Classification		
Class A/B	57	15,0
Class C	244	64,2
Class D/E	79	20,8
Physical Activity		
Sufficiently active	184	48.0
Insufficiently active	198	52.0
Alcohol consumption in the previous year		
Yes	176	45.8
No	208	54.2
Cigarette use in the previous year		
Yes	44	11.5
No	339	88.3
Not informed	1	0.2
Diet quality		
Inadequate	123	32.0
Needs changes	252	65.6
Healthy	9	2.4
Body Mass Index		
Underweight	62	16.5
Normal	260	69.3
Overweight	36	9.7
Obesity	17	4.5
Inflammatory markers	Median	(P25-P75)
CRP-us (mg/L)	0.11	(0.00-0.28)
IL6 (mg/L)	1.18	(0.76-2.05)
TNF-α (mg/L)	2.81	(1.68-4.11)

CRP-us: C-Reactive Ultrasensitive Protein; IL6: Interleukin 6; TNF-α:Tumor Necrosis Factor α.

Among the evaluated adolescents, 32.0% were classified with an inadequate diet, 65.6% with a diet that needs modification and only 2.4% had a healthy diet (Table 1). The average score of the IQD-R was 55.3 (SD±12.7) and the median, 56.2 with interquartile range of 48.1-63.0. The study found low scores for the following components: whole cereals (0.4 points), whole fruits (2.1 points), total fruits (2.7 points), oils (2.6 points), and milk and derivatives (3.7 points). Higher scores were observed for the following components: meat, eggs, and legumes (9.4 points), saturated fat (7.3 points), total cereals (4.7 points), dark green/orange vegetables and legumes (4.1 points), and total vegetables (4.1 points) (Table 2).

When compared to the scores of the components per tertile of the IQD-R, the individuals who belonged to the highest tertile presented greater scores for the components "total

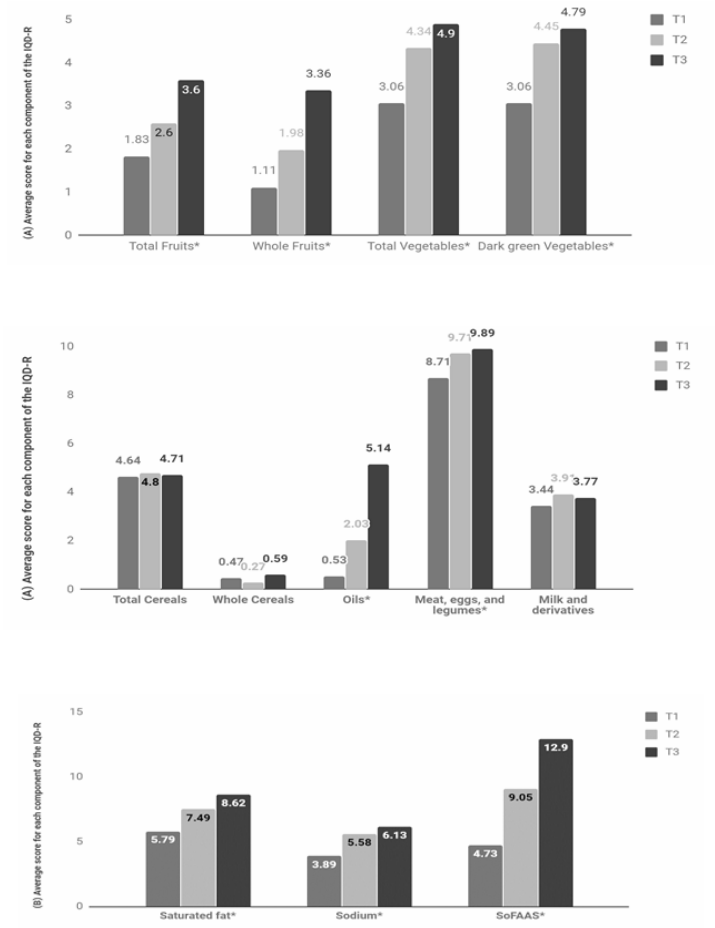
Table 2. Descriptive statistics of the scores of the Revised Diet Quality Index (IQD-R) and its components in adolescents. São Luís - MA, Brazil, 2014-2016.

Variables	Maximum score	Mean (±SD)
Components IQD-R		
Total fruits	5	2.7 (± 2.2)
Whole fruits	5	2.1 (± 2.4)
Total vegetables	5	4.1 (± 1.7)
Dark green/orange vegetables and legumes	5	4.1 (± 1.8)
Total cereals	5	4.7 (± 0.6)
Whole cereals	5	0.4 (±1.2)
Meats, eggs, and legumes	10	9.4 (± 1.6)
Milk and derivatives	10	3.7 (± 2.9)
Oils	10	2.6 (± 4.2)
Saturated fat	10	7.3 (± 2.8)
Sodium	10	5.2 (± 2.9)
SoFAAS*	20	8.9 (±5.7)
Total IQD-R	100	55.3 (± 12.7)
Tertile IQD-R		
T1 (points)	100	41.3 (± 8.2)
T2 (points)	100	56.2 (± 2.5)
T3 (points)	100	68.4 (± 6.6)

*SoFAAS: calories from solid fat, alcohol, and added sugar.

fruits", "whole fruits", "total vegetables", "green/orange vegetables and legumes", "meat, eggs, and legumes", and "oils", indicating higher consumption of these food groups.

There were also higher scores, indicating lower consumption, for the components "saturated fat", "sodium", and "SoFAAS". There was no statistical significant difference between the tertiles of the IDQ-R for the consumption of "total cereals" and "whole cereals" (Figure 1).



IQD-R: Revised Diet Quality Index. T1: tertile 1. T2: tertile 2. T3: tertile 3. (A) Higher means indicate higher consumption. (B) Higher means indicate lower consumption.*p<0.001. Kruskal Wallis test. Compare the consumption of the components according to the tertile of the IQD-R

Figure 1. Average score of each component of the IQD-R according to the tertiles of contribution. São Luís - MA, Brazil, 2014 -2016

Table 3. Correlation between IQD-R, BMI, and inflammatory markers in adolescents. São Luís - MA, Brazil, 2014-2016.

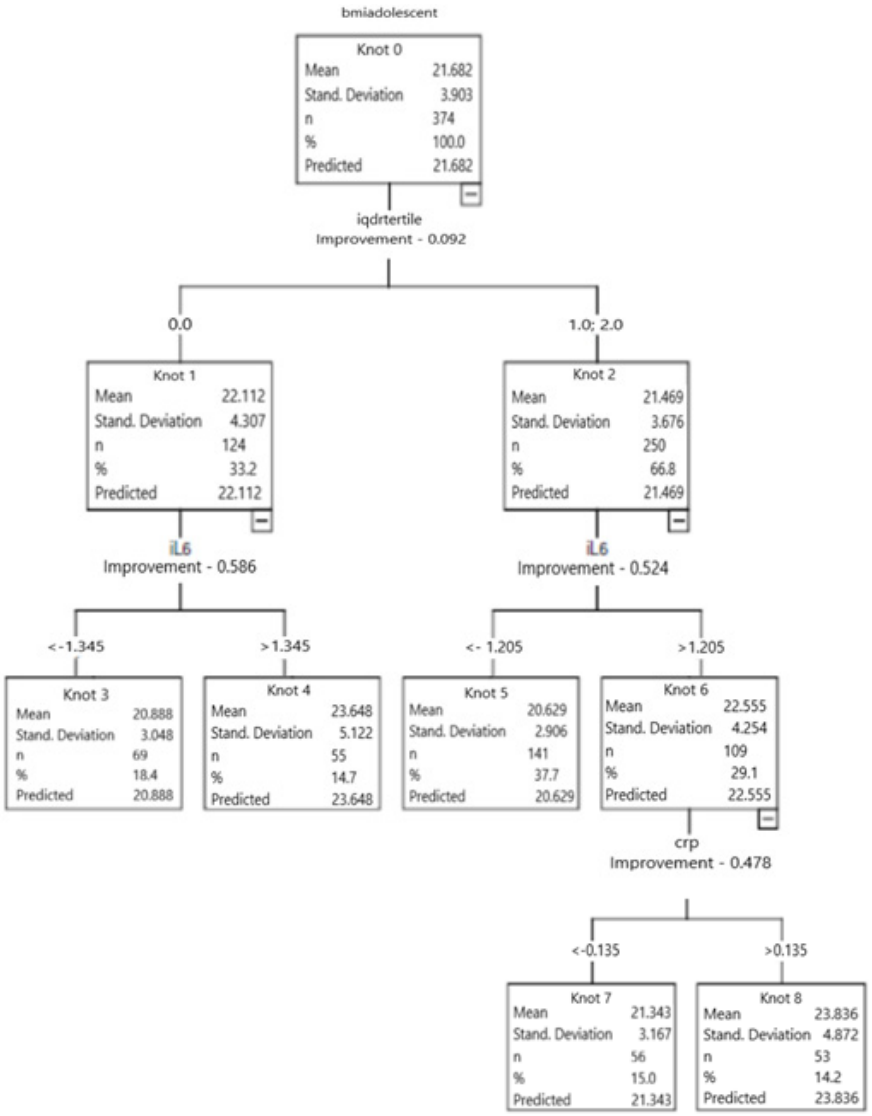
Variables	IQD-R r	BMI R
BMI	-0.006	
CRP-us	-0.102	0.124*
IL6	-0.017	0.233#
TNF-α	-0.045	0.154*

r: Spearman's Correlation Coefficient. *p<0.05 #p<0.001; PCR-us: C-Reactive Ultrasensitive Protein. IL6: Interleukin 6. TNF-α: Tumor Necrosis Factor α.

The IQD-R did not present correlation with the BMI and the inflammatory markers. The BMI was correlated to all of the evaluated inflammatory markers: CRP-us (r=0.124; p<0.05), IL-6 (r=0.233; p<0.001), and TNF-α (r=0.154; p<0.05); however, with weak magnitude (Table 3).

Figure 2 represents the DT for the studied sample, which identified that the adolescents in the lowest tertile of the IQD-R (T1) presented higher BMI average (22.1±4.3 kg/m^2), when compared to the adolescents in the highest tertiles (T2 and T3) (21.5±3.7 kg/m^2). Higher levels of IL-6 were observed in those located in the T1 of the IQD-R (1.345 mg/L vs 1.205 mg/L). In the same group (T1), the adolescents that had levels of IL-6 higher than 1.345 mg/L also had greater BMI average (23.6±5.1 kg/m^2 vs 20.8±3.0 kg/m^2).

Among the participants in the highest tertiles of the IQD-R (T2 and T3) and that presented higher concentrations of IL-6 (>1.205 mg/L), it was observed greater BMI average (22.5±4.2 kg/m^2 vs 20.6±2.9 kg/m^2). In the adolescents with higher concentrations of IL-6 (>1.205 mg/L) and CRP-us (>0.135 mg/L), the BMI average was also greater (23.8±4.9 kg/m^2) (Figure 2).



QD-R Tertile 1: tertile 1 of the IQD-R; IQD-R Tertile 2 and 3: tertiles 2 and 3 of the IQD-R. IL-6: interleukin 6; CRP: C Reactive Protein. Dependent variable: BMI; Independent variables: gender, physical education, IQD-R, and inflammatory markers (CRP, IL-6, and TNF-α).

Figure 2. Decision Tree of the studied sample

Discusion

In the present study, the mean of the total IQD-R showed that the diet of the evaluated adolescents needs modifications, and only 2.4% of them had a healthy diet. The average values of the BMI ranged with the tertiles of diet quality and with the serum levels of the inflammatory markers (IL-6 and CRP-us).

Endorsing the present study, Andrade *et al*. also used a 24hR to determine the IQD-R and observed a close average score (59.7) for the adolescents in the Health Survey in the state of São Paulo (ISA-SP) (11). Other national research performed with adolescents identified higher average values of IQD-R, ranging from 62.4 to 75.1 points (7,8,13). However, these authors used the FFQ to evaluate the consumption and to determine the IQD-R. Such instrument can limit the variety

of the evaluated food and, possibility, interfere with the scores of the IQD-R.

In this study, the consumption of fruits, whole cereals, milk and derivatives and vegetable oils was below the recommended. The low intake of food and vegetables was observed in European adolescents, comparing to the investigations in other countries such as Australia, Canada, United Kingdom and USA (22).

In Brazil, Castilhos *et al*. also observed low averages for the consumption of total fruits and milk and derivatives when evaluating the diet of adolescents from Pelotas (RS) (8). The low intake of milk and derivatives may be a result of the omission of breakfast, a practice that is very common in the population. In addition, milk consumption is possibly being substituted by the ingestion of sugary beverages (7). This negative aspect of the present study needs to be reversed, since this habit could compromise the calcium intake, a mineral that is essential for growth and skeletal maturing in adolescents (23).

The low consumption of fruits and whole cereals observed in this study can compromise the ingestion of micronutrients and fibers and contribute to a higher calorie density diet and risks for cardiovascular diseases, obesity, diabetes, and cancer (24).

In the scoring of the "SoFAAS" group, it was not possible to include calories from trans fat due to the lack of information on the software. Nevertheless, the low scores indicate high consumption of other food components in this group. In this investigation, the consumption of "SoFAAS" was similar to that observed in other national studies (7,8,13). It is important to highlight that the high intake of such component is a negative aspect in the diet of the evaluated adolescents, since it indicates high consumption of ultra processed food, constituted mainly of sugars and fats, and which predispose the consumer to the development of NCDs (25).

On the other hand, a positive aspect of the diet was a higher score for "meat, eggs, and legumes", "vegetables", and "green/orange vegetables and legumes", indicating higher consumption of these food. This finding differs from results observed in other national studies with adolescents, which presented low consumption of these groups (7, 26).

Despite the fact that national studies showed reduction in consumption of beans by Brazilians (27), The National Adolescent School-based Health Survey (PeNSE) identified the frequent consumption of such food by adolescents, supporting the results of the present study (28). The ingestion of beans by adolescents in this research contributed to the increase in the score of "meat, eggs, and legumes", "vegetables", and "dark green/orange vegetables and legumes". Therefore, it is possible that the consumption of meats and eggs and dark green/orange vegetables is overestimated due to the inclusion of legumes in the scores of these groups according to the method adopted to calculate the IQD-R. It is important to mention that, although beans are considered a source of low biological value protein, this food is important in the diet of low income populations, because it contributes to the calculation of the total protein in the diet (29).

The consumption of saturated fat was near what is considered adequate (6) and deviated from studies performed with adolescents in the Southern and Central-West regions of Brazil (7, 9), which observed greater ingestion of this nutrient. This was one more favorable aspect of the present study, since the high consumption of saturated fat is associated with alterations in the lipidic profile and development of cardiovascular diseases (29).

In this investigation, the adolescents in the lowest tertile of diet quality had a BMI average greater than those in higher tertiles, suggesting a possible inverted relationship between diet quality and BMI. Similarly, Pinheiro and Atalah identified lower scores of IQD-R associated to excess weight in the Chilean population (12). This relationship is still controversial in the field, since other studies performed in Brazil have not found correlation between BMI and IQD-R (11,13). It is worth mentioning that the mean BMI values among the adolescents in this study are within acceptable levels (30).

Another relevant aspect was that the adolescents located in higher tertiles of the IQD-R did not necessarily have good quality diet. In these tertiles, the scores of the IQD-R were intermediate and only 2.4% of the adolescents in the highest tertile presented scores that indicate good quality diet.

Literature confirms that excess weight, especially

obesity, is associated to inflammation. However, it is still inconsistent if inflammation is a consequence of obesity or if obesity is a result of the inflammatory disease (3).

The inflammatory trigger in obesity is metabolic, caused by the excessive consumption of nutrients and energy. Thus, inflammation is capable of compromising metabolic homeostasis over time, affecting different organs (31). Among the adult population, in which the exposure time to excess weight contributes to the development of the inflammatory process, this association seems to be well established. However, the youth population still needs to be more explored and studied in order to investigate if the process of subclinical inflammation would already be present (3).

In the present study, the adolescents in lower tertiles of the IDQ-R had greater BMI average and lower concentrations of IL-6, while those in the highest tertiles had higher BMI averages when they had higher concentrations of IL-6 and PCR-us.

A few studies that found an association between diet and inflammatory markers, after adjustments for the nutritional status, did not observe a preservation of this association. Bibiloni *et al*., when evaluating Spanish adolescents, verified an association of the dietary patterns of the Mediterranean to higher plasmatic concentrations of adiponectin. At the same time, the Western dietary pattern was negatively associated to adiponectin and positively associated to IL-6 in female adolescents. It is important to highlight that such findings were not significant after adjustment for BMI (32).

Experimental studies suggest that the increase of adiposity is associated to inflammatory markers, cardiovascular diseases and, consequently, to lesions in the coronary arteries since adolescence (33). Silva *et al*. observed that the CRP content was positively correlated to all of the evaluated anthropometric parameters, including BMI (34). Other authors found positive association between CRP and BMI in adolescents (35).

A positive association between overweight/obesity and IL-6 has been observed among adolescents, reinforcing the hypothesis about the relationship between this marker with lipids metabolism (5).

Arouca *et al*. emphasize that, in the youth population, a diet that is high in antioxidants and essential nutrients, which is considered healthy, can reduce the concentration of inflammatory biomarkers caused by adiposity. However, a diet that is low in these components seems to contribute to the beginning of the inflammatory process and oxidative stress (36).

This study presented as a limitation the transversal design, which does not allow for the establishment of causality relationships between diet quality, excess weight, and inflammatory markers. Although the IQD-R is an instrument used to evaluate diet quality in populational groups, it does not deduct from the scores of components that are considered healthy when the consumption is excessive (7).

The strength of this study is the use of early inflammatory markers in a young population and the use of two 24hR to investigate the food consumption, which enabled the evaluation of the usual intake of nutrients and diet quality.

Conclusion

It is concluded that the diet quality of adolescents needs modifications. The participants with the worst diet had higher BMI averages and serum levels of IL-6. Similarly, but with less intensity, the adolescents that were in the highest tertiles of IQD-R and had greater levels of IL-6 also presented higher BMI averages. Those that also presented more elevated concentrations of CRP-us had an even greater BMI average, despite being in the highest tertiles of IQD-R.

Acknowledgements

The authors are grateful to the Foundation for Research in the State of Maranhão (FAPEMA), Department of Science and Technology from the Ministry of Health – DECIT, and for the National Council for Scientific and Technological Development – CNPq for the financial support, and to individuals who agreed to participate.

Conflicts of interest:

The authors report no conflicts of interest.

References

1. World Health Organization. Global Status Report on Noncommunicable Diseases. Geneva, 2014. Disponível em: < https://www.who.int/nmh/publications/ncd-status-report-2014/en/ >. Acesso em: 08 de setembro de 2020.
2. Melo S, Cesse E, Lira P, Rissin A, Cruz R, Filho M. Doenças crônicas não transmissíveis e fatores associados em adultos numa área urbana de pobreza do nordeste brasileiro. Ciênc Saúde Colet, 2019; 24(18): 3159-3168.
3. Miraglia, F, Mello, E. Como avaliar o processo inflamatório em crianças com excesso de peso? Rev. HCPA. 2012; 32(3): 332-339.
4. Teixeira BC, Lopes AL, Macedo RCO, Correa CS, Ramis TR, Ribeiro JL *et al*. Marcadores inflamatórios, função endotelial e riscos cardiovasculares. J Vasc Bras, 2014; 13(2):108 – 115.
5. Guedes J, Neto J, Santos J, Cândido R, Andaki A, Mendes E. Concentrações de IL-6, TNF-α e MCP-1 em crianças com excesso de massa corporal. ABCS Health SCI. 2015; 40(2): 85-91.
6. Previdelli A, Andrade S, Pires M, Ferreira S, Fisberg R, Marchioni D. A revised version of the Healthy Eating Index for the Brazilian population. Rev Saude Publica. 2011; 45(4): 794-8.
7. Wendpap L, Ferreira M, Rodrigues P, Pereira R, Loureiro A, Silva R. Qualidade da dieta de adolescentes e fatores associados. Cad Saude Publica, 2014; 30(1):97-106.
8. Castilhos C, Schneider B, Muniz L, Assunção M. Qualidade da dieta de jovens aos 18 anos de idade, pertencentes à coorte de nascimentos de 1993 da cidade de Pelotas (RS), Brasil. Ciênc Saúde Colet, 2015; 20(11): 3309-3318.
9. 9. Tanaka L, Dias R, Medeiros A, Roma T, Mendes E, Souza H. Poor diet quality among Brazilian adolescents with HIV/AIDS. J Pediatr, 2015; 91(2): 152-159.
10. Ferrari T, Cesar C, Alves M, Barros M, Goldbaum M, Fisberg R. Estilo de vida saudável em São Paulo, Brasil. Cad Saúde Pública. 2017; 33(1).
11. Andrade S, Barros M, Carandira L, Goldbaum M, César C, Fisberg R. Dietary quality index and associated factors among adolescentes of the state of Sao Paulo, Brazil. J Pediatr, 2010; 156(3): 456-60.
12. Pinheiro A, Atalah E. Propuesta de una metodología de análisis de lacalidad global de laalimentación. Rev Med Chil, 2005; 133(2):175-82.
13. Ramos, J. M. Índice de Qualidade da Dieta e Indicadores do Estado Nutricional de Adolescentes Assistidos no Programa Médico de Família em Niterói-RJ: Projeto CAMELIA. [Dissertação]. Universidade Federal Fluminense, Instituto de Saúde da Comunidade, 2010.
14. Torres, R. H. Componentes inflamatórios e antiinflamatórios da dieta, perfil metabólico e aptidão física em meninas adolescentes. [Dissertação]. Universidade Federal do Paraná, Setor de Ciências Biológicas, 2014.
15. ABEP. Associação Brasileira de Empresas de Pesquisa. Critério de classificação econômica Brasil - CCEB. São Paulo: ABEP, 2008. Disponível em: <http://www.abep.org/criteriobrasil>. Acesso em: 20 de julho de 2017.
16. Farias-Júnior J, Lopes A, Mota J, Santos M, Ribeiro J, Hallal P. Validade e reprodutibilidade de um questionário para medida de atividade física em adolescentes: uma adaptação do Self - Administered Physical Activity Check list. Rev. Bras. Epidemiol., 2012; 15(1): 198-210.
17. Biddle S, Sallis J, Cavill N. Young and active? Young people and health enhancing physical activity: Evidence and implication. London: Health Education Authority, 1998.
18. World Health Organization. Multicenter Growth References Study Group. WHO Child Growth Standards: length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: methods and development. Geneva, 2007.
19. Bowmann S, Lino M, Gerrior S. The Healthy Eating Index: 1994-96. U.S. Department of Agriculture. Center for Nutrition Policy and Promotion. 1998.
20. Pett MA, Lackey NR, Sullivan JJ. Making sense of factor analysis: the use of factor analysis for instrument development in health care research. Sage Publications, 2003.
21. Breiman L, Friedman R, Stone C. Classification and regression trees. Belmont: Chapman & Hall; 1984.
22. Ayuso-Mielgo J, Valtueña J, Huybrechts I, Breidnassel C, Cuenca-García M, De Henauw S *et al*. Fruit and vegetables consumption is associated with higher vitamin intake and blood vitamin status among European adolescents. Eur J Clin Nutr, 2017; 71(4): 458-467.
23. Leal G, Philippi S, Matsudo S, Toassa E. Food intake and meal patterns of adolescents, São Paulo, Brazil. Rev. Bras. Epidemiol. 2010; 13(3): 457-67.
24. Silva F, Menezes A, Duarte M. Consumo de frutas e vegetais associados a outros comportamentos de risco em adolescentes no nordeste do Brasil. Rev Paul Pediatr. 2016; 34(3): 309-315.
25. Louzada M, Martins A, Canella D, Baraldi L, Levy R, Claro R *et al*. Alimentos ultraprocessados e perfil nutricional da dieta no Brasil. Rev Saúde Pública. 2015; 49(38): 1-11.
26. Previdelli, A. N. Padrões de dieta de adolescentes do município de São Paulo e fatores associados: estudo de base populacional [Tese]. Universidade de São Paulo, Faculdade de Saúde Pública 2013.
27. Meléndez G, Mendes L, Pessoa M, Sardinha L, Yokota R, Bernal R *et al*. Tendências da frequência do consumo de feijão por meio do inquérito telefônico nas capitais brasileiras, 2006 a 2009. Ciênc. Saúde Colet. 2012; 17(12): 3363-3370.
28. Brasil. Instituto Brasileiro de Geografia e Estatística. Coordenação de População e Indicadores Sociais. Pesquisa Nacional de Saúde do Escolar (PeNSE). Rio de Janeiro, 2016.

29. Brasil. Ministério da Saúde. Secretaria de Atenção à Saúde. Guia alimentar para a população brasileira: promovendo a alimentação saudável. Brasília/DF, 2006.
30. Bloch K, Klein C, Szklo M, Kuschnir M, Abreu G, Barefaldi L *et al*. ERICA: prevalences of hypertension and obesity in Brazilian adolescents. Rev Saúde Pública. 2016; 50(1):1-13.
31. Saltiel A, Olefsky J. Inflammatory mechanisms linking obesity and metabolic disease. J Clin Invest. 2017; 127(1): 1-4.
32. Bibiloni M, Llompart I, Pons A, Tur JA. Dietary factors associated with subclinical inflammation among girls. Eur J Of Clin Nutr, 2013; 67 (12): 1264-70.
33. Miranda V, Peluzio M, Franceschini S, Priore S. Marcadores inflamatórios na avaliação nutricional: relação com parâmetros antropométricos, composição corporal e níveis de atividade física. Rasbran, 2014; 6(1): 61-72.
34. Silva I, Sanches L, Mello A, Damasceno N. Impacto da proteína-C reativa no risco cardiovascular de adolescentes. Arq Bras Cardiol. 2010; 94(5): 585-95.
35. Oliveira AC, Oliveira AM, Almeida MS, Silva AM, Adan L, Adeia AM. Alanine aminotranferase and high sensivity C-reactive protein: correlates of cardiovascular risk factors in youth. J Pediatr. 2008; 152(3): 337-42.
36. Arouca A, Moreno A, Gonzalez-Gil E, Marcos A, Widhalm K, Molnár Denes *et al*. Diet as moderador in the association of adiposity with inflamatory biomarkers among adolescentes in the HELENA study. Eur J Nutr. 2018.

Recibido: 11/05/2020
Aceptado: 12/09/2020

ARCHIVOS LATINOAMERICANOS DE NUTRICIÓN
Revista de la Sociedad Latinoamericana de Nutrición
Doi: 10.37527/2020.70.4.002

Vol. 70 N° 4, 2020
Artículo Original

Estado nutricional y preferencia del sabor dulce en adultos chilenos

Paula Ledesma Gutiérrez[1], Rocío Martínez Garrido[1], Fanny Flores Sandoval[1], Ana Acuña Dericke[1], Favián Treulen Seguel[1], Luis Bustos Medina[2], Marcell Leonario Rodriguez[1,3].

Resumen: Estado nutricional y preferencia del sabor dulce en adultos chilenos. El dramático aumento de la prevalencia e incidencia de la obesidad sugiere que factores ambientales y cambios en el estilo de vida contribuyen de forma importante a su tendencia epidémica. En humanos, se han reportado diferencias interindividuales en los umbrales de detección y preferencia del sabor dulce, lo que podría afectar la ingesta habitual de azúcares, y por ende al estado nutricional. Objetivo: El presente estudio busca determinar la relación entre el estado nutricional y la preferencia al sabor dulce en la comunidad de un establecimiento de educación superior. Método: Muestra fue constituida por estudiantes, funcionarios y docentes, entre 18 y 60 años, pertenecientes a la Universidad Mayor, Sede Temuco. Para determinar preferencia al sabor dulce se empleó prueba organoléptica que mide grado de satisfacción frente a solución dulce, junto a ello se realizaron mediciones de peso y talla para determinar el Índice de Masa Corporal. Resultados: Muestra final comprendió de 319 personas, de las cuales un 30,1% fueron hombres y 69,9% mujeres. No se observaron diferencias significativas en la preferencia hacia las soluciones con mayor concentración de sacarosa según el estado nutricional. Sin embargo, el modelo predictivo desarrollado arrojó que hombres prefieren las soluciones con mayor concentración de azúcar independiente de la edad y estado nutricional. Conclusiones: Es necesario desarrollar nuevos estudios que permitan aclarar si la preferencia al sabor dulce favorece el desarrollo de obesidad y sobrepeso, o si es la composición nutricional de los alimentos procesados o ultraprocesados, lo que está teniendo un mayor impacto negativo en el estado nutricional de la población. **Arch Latinoam Nutr 2020; 70(4): 247-254.**

Palabras clave: Estado nutricional, sabor dulce, hábitos alimentarios.

Summary: Nutritional status and sweet taste preference in Chilean adults. The dramatic increase in the prevalence and incidence of obesity seems to suggest that environmental factors and lifestyle changes are contributing significantly to the epidemic trend of this pathology. In humans, inter-individual differences in the thresholds of preference of sweet taste have been reported, which could affect habitual sugar intake, and therefore the nutritional status. Objective: The present study seeks to determine the relationship between nutritional status and the preference of sweet taste in the population of a higher education establishment. Method: Sample was constituted by students, officials and teachers between 18 and 60 years, belonging to the Universidad Mayor, Temuco. To determine the perception of the sweet taste, an organoleptic test was used that measures the degree of satisfaction with the sweet solution, along with this, weight and height measurements were made to determine the Body Mass Index. Results: Final sample comprised 319 people, of which 30.1% were men and 69.9% women. No significant differences were observed in the preference for solutions with a higher concentration of sucrose according to nutritional status. However, a predictive model developed showed that men prefer the solutions with the highest concentration of sugar regardless of age and nutritional status. Conclusions: It is necessary to develop new studies to clarify whether the preference for sweet taste favors the development of obesity and overweight, or if it is the nutritional composition of processed or ultraprocessed foods, which is having a greater negative impact on the nutritional status of the population. **Arch Latinoam Nutr 2020; 70(4): 247-254.**

Key words: Nutritional status, sweet taste, eating habits.

Introducción

El sobrepeso y la obesidad son factores de riesgo para numerosas enfermedades crónicas, entre las que se incluyen la diabetes, las enfermedades cardiovasculares y el cáncer (1).En Chile, de un total de 74,2% de personas con malnutrición por exceso, 39,8% presentan sobrepeso,

[1]Carrera de Nutrición y Dietética, Facultad de Ciencias, Universidad Mayor, Temuco, Chile. [2]Departamento de Salud Pública y CIGES, Facultad de Medicina, Universidad de La Frontera, Temuco, Chile. [3]Centro de Biología Molecular y Farmacogenética, Departamento de Ciencias Básicas, Facultad de Medicina, Universidad de La Frontera, Temuco, Chile.
Autor para la correspondencia: Paula Elisa Ledesma Gutiérrez, email: paula.ledesma@umayor.cl

31,2% obesidad y 3,2% obesidad mórbida. Estas cifras preocupan al país, ya que en comparación con la Encuesta Nacional de Salud 2009-2010, las personas con malnutrición por exceso aumentaron significativamente en las categorías de obesidad y obesidad mórbida en solo 6 años (2,3). Sumado a esto, Chile se posiciona como uno de los mayores consumidores de bebidas azucaradas y productos ultra procesados en el mundo (4), situación que motivó a las autoridades sanitarias y legislativas a proponer nuevas regulaciones en el etiquetado de alimentos. Así es como entra en vigor la ley 20.606 en junio de 2016 (5), iniciativa que ya demostró tener resultados positivos en escolares, población que identifica sellos negros impuestos, además de considerarlos al momento de adquirir alimentos (6). Sin embargo, la regulación de la oferta propuesta por la industria alimentaria es solo una de las aristas a considerar en las estrategias para atenuar el carácter epidémico de la obesidad.

Se considera que la ganancia de peso y su consecuente incremento en la prevalencia del sobrepeso y obesidad a nivel poblacional, se debe al desequilibrio energético del individuo acompañado de un descenso en la actividad física (7–9). El desequilibrio energético, provocado por una sobre ingesta de nutrientes, está presente en individuos con malnutrición por exceso, quienes manifiestan una mayor preferencia por alimentos con alto contenido de azúcares (10). Curiosamente, se han reportado diferencias interindividuales en los umbrales de detección del sabor dulce, lo que podría regular la ingesta habitual de azúcares en la dieta (11). Incluso se ha sugerido que el consumo de sacarosa puede ser parcialmente regulado por un sistema de detección oral, por lo que la confirmación y comprensión de este mecanismo puede ser un factor importante para identificar las razones de la sobre ingesta de energía (12). Si bien, se plantea que el gusto nos asegura el consumo de nutrientes esenciales que se requieren para el funcionamiento y la supervivencia (13)(14), existen respuestas afectivas a los alimentos que conducen a su consumo. Su variación individual podría influir en la elección de alimentos azucarados, promover su consecuente ingesta de forma excesiva, y constituirse como un factor crítico en el desarrollo de enfermedades relacionadas con la dieta, tales como la obesidad (15).

Entendiendo que, la preferencia por el gusto dulce es universal en niños de todo el mundo, y que debe declinar durante la adolescencia media y la adultez (16), su alteración en esta época, donde existe una elevada disponibilidad de alimentos con alta densidad energética, contribuiría a la malnutrición por exceso, o a la mantención de esta (17). Su identificación como factor de riesgo, podría modificar las estrategias dieto terapéuticas actuales, añadiendo elementos antes no considerados. Frente a esto, el objetivo del presente estudio fue determinar si la preferencia del sabor dulce difiere según el estado nutricional en población adulta.

Materiales y métodos

Población de estudio

Estudio transversal realizado en la comunidad universitaria correspondiente a estudiantes, funcionarios y docentes de la Universidad Mayor, Sede Temuco, Chile. Se evaluó una muestra no probabilística por conveniencia de 319 personas. Los sujetos de estudio correspondieron a personas entre 18 años y 60 años, indistintamente del sexo, que quisieron participar de forma voluntaria. Todos firmaron el consentimiento informado aprobado por el Comité Ético Científico de la Universidad Mayor, Sede Temuco. Entre los criterios de exclusión se encuentran:

- Consumo de tabaco, entendiéndose como todo individuo que fume a diario productos que están hechos total o parcialmente con tabaco, sean además para fumar, masticar o succionar. Considerando que componentes del cigarrillo obstaculizan regeneración de papilas gustativas.
- Embarazadas, por la alteración del sabor debido a los cambios hormonales propio del estado fisiológico en cuestión.
- Historia médica o evidencia de condiciones clínicas que podrían alterar el sentido del gusto o la valoración nutricional: hipogeusia, tratamiento de quimioterapia y radioterapia de cabeza o cuello, falla renal o hepática, proceso febril dentro de las 36 horas, etc.
- Diabetes Mellitus o Pre-Diabetes (resistencia a la insulina, intolerancia a la glucosa y glicemia de ayuno alterada).

- Alteraciones cognitivas, que interfieran en la interpretación y análisis de las pruebas sensoriales a utilizar.

Protocolo de intervención:

A cada sujeto que deseó participar voluntariamente de la investigación, se le solicitó leer y firmar el documento de consentimiento informado, así como también completar la encuesta de participación en el proyecto de investigación, previo a la realización de la evaluación nutricional y prueba sensorial. Para establecer la medición de las variables en cuestión, a las personas que participaron en la investigación, se les realizó una evaluación nutricional y una prueba de preferencia, para lo cual tuvieron que cumplir con la siguiente secuencia de actividades:

Evaluación nutricional

- Para determinar el estado nutricional se realizó por método antropométrico a cargo de nutricionista docente en Box de atención nutricional de la Universidad Mayor, sede Temuco, Chile. Con una duración de 10 minutos por cada procedimiento. Para determinar el peso, se procedió a pesar a los voluntarios descalzos, erguidos y con los brazos al costado hasta que balanza digital SECA BMI 804 registrara peso. Respecto a la talla, voluntarios fueron medidos descalzos, erguidos y manteniendo la cabeza en plano de Frankfurt, con los brazos al costado hasta la lectura de medición en tallímetro portátil SECA 213. IMC(18) se calculó mediante la relación entre el peso (kg) dividido por el cuadrado de la talla (cm) y se clasificó a los pacientes en: normopeso (18,5-24,9 kg/m^2), sobrepeso (25-29,9 kg/m^2), obesidad ($\geq$ 30 kg/m^2) y bajo peso ($<$ 18 kg/m^2).

Evaluación Sensorial

- Para determinar la percepción al sabor dulce, se realizó prueba de preferencia de solución dulce a cargo de químico laboratorista en el Laboratorio de Evaluación Sensorial de los Alimentos de la Escuela de Nutrición y Dietética de la Universidad Mayor, sede Temuco. Con una duración de 10 minutos por procedimiento.

  En la prueba se solicitó a los voluntarios sentarse en una estación de evaluación sensorial en la cual había un set de 4 muestras a degustar y 200 cc de agua pura para el enjuague bucal. Cada muestra consistió en 30 mililitros de solución acuosa de sacarosa al 2,5% m/v; 5% m/v; 10% m/v; 15% m/v; codificadas con números de 4 dígitos seleccionados en forma aleatoria. Se entregó a cada sujeto la encuesta de preferencia que incluyó las instrucciones del procedimiento a realizar. El miembro del equipo investigador que dirigió la sesión evaluativa leyó en voz alta las instrucciones para aclarar la ejecución de la evaluación sensorial a realizar:

  - o Deguste las muestras de agua con azúcar en distintas concentraciones. Es importante que mantenga la solución en la boca por 5 segundos. Elimine y enjuague la boca con agua purificada para luego probar la otra solución.
  - o Ordénelas según su preferencia, registrando en el primer lugar la que más le agrade y en el último lugar, la que menos le agrade. No es necesario ingerir las muestras, enjuague su boca con agua pura entre cada muestra.
  - o Usted podrá degustar las muestras las veces que estime conveniente para emitir su juicio evaluativo, sin olvidar realizar un enjuague bucal, con agua pura que le permita eliminar todo rastro de la muestra anterior.
  - o Usted puede expresar en forma voluntaria algún comentario acerca de su respuesta.

Análisis estadístico

Para el procesamiento de los datos se utilizó programa SPSS 23.

Se realizó un análisis descriptivo a través de frecuencias, porcentajes, promedios, desviación estándar, mínimo y máximo. Para la comparación de los porcentajes se utilizó la prueba exacta de Fisher, para los promedios la prueba de ANOVA y comparaciones múltiples de T2 de Tamhane para varianzas distintas. El nivel de significación fue de 5%.

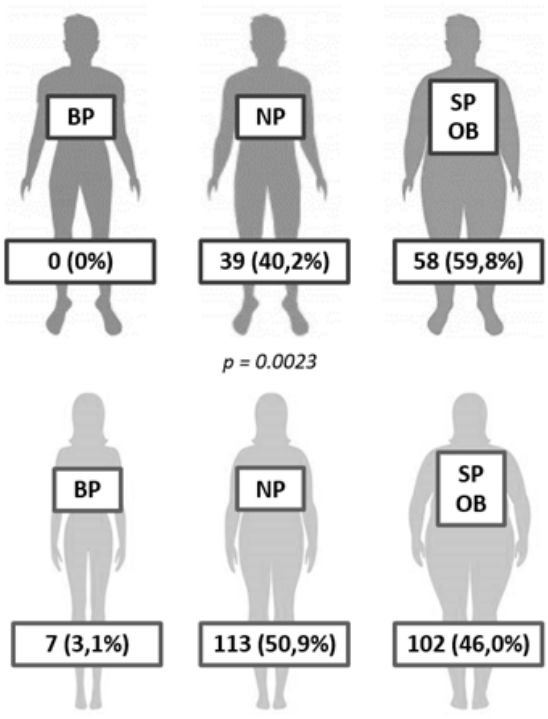
Resultados

La muestra total fue de 319 personas de la comunidad UM, siendo el 69,6% fueron mujeres. El promedio de edad fue de 26,6±11,02 años, con un mínimo de 18 y máximo de 60 años; el promedio de peso fue de 68,5±13,73 kg, mínimo de 41,1 y máximo de 110,7; el promedio de

estatura fue de 1,63±0,09 metros, mínimo de 1,45 y máximo de 1,87 metros, y el promedio de IMC fue de 26±4,34, mínimo de 17,4 y máximo de 45,7 kg/m^2. Se observaron diferencias estadísticamente significativas al comparar el estado nutricional en sus distintas categorías frente al sexo, así como también en función de la edad (Figura 1 y 2).

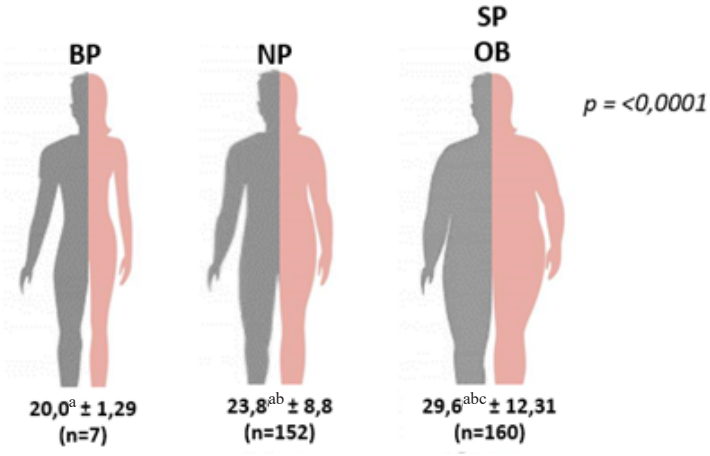
Respecto a las soluciones acuosas con sacarosa en distintas concentraciones, en primera preferencia se observó que un 37,9% eligió la solución al 2,5%, seguida por la solución al 5% (27,59%) y las soluciones entre 10% y 15% (17,24%). En las distintas preferencias no se observaron diferencias estadísticamente significativas entre las concentraciones y la edad (Tabla 1).

Al comparar las soluciones acuosas con sacarosa en relación con el sexo, se observó que en la primera preferencia existieron diferencias significativas, donde el mayor porcentaje de mujeres (43,24%) escogió la concentración al 2,5% de sacarosa, mientras que el mayor porcentaje de hombres (49,48%) escogió las concentraciones al 10 y 15% de sacarosa. En las preferencias 2°, 3° y 4° las concentraciones difieren significativamente entre mujeres y hombres (Tabla 2). Al contrastar el



Prueba Exacta de Fisher

Figura 1: Comparación del estado nutricional según sexo



Prueba de ANOVA y comparaciones múltiples de T2 de Tamhane

Figura 2: Comparación del estado nutricional según edad

Tabla 1: Comparación entre la edad y las distintas preferencias de soluciones acuosas con sacarosa según evaluación sensorial.

Prefe-rencias	Concentra-ciones	Promedio ± Des. Est.	n (%)	p
1°	2,5%	27,2 ± 11,83	121 (37,93)	0,5339
	5%	25,5 ± 10,28	88 (27,59)	
	10-15%	26,8 ± 10,76	110 (34,48)	
2°	2,5%	25,5 ± 9,93	71 (22,33)	0,590
	5%	26,7 ± 11,12	152 (47,80)	
	10-15%	27,2 ± 11,71	95 (29,87)	
3°	2,5%	25,5 ± 9,86	62 (19,5)	0,5411
	5%	27,6 ± 12,07	67 (21,07)	
	10-15%	26,6 ± 11,03	189 (59,43)	
4°	2,5%	27,5 ± 11,67	65 (20,38)	0,7497
	5%	26,9 ± 9,34	15 (4,7)	
	10-15%	26,4 ± 11,00	239 (74,92)	

Prueba de Anova

Tabla 2: Preferencias de soluciones acuosas según sexo.

Preferencias	Concentraciones	Mujer n (%)	Hombre n (%)	p
1°	2,5%	96 (43,24)	25 (25,77)	0,001
	5%	64 (28,83)	24 (24,74)	
	10-15%	62 (27,93)	48 (49,48)	
2°	2,5%	50 (22,62)	21 (21,65)	0,046
	5%	114 (51,58)	38 (39,18)	
	10-15%	57 (25,79)	38 (39,18)	
3°	2,5%	40 (18,10)	22 (22,68)	0,004
	5%	37 (16,74)	30 (30,93)	
	10-15%	144 (65,16)	45 (46,39)	
4°	2,5%	36 (16,22)	29 (29,9)	0,019
	5%	10 (4,50)	5 (5,15)	
	10-15%	176 (79,28)	63 (64,95)	

Prueba Exacta de Fisher

estado nutricional con las soluciones acuosas en distintas concentraciones de sacarosa, no se informó diferencia significativa en ninguna categoría de preferencia (Tabla 3).

Al realizar modelo de regresión ordinal, la percepción al gusto dulce en primera preferencia en función del estado nutricional, sexo y edad, mejora el ajuste de forma significativa. Se aplicó estadística de Chi-cuadrado de Pearson para el modelo y para la base de la desviación, encontrando que los datos observados son compatibles con el modelo ajustado. Al desarrollar prueba Nagelkerke indicó que el 5,1% de la variabilidad explicada por el modelo para la percepción al gusto dulce en primera preferencia estaba asociada a los factores de predicción (estado nutricional, sexo y edad). Sin embargo, al momento de establecer parámetros, se reportó que la edad y el estado nutricional correspondían a variables que tienen poca significancia estadística en el modelo presentado, por lo tanto, fueron eliminadas. Frente a esto, el modelo final sería entre la primera preferencia por las soluciones azucaradas y el sexo de los participantes, donde se mejoró el ajuste de forma significativa respecto al modelo anterior que solo consideraba la constante ($p<0.0001$). Se aplicò prueba estadística Chi-cuadrado de Pearson ($p=0,567$) y Desviación ($p=0,565$) para confirmar adecuación. Al aplicar el modelo planteado se obtuvo que las mujeres tienen 1,78 veces más probabilidad de elegir una solución al 2,5% en

Tabla 3: Comparación entre el estado nutricional y preferencia de soluciones con sacarosa en distintas concentraciones.

Preferencias	Concentraciones	Bajo peso n (%)	Normal n (%)	Sobrepeso n (%)	Obeso n (%)	p
1°	2,5%	3 (42,86)	56 (36,84)	44 (36,97)	18 (43,90)	0,979
	5%	2 (28,57)	44 (28,95)	33 (27,73)	9 (21,95)	
	10%-15%	2(28,57)	52 (24,21)	42 (35,29)	14 (34,15)	
2°	2,5%	2 (28,57)	29 (19,21)	28(23,53)	12 (29,27)	0,598
	5%	4 (57,14)	72 (47,68)	60 (50,42)	16 (39,02)	
	10%-15%	1 (14,29)	50 (33,11)	31 (26,05)	13 (31,71)	
3°	2,5%	0	31 (20,53)	24 (20,17)	7 (17,07)	0,599
	5%	1 (14,29)	35 (23,18)	20 (16,81)	11 (26,83)	
	10%-15%	6 (85,71)	85 (56,29)	75 (63,03)	23 (56,10)	
4°	2,5%	2 (28,57)	35 (23,03)	24 (20,17)	4 (9,76)	0,139
	5%	0	4 (2,63)	6 (5,04)	5 (12,20)	
	10%-15%	5 (71,43)	113(71,34)	89 (74,79)	32 (78,05)	

Tabla 4: Modelo final de regresión ordinal para la percepción al gusto dulce en primera preferencia (op1)

		Estimaciones de parámetro					Intervalo de confianza al 95%	
		Estimación	Error estándar	Wald	gl	Sig.	Límite inferior	Límite superior
Umbral	[op1= 2,5%]	-1,124	0,205	30,059	1	0,000	-1,525	-0,722
	[op1= 5%]	0,054	0,194	0,078	1	0,780	-0,327	0,435
Ubicación	[sexo=Mujer]	-0,868	0,230	14,283	1	0,000	-1,319	-0,418
	[sexo=Hombre]	0a	.	.	0	.	.	.

Función de enlace: Logit.
a. Este parámetro está establecido en cero porque es redundante.
Del modelo de regresión ordinal final se tiene la ecuación del riesgo acumulativo siguiente:

$$P(op1 \leq g) = \frac{1}{1+e^{-\left(\delta_g - \beta_1(sexo=Mujer)\right)}}$$

g = Soluciones acuosas con sacarosa al 2,5%; 5%; 10-15%
α =Estimación del modelo para cada solución a comparar
β = Estimación del modelo para las mujeres

primera preferencia en relación con los hombres. Al comparar la solución al 5%, las mujeres tienen 1,04 veces más probabilidad que los hombres y la solución que está entre el 10% y 15%, los hombres tienen 1,71 veces más probabilidad de escogerla que las mujeres (Tabla 4).

Discusión

Considerando el carácter pandémico de la obesidad es necesario identificar todas las variables que podrían incidir en el desarrollo de esta patología, y establecer estrategias que nos permitan prevenir su aparición. Respecto a la percepción al sabor dulce, podría tener un efecto en las elecciones dietéticas de los individuos y con ello incidir en la predisposición a la obesidad. Recientes publicaciones han reportado que en poblaciones adolescentes especificas el umbral de sabor difiere dependiendo del IMC, siendo su umbral más bajo para la malnutrición por exceso (17), y que incluso define los hábitos alimentarios, número de comidas diarias, además de la preferencia por bocadillos dulces (19). En adultos alemanes también se ha notificado que personas con obesidad presentan umbrales menores para sacarosa y cloruro de sodio, frente al umbral para estos sabores de población con estado nutricional normal (20). Sin embargo, los resultados son inconsistentes debido a que varían dependiendo del grupo etario y origen de la muestra, además de que en los ensayos donde se encuentra asociación el número de sujetos evaluados es bastante pequeño o va acompañado de intervenciones especificas (21,22).

Este estudio, el primero de su naturaleza a nivel nacional, indica que la población con malnutrición por exceso no posee una mayor preferencia al sabor dulce frente a sujetos normales, proporcionando datos que deberían ser confirmados con muestras mayores a la analizada y que representen la heterogeneidad poblacional de Chile. Además, sería importante evaluar si la ingesta de alimentos previo a las mediciones puede influir en los resultados, siendo una limitante del presente trabajo. Comparaciones con otras muestras locales no son posibles, debido a la falta de estudios de este tipo. A la fecha solo existen reportes de tesis de pregrado no publicadas, donde consideran población infantil con condiciones patológicas (23).

Una de las particularidades del presente estudio es que el sexo masculino presentó mayor preferencia por los sabores dulces, lo cual podría explicarse por las diferencias hormonales con el sexo femenino (24). Esto contrasta con lo informado en estudiantes universitarios argentinos (25) y en población sana

española (26). Las diferencias con otros estudios podrían ser explicadas por el estado de ánimo de los participantes, el cual no fue analizado y constituye una limitante de nuestro estudio, al igual que las fases del ciclo menstrual en mujeres (27), estado socioeconómico y etnia de los sujetos (28) . Es necesario considerar estas variables en futuros estudios al igual que la definición de grupos etarios más específicos, por la evolución de la percepción al sabor dependiendo de la edad (29). Además, sería interesante comparar preferencia por otros sabores, ya que se han observado correlaciones positivas con gustos opuestos, donde una mayor agudeza para el sabor dulce se asocia significativamente con una mayor preferencia por los sabores amargos (26).

Finalmente, sería interesante verificar si existen diferencias en las preferencias de sabor dulce de origen sintético por sobre el natural, sobre todo considerando el contexto actual donde la industria alimentaria, ya estableció y masificó el uso de edulcorantes artificiales no calóricos, sustancias reconocidas por su potente sabor dulce y que podría modular nuestra ingesta debido a su interacción con los receptores a nivel oral e intestinal, y cada vez a edades más tempranas (30,31).

Conclusiones

La muestra evaluada no presenta diferencias en la preferencia del sabor dulce en función de su estado nutricional. Es necesario realizar más estudios a nivel nacional para descartar este factor como un posible nicho estratégico para la prevención de la obesidad.

Agradecimientos

Agradecemos a toda la comunidad de estudiantes, docentes y trabajadores de la Universidad Mayor, Sede Temuco, por su participación, y a la Vicerrectoría de Investigación de la Universidad Mayor – Sede Temuco que financio esta investigación a través del proyecto FIDUM114.

Financiamiento

Proyecto financiado por Vicerrectoría de Investigación de la Universidad Mayor – Sede Temuco a través de iniciativa FIDUM114.

Conflictos de interés:

Los autores declaran no tener conflictos de interés en relación con el presente artículo.

References

1. Kearns K, Dee A, Fitzgerald AP, Doherty E, Perry IJ. Chronic disease burden associated with overweight and obesity in Ireland: The effects of a small BMI reduction at population level. BMC Public Health. 2014; 14, 143.
2. Ministerio de Salud (MINSAL). Encuesta Nacional de Salud ENS 2009-2010 [Internet]. 2011. Available from: https://www.minsal.cl/portal/url/item/bcb03d7bc28b64dfe040010165012d23.pdf
3. Ministerio de Salud (MINSAL). Encuesta Nacional de Salud 2016-2017 Primeros resultados [Internet]. Departamento de Epidemiología, División de Planificación Sanitaria, Subsecretaría de Salud Pública. 2017. Available from: http://web.minsal.cl/wp-content/uploads/2017/11/ENS-2016-17_PRIMEROS-RESULTADOS.pdf
4. Popkin BM, Hawkes C. Sweetening of the global diet, particularly beverages: Patterns, trends, and policy responses. Lancet Diabetes Endocrinol. 2016;4(2):174–86.
5. Durán-Agüero S, Parra S, Ahumada D, Castro P, Brignardello J, Riedemann K, *et al*. Ley de Alimentos: Una mirada de los nutricionistas y estudiantes de Nutrición y Dietética de Chile. Rev Esp Nutr Humana y Diet. 2017;21(4):327–34.
6. Alaniz-Salinas N, Castillo-Montes M. Evaluation of the front-of-package warning labels of the chilean food law by adults responsible for schoolchildren in the districts of la serena and coquimbo. Rev Chil Nutr. 2020;47(5):738–49.
7. OMS. Obesidad y sobrepeso [Internet]. Obesidad y sobrepeso. 2018. Available from: https://www.who.int/es/news-room/fact-sheets/detail/obesity-and-overweight
8. Harvey-Berino J. Calorie restriction is more effective for obesity treatment than dietary fat restriction. Ann Behav Med. 1999;21(1):35–9.
9. Shields M, Tremblay MS. Sedentary behaviour and obesity. Health Rep. 2008;19(2):19–30.
10. Bray GA, Popkin BM. Dietary sugar and body weight: Have we reached a crisis in the epidemic of obesity and diabetes?: Health be damned! Pour on the sugar. Diabetes Care. 2014;37(4):950–6.
11. Ramos-lópez O, Ojeda-Granados C, Román S, Panduro A. Influencia genética en las preferencias alimentarias. Rev Endocrinol y Nutr. 2013;21(2):74–83.
12. Liu D, Archer N, Duesing K, Hannan G, Keast R. Me-

chanism of fat taste perception: Association with diet and obesity. Prog Lipid Res [Internet]. 2016;63:41–9. Available from: http://dx.doi.org/10.1016/j.plipres.2016.03.002
13. Boesveldt S, de Graaf K. The differential role of smell and taste for eating behavior. Perception. 2017;46(3–4):307–19.
14. Lindemann B. Receptors and transduction in taste. Nature. 2001;413(6852):219–25.
15. Laffitte A, Neiers F, Briand L. Functional roles of the sweet taste receptor in oral and extraoral tissues. Curr Opin Clin Nutr Metab Care. 2014;17(4):379–85.
16. Mennella JA, Bobowski NK, Reed DR. The development of sweet taste: From biology to hedonics. Rev Endocr Metab Disord. 2016;17(2):171–8.
17. Ashi H, Campus G, Klingberg G, Forslund HB, Lingström P. Childhood obesity in relation to sweet taste perception and dental caries – A cross-sectional multicenter study. Food Nutr Res. 2019;63:1–7.
18. Pons Raventos ME, Rebollo Rubio A, Amador Coloma R. Utilidad del índice de masa corporal en pacientes con enfermedad renal crónica. Enfermería Nefrológica [Internet]. 2017;20(4):316–22. Available from: http://search.ebscohost.com/login.aspx?direct=true&db=ccm&AN=127951232&lang=es&site=ehost-live&scope=site
19. Ashi H, Campus G, Bertéus Forslund H, Hafiz W, Ahmed N, Lingström P. The Influence of Sweet Taste Perception on Dietary Intake in Relation to Dental Caries and BMI in Saudi Arabian Schoolchildren. Int J Dent. 2017;2017:14–6.
20. Hardikar S, Höchenberger R, Villringer A, Ohla K. Higher sensitivity to sweet and salty taste in obese compared to lean individuals. Appetite [Internet]. 2017;111:158–65. Available from: http://dx.doi.org/10.1016/j.appet.2016.12.017
21. Ariza AC, Sánchez-Pimienta TG, Rivera JA. Taste perception as a risk factor for childhood obesity. Salud Publica Mex. 2018;60(4):472–8.
22. Nishihara T, Nozaki T, Sawamoto R, Komaki G, Miyata N, Hosoi M, *et al*. Effects of Weight Loss on Sweet Taste Preference and Palatability following Cognitive Behavioral Therapy for Women with Obesity. Obes Facts. 2019;12(5):529–42.
23. Muñoz V, Ternicier S. Tesis de pregrado: Estudio comparativo de los umbrales de percepción y reconocimiento del gusto en niños de 9 a 11 años con y sin respiración bucal de establecimientos particular pagado y municipal de la provincia del Bio Bio, Chile. Universidad del Desarrollo; 2016.
24. Cornier M, Shott ME, Thomas EA, Bechtell JL, Bessesen DH, Tregellas JR, *et al*. The effects of energy balance, obesity-proneness and sex on the neuronal response to sweet taste. Behav Brain Res [Internet]. 2015 Feb;278:446–52. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0166432814006895
25. Torresani ME, Garrido M, Mariel Y, Sainza M, Pedernera A, Simonet LE. Comparative study by gender on taste preferences and emotional profile during intake of university students. Actual. Nutr. 2018;19:104–112.
26. Barragán R, Coltell O, Portolés O, Asensio EM, Sorlí J V., Ortega-Azorín C, *et al*. Bitter, sweet, salty, sour and umami taste perception decreases with age: Sex-specific analysis, modulation by genetic variants and taste-preference associations in 18 to 80 year-old subjects. Nutrients. 2018;10(10):1539.
27. Bedwell JS, Spencer CC, Chirino CA, O'Donnell JP. The Sweet Taste Test: Relationships with Anhedonia Subtypes, Personality Traits, and Menstrual Cycle Phases. J Psychopathol Behav Assess. 2019;41(2):235–48.
28. Pedersen DC, Aarestrup J, Pearson S, Baker JL. Ethnic inequalities in overweight and obesity prevalence among copenhagen schoolchildren from 2002 to 2007. Obes Facts. 2016;9(4):284–95.
29. Carnero JG, Montaña J De, Bernárdez MM. Estudio de la percepción de sabores dulce y salado en diferentes grupos de la población. Nutr. Hosp. 2002;17(5):256–258.
30. Garavaglia MB, García VR, Zapata MME, Rovirosa A, González V, Marco FF, *et al*. Non-nutritive sweeteners: children and adolescent consumption and food sources. Arch Argent Pediatr. 2018;116(3):186–91.
31. Pepino MY. Metabolic effects of non-nutritive sweeteners. Physiol Behav [Internet]. 2015 Dec;152(5):450–5. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0031938415003728

Recibido: 25/07/2020
Aceptado: 15/03/2021

ARCHIVOS LATINOAMERICANOS DE NUTRICIÓN
Revista de la Sociedad Latinoamericana de Nutrición
Doi: 10.37527/2020.70.4. 003

Vol. 70 N° 4, 2020
Artículo Original

Relação entre ganho de peso e consumo de refrigerantes em adolescentes brasileiros do ensino médio

Nayra Suze Souza e Silva[1], Lílian Ferreira Neves[2], Mariana Mendes Pereira[1], Luana Lemos Leão[1], Maria Fernanda Santos Figueiredo Brito[1], Rosângela Ramos Veloso Silva[1], Lucinéia de Pinho[1].

Resumo: Relação entre ganho de peso e consumo de refrigerantes em adolescentes brasileiros do ensino médio A adolescência é um período de diversas transformações, sendo observadas mudanças em relação à nutrição, que podem resultar em excesso de peso corporal. Assim, o estudo teve como objetivo verificar a associação entre excesso de peso corporal e consumo de refrigerante em adolescentes escolares estratificado por sexo. Trata-se de um estudo transversal, realizado com estudantes do ensino médio. Utilizou-se um questionário autoaplicável. A variável desfecho foi a mediana do escore de IMC (eutrófico e excesso de peso) e o consumo de refrigerante foi a variável de exposição principal. Foi utilizado o modelo de Poisson, estratificado por sexo. Participaram do estudo 1.225 adolescentes, 53,4% do sexo feminino e 15,6% consumiam refrigerante diariamente. Nos adolescentes eutróficos não houve associação de consumo de refrigerantes e zIMC. Nos meninos com excesso de peso e consumo de refrigerante mais de duas vezes na semana apresentaram maior chance de estarem acima da mediana de zIMC. Os resultados apontaram que o consumo diário de refrigerantes por adolescentes do sexo masculino com excesso de peso pode aumentar as chances de ter zIMC ainda mais alto, reforçando assim, a necessidade de medidas que visem a redução do consumo de refrigerante. **Arch Latinoam Nutr 2020; 70(4): 255-262.**

Palavras-chave: Peso corporal, índice de massa corporal. refrigerante, fatores de risco, saúde do adolescente.

Summary: Relationship between weight gain and the consumption of soft drinks in Brazilian adolescents of secondary education Adolescence is a period of several changes, with changes related to nutrition, which can result in excess body weight. Thus, the study aimed to verify the association between excess body weight and soft drink consumption in school adolescents stratified by sex. This is a cross-sectional study, carried out with high school students. A self-administered questionnaire was used. The outcome variable was the median BMI score (eutrophic and overweight) and soft drink consumption was the main exposure variable. The Poisson model, stratified by sex, was used. The sample consisted of 1,225 adolescents, which 53.4% were female and 15.6% consumed soft drinks daily. In eutrophic adolescents, there was no association between consumption of soft drinks and the BMI Z-score. In overweight boys and soda consumption more than twice a week, they were more likely to be above the BMI Z-score median. The results showed that the daily consumption of soft drinks by overweight male adolescents may increase the chances of having even higher BMI Z-score, thus reinforcing the need for measures aimed at reducing the consumption of soft drinks. **Arch Latinoam Nutr 2020; 70(4): 255-262.**

Key words: Body weight, body mass index, carbonated beverages, risk factors, adolescent health.

Introdução

A adolescência, período compreendido entre 10 aos 19 anos, contempla diversas transformações fisiológicas, psicológicas e sociais (1). Nessa fase, são observadas mudanças em relação à nutrição, que podem resultar em excesso de peso corporal (2). O sobrepeso consiste no excesso de gordura corporal que causa risco à saúde (3).

O excesso de peso é um grave problema de saúde pública, em virtude da elevada prevalência de obesidade em todo o mundo (4), gradativo em todas as idades, inclusive na adolescência (2). Dados de uma revisão sistemática mostrou que a prevalência de excesso de peso na adolescência varia de 17 a 36% em países da América Latina (5).

[1]Universidade Estadual de Montes Claros – UNIMONTES.
[2]Universidade Federal de Minas Gerais – UFMG.
Autor para la correspondencia: Nayra Suze Souza e Silva. E-mail: nayrasusy@hotmail.com

Diante da Pesquisa Nacional de Saúde do Escolar (PeNSE) foi possível identificar e acompanhar o estado nutricional dos adolescentes brasileiros, com prevalência de 23,81% de excesso de peso entre os adolescentes (6). O excesso de peso ao final da adolescência pode causar prejuízos na saúde na fase adulta (2). Esse estado nutricional pode provocar o desenvolvimento precoce de doenças cardiovasculares, diabetes, síndrome metabólica, depressão e ansiedade (7,8).

O alto consumo de alimentos açucarados também está relacionado ao excesso de peso, em que se destaca o consumo de refrigerantes (9). Dados da PeNSE mostraram que 21,69% dos adolescentes brasileiros consomem refrigerantes diariamente, com consumo maior entre os adolescentes do sexo masculino (6). O elevado consumo de refrigerantes está relacionado ao excesso de peso, colesterol elevado, hipertensão arterial e elevada circunferência abdominal (10).

Embora os malefícios biológicos causados pela associação do consumo de refrigerantes com o excesso de peso já sejam bastante conhecidos na literatura, os resultados e as relações de causalidade são controversos (11,12). Faz-se necessário avaliar a exposição a grupos populacionais e categorias específicas do estado nutricional, já que o desfecho pode ser distinto em cada categoria, sexo e idade, bem como ao contexto social e cultural a que público estudado está inserido (6).

Estudos iniciaram investigações sobre excesso de peso corporal e consumo de refrigerantes em diferentes grupos populacionais (13-16). A realização da investigação direcionada ao ambiente escolar se faz importante por esse espaço apresentar potencial para promover a saúde do adolescente no estímulo à hábitos saudáveis, conforme a Lei de Diretrizes e Bases da Educação, Nº 13.666/2018, que dispõe sobre a inclusão da Educação Nutricional como tema transversal do currículo escolar. Diante disso, o presente estudo teve como objetivo verificar a associação entre excesso de peso corporal e consumo de refrigerante em adolescentes escolares estratificado por sexo.

Métodos

Este estudo faz parte da pesquisa intitulada: "Fatores associados ao uso de drogas entre adolescentes da rede pública de ensino da cidade de Montes Claros, Minas Gerais". Trata-se de um estudo transversal, epidemiológico, analítico, realizado com estudantes do ensino médio da zona urbana do município de Montes Claros, Minas Gerais. A cidade de Montes Claros – MG tinha 38 unidades de escolas públicas da rede estadual com ensino médio, com 12.342 escolares matriculados no ano de 2017.

O tamanho amostral foi definido considerando os seguintes parâmetros: prevalência do evento de interesse em 50%, nível de confiança de 95%, margem de erro de 3%, deff=1,5, e acréscimo de 20% para compensar possíveis perdas. Assim, os cálculos evidenciaram um tamanho amostral de, no mínimo, 1768 escolares. A seleção da amostra foi do tipo probabilística por conglomerados em dois estágios, sendo o primeiro constituído pelas escolas e o segundo pelas turmas das escolas selecionadas. No primeiro estágio, as escolas foram selecionadas por amostragem probabilística proporcional ao tamanho (PPT). No segundo estágio, foi definida por amostragem aleatória simples e selecionada uma fração amostral das turmas em cada uma das escolas sorteadas, estratificadas por turno (matutino, vespertino e noturno). A fração amostral foi definida após o sorteio das escolas. Em cada escola sorteada para participar do estudo, foi levantada a quantidade de turmas do 1º, 2º e 3º ano e seus respectivos turnos. O nome de cada turma foi inserido em uma urna, na qual foi realizado o sorteio de três turmas por escola, sendo uma turma de cada ano de escolaridade, de modo a garantir a proporcionalidade da amostra. Quando a escola sorteada apresentou três ou menos turmas, todas participaram da pesquisa, todos os alunos das turmas sorteadas foram convidados a participar. A coleta de dados ocorreu a partir de maio 2017 a março de 2018, com dias agendados em cada escola.

A pesquisa incluiu alunos de ambos os sexos, com idade entre 14 a 19 anos. Os adolescentes que concordaram em participar da pesquisa apresentaram o TALE (Termo de Assentimento Livre e Esclarecido) e TCLE (Termo de Consentimento Livre e Esclarecido) devidamente assinados. Para este estudo foram excluídos os participantes com os dados de peso e altura ausentes no instrumento de coleta de dados. Desse modo, a amostra final foi constituída por 1107 adolescentes escolares.

Para a coleta de dados, utilizou-se um questionário autoaplicável. O questionário foi preenchido por cada adolescente individualmente. Os alunos correspondentes as turmas sorteadas, eram encaminhados para uma sala separada para responderem o questionário, ao final, o questionário era inserido em uma urna, garantindo o anonimato de cada adolescente.

A variável desfecho do estudo foi o IMC, calculado de acordo com a altura e o peso autorreferidos pelos participantes, por meio da equação IMC= peso (kg)/altura $(m)^2$. O IMC foi categorizado em adolescentes eutróficos e com excesso de peso, classificados em ≤ mediana e > mediana, a partir da distribuição do escore Z (zIMC).

O consumo de refrigerante, variável de exposição principal do estudo, foi avaliada a partir da sua frequência de consumo semanal, variando de nunca a todos os dias da semana. Os adolescentes foram categorizados em dois grupos: consumo de refrigerante até um dia na semana e 2 ou mais dias na semana. As variáveis de ajuste foram: idade (≤ 16, > 16 anos), cor de pele (branca, não branca), ano de escolaridade (1º, 2º e 3º ano), escolaridade do chefe da família (ensino fundamental, ensino médio e superior) e escore de bens e serviços do domicílio (≤ mediana, > mediana). Para a construção do escore de bens e serviços do domicílio foi considerada a posse de televisão, geladeira, fogão, micro-ondas, máquina de lavar, telefone fixo, telefone celular, aparelho de DVD, computador, automóvel, banheiro dentro da casa e presença de empregada doméstica em cinco dias ou mais na semana. Cada item recebeu um peso equivalente à frequência de posse dos bens ou presença do serviço. Os pesos dos respectivos itens foram somados para a obtenção do escore final e, em seguida categorizados em ≤ mediana e > mediana.

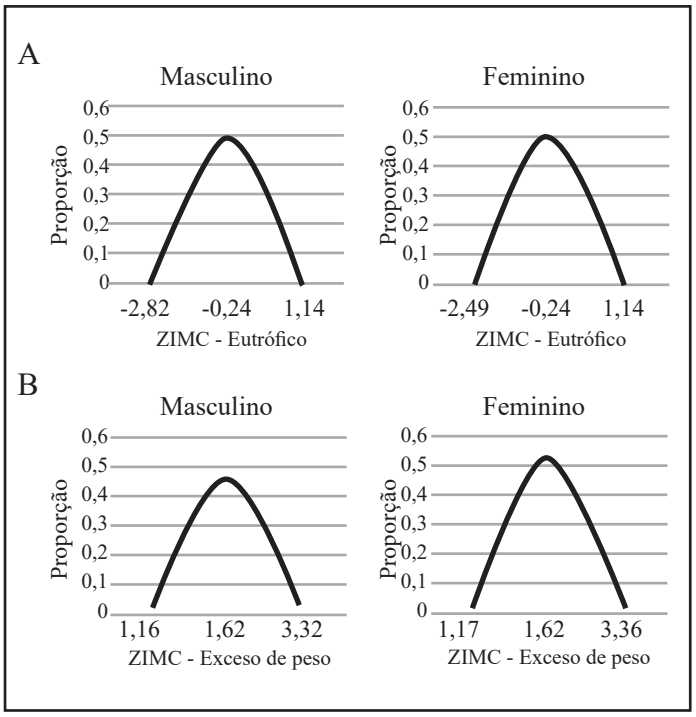


Figura 1. Distribuição do escore Z de índice de massa corporal em mediana, (A) em adolescentes eutróficos (Md= 1,-0,24) e (B) em adolescentes com excesso de peso (Md= 1,64)

Foi realizada análise descritiva das variáveis. Em seguida, procedeu-se a análise bivariada entre consumo de refrigerantes e mediana de zIMC, e foram estimadas as razões de prevalência (RP) bruta e ajustada e seus intervalos de confiança de 95% (IC95%). Utilizou-se modelos de regressão de Poisson com variância robusta estratificados por sexo, estimados separadamente para cada subgrupo de adolescentes — eutróficos e com excesso de peso — e ajustadas pelas potenciais variáveis de confusão. O teste Deviance foi utilizado para avaliar a qualidade dos modelos ajustados. Todas as análises foram realizadas utilizando-se o Statistical Package for Social Sciences (SPSS®), versão 20.0 (17).

O projeto dessa pesquisa foi aprovado pelo Comitê de Ética em Pesquisa da Universidade Estadual de Montes Claros – Unimontes, com parecer consubstanciado nº 2.073.215. Todos os preceitos éticos da resolução 466 de 2012 foram devidamente respeitados.

Resultados

Participaram do estudo 1.225 adolescentes, sendo que 53,4% eram do sexo feminino. A proporção do consumo de refrigerante na frequência de 2 ou mais dias na semana foi de 54,3% (IC 95% = 51,5-57,1)) entre os participantes. A prevalência de excesso de peso foi de 9,6% (n=118), sendo

53,4% no sexo feminino e 46,6% no sexo masculino. Para os adolescentes eutróficos a mediana de IMC neste estudo foi de -0,24 e para os adolescentes com excesso de peso, a mediana foi 1,64 (Figuras 1A e 1B). Na tabela 1 e 2 apresentam características dos adolescentes, estratificadas por sexo e segundo a mediana do IMC em subgrupos de adolescentes eutróficos e com excesso de peso, respectivamente.

Na análise de associação entre zIMC e a frequência de consumo de refrigerantes, observou-se que entre os adolescentes do sexo masculino (p=0,900) e feminino (p=0,188) eutróficos não houve associação significativa (Tabela 3).

Entre os adolescentes do sexo masculino com excesso de peso, o consumo de refrigerantes entre dois ou mais dias da semana esteve associado a aumento na chance 2,18 vezes de estarem acima da mediana de zIMC, quando comparado aos adolescentes com consumo até um dia na semana. A associação permaneceu antes e após o ajuste por idade (p<0,005). Já para o sexo feminino com excesso de peso, não houve associação entre consumo de refrigerantes e zIMC (p=0,280) (Tabela 4).

Tabela 1. Características dos adolescentes segundo mediana do índice de massa corporal em subgrupo de adolescentes eutróficos.

Características	Eutrófico					
	Masculino (%)			Feminino (%)		
	≤ Mediana	> Mediana	p	≤ Mediana	> Mediana	p
Consumo de refrigerante						
Até 1 dia	50,5	49,5	-	47,4	52,6	-
2 dias ou mais	51,4	48,6	0,845	52,9	47,1	0,165
Idade						
≤ 16 anos	58,0	42,0	-	53,4	46,6	-
> 16	42,9	57,1	0,001	46,2	53,8	0,072
Cor de pele						
Branca	61,2	38,8	-	52,3	47,7	-
Não branca	48,2	51,8	0,031	49,8	50,2	0,645
Ano de escolaridade						
1º ano	55,8	44,2	-	52,4	47,6	-
2º ano	49,7	50,3	0,476	52,6	47,4	0,169
3º ano	45,4	54,6	0,061	45,7	54,3	0,160
Escolaridade do chefe						
Ensino fundamental/médio	51,4	48,6	-	50,6	49,4	-
Superior	50,3	49,7	0,823	49,6	50,4	0,796
Escore de bens e serviços						
≤ Mediana	53,0	47,0	-	50,1	49,9	-
> Mediana	49,4	50,6	0,439	50,4	49,6	0,951

Tabela 2. Características dos adolescentes segundo mediana do índice de massa corporal em subgrupo de adolescentes com excesso de peso.

Características	Excesso de peso					
	Masculino (%)			Feminino (%)		
	≤ Mediana	> Mediana	p	≤ Mediana	> Mediana	p
Consumo de refrigerante						
Até 1 dia	32,0	68,0	-	54,5	45,5	-
2 ou mais	66,7	33,3	0,015	43,3	56,7	0,375
Idade						
≤ 16 anos	55,0	45,0	-	36,7	63,3	-
> 16	48,6	51,4	0,653	60,6	39,4	0,064
Cor de pele						
Branca	44,4	55,6	-	57,1	42,9	-
Não branca	52,2	47,8	0,655	46,9	53,1	0,526
Ano de escolaridade						
1º ano	33,3	66,7	-	42,1	57,9	-
2º ano	61,1	38,9	0,146	47,8	52,2	0,346
3º ano	57,9	42,1	0,112	57,1	42,9	0,710
Escolaridade do chefe						
Ensino fundamental/médio	40,6	59,4	-	50,0	50,0	-
Superior	65,2	34,8	0,096	47,4	52,6	0,846
Escore de bens e serviços						
≤ Mediana	46,2	53,8	-	47,1	52,9	-
> Mediana	55,2	44,8	0,504	51,7	48,3	0,713

Tabela 3. Razão de Prevalência (RP) e intervalos de confiança de 95% para a mediana do escore Z do índice de massa corporal e a frequência de consumo de refrigerantes no grupo de adolescentes eutróficos.

Consumo de refrigerante	Masculino RP (IC95%)				Feminino RP (IC95%)			
	Não ajustado	p	Ajustado*	p	Não ajustado	p	Ajustado*	p
Até 1 dia	1	-	1	-	1	-	1	-
2 dias ou mais	1,02 (0,85-1,23)	0,845	1,01 (0,84-1,22)	0,900	1,12 (0,96-1,31)	0,165	1,11 (0,95-1,30)	0,188

RP: razão de prevalência; IC95%: intervalo de confiança de 95%; *ajustado por idade

Tabela 4. Razão de Prevalência (RP) e intervalo de confiança de 95% para a mediana do escore Z de índice de massa corporal e a frequência de consumo de refrigerantes no grupo de adolescentes com excesso de peso.

Consumo de refrigerante	Masculino RP (IC95%)				Feminino RP (IC95%)			
	Não ajustado	p	Ajustado*	p	Não ajustado	p	Ajustado*	p
Até 1 dia	1	-	1	-	1	-	1	-
2 dias ou mais	0,49 (0,28-0,87)	0,015	2,18 (1,28-3,71)	0,004	1,25 (0,77-2,03)	0,375	0,77 (0,48-1,24)	0,280

RP: razão de prevalência; IC95%: intervalo de confiança de 95%; *ajustado por idade

Discussão

Esse estudo teve como objetivo analisar a associação entre o excesso de peso corporal e consumo de refrigerante em adolescentes escolares. Dessa forma, verificou-se que entre os adolescentes do sexo masculino com excesso de peso, o consumo de refrigerantes entre dois ou mais dias da semana esteve associado ao aumento da chance desses adolescentes estarem acima da mediana de zIMC, quando comparado aos adolescentes com consumo até um dia na semana.

A adolescência é o período no qual transformações intensas ocorrem. O indivíduo está definindo e aprimorando sua identidade, estilo de vida e desenvolvendo preocupações ligadas ao corpo e à aparência (18). Essas características são importantes para a formação de seus hábitos e comportamento alimentar. Dessa forma, nem todos adolescentes adotam os níveis recomendados de comportamentos positivos à saúde. Podem ser observadas condutas prejudiciais; por exemplo, baixa ou ausente aderência à prática de atividades físicas, maior tempo de uso de telas - computadores/televisão/telefone, tabagismo e elevado consumo de alimentos ultraprocessados (19).

Chaves *et al*. (6) avaliaram a associação entre consumo de refrigerantes e o zIMC em adolescentes eutróficos e com excesso de peso. Assim como no presente estudo, Chaves *et al*. (6) também verificaram que nos meninos eutróficos, o consumo de refrigerantes esteve associado à maior chance de estar nos tercis mais altos de zIMC comparados aos que não consumiam. Katzmarzyk *et al*. (20) também encontraram resultados similares. Esse resultado se dá possivelmente pelo fato de que os adolescentes do sexo masculino se preocupem menos com sua imagem corporal em comparação às meninas. Além de que elas tendem também a ser mais preocupadas com a saúde (21, 22).

Uma metanálise analisou a associação entre ingestão de bebidas açucaradas ou leite e IMC em adolescentes. Foi observado que em 55% dos 20 estudos utilizados no trabalho apresentaram associação entre a ingestão dessas bebidas e aumento do IMC. Em se tratando de refrigerantes, 100% dos estudos relataram associação com aumento do IMC (23).

A relação entre obesidade e consumo de bebidas açucaradas por adolescentes vem sendo apontada na literatura internacional. Hwang *et al*. (24) avaliaram a relação entre o consumo de refrigerantes e obesidade em crianças e adolescentes coreanas. Foi observado que a razão de chances de prevalência de obesidade tende a ser maior para aqueles que fazem consumo de refrigerantes do que para outros tipos de bebidas. Em outro estudo realizado na Nigéria, verificou-se a prevalência de sobrepeso e obesidade de 21,3% e 14,0%, respectivamente. Dentre os indivíduos obesos entrevistados, apenas um não consumia refrigerantes regularmente (25).

É importante salientar que os refrigerantes e bebidas açucaradas apresentam alto índice glicêmico, o que acarreta um estado crônico de hiperglicemia e hiperinsulinemia, o que pode impactar no aumento de peso e gordura corporal. Além disso, por serem alimentos líquidos, saciam menos que os sólidos, influenciando a compensação energética no controle da ingestão alimentar, e pode resultar em ingestão excessiva de calorias, favorecendo o ganho de peso (26).

O estudo apresenta algumas limitações. A primeira

é o desenho do estudo, uma vez que os estudos transversais impossibilitam inferir causalidade, não sendo possível afirmar em qual momento do tempo ocorreu a exposição e o desfecho. A segunda limitação é com relação a variável IMC que foi criada a partir do auto relato dos adolescentes referente ao peso e estatura dos mesmos. A adolescência é considerada uma faixa etária identificada pelo constante desenvolvimento físico e altas prevalências de auto percepção negativa da imagem corporal, favorecendo assim, a subestimação dos dados (23). No entanto, um estudo comparou medidas auto referidas e as aferidas, demonstrando bons índices de confiabilidade para utilização em estudos epidemiológicos (27). E finalmente, não houve a quantificação das bebidas, sendo quantificada apenas a frequência de consumo das bebidas.

Conclusão

Considerando a adolescência como um período crítico na vida do indivíduo, é importante ressaltar que a prevalência de obesidade nessa população é particularmente preocupante, não somente pelos impactos negativos na saúde já amplamente conhecidos. O presente estudo também mostrou associação positiva entre consumo de refrigerantes e as categorias mais altas de zIMC em adolescentes do sexo masculino com excesso de peso. Sugere-se assim, implementação de estratégias capazes de diminuir a prevalência do excesso de peso e do consumo de refrigerantes a fim de melhorar a qualidade da alimentação e reduzir a incidência de doenças crônicas. Os programas de educação nutricional devem pensar em como priorizar o consumo de outras bebidas, além de orientar a comercialização desses produtos nas escolas, com o objetivo de estimular o consumo de bebidas mais saudáveis nessa faixa etária.

Agradecimentos

Agradecemos à Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – CAPES pela concessão de Bolsas.

Referências

1. World Health Organization. Child and adolescent health and development: progress report 2009: highlights. Geneva: WHO; 2010.
2. Bloch KV, Klein CH, Szklo M, Kuschnir MCC, Abreu GDA, Barufaldi LA, *et al*. ERICA: prevalências de hipertensão arterial e obesidade em adolescentes brasileiros. Rev Saúde Pública. 2016; 50: 1-13. Doi: https://doi.org/10.1590/S01518-8787.2016050006685
3. World Health Organization. Obesity and Overweight. World Obesity Federation: WHO; 2013.
4. Barroso WKS, Souza ALL. Obesity, Overweight, Body Adiposity and Cardiovascular Risk in Children and Adolescents. Obesidade, Sobrepeso, Adiposidade Corporal e Risco Cardiovascular em Crianças e Adolescentes. Arq Bras Cardiol. 2020;115(2):172-173. doi:10.36660/abc.20200540
5. Rivera JÁ, de Cossío TG, Pedraza LS, Aburto TC, Sánchez TG, Martorell R. Childhood and adolescent overweight and obesity in Latin America: a systematic review. Lancet Diabetes Endocrinol. 2014; 2(4): 321- 32. Doi: https://doi.org/10.1016/S2213-8587(13)70173-6
6. Chaves OC, Velasquez-Melendez G, Costa DADS, Caiaffa WT. Consumo de refrigerantes e índice de massa corporal em adolescentes brasileiros: Pesquisa Nacional de Saúde do Escolar. Rev bras epidemiol. 2018; 21: e180010. Doi: https://doi.org/10.1590/1980-549720180010.supl.1
7. Aguirre MDJX, Aguirre MAC, de Medeiros Carvalho GK, da Costa Silva WS, de Lima VB, de Araújo Gomes LK. Marcadores de consumo alimentar e excesso de peso em adolescentes do Brasil. Anais. 2019; 1-12.
8. Pryor L, Brendgen M, Boivin M, Dubois L, Japel C, Falissard B, *et al*. Overweight during childhood and internalizing symptoms in early adolescence: The mediating role of peer victimization and the desire to be thinner. J Affect Disord. 2016; 15(202): 203-209. Doi: https://doi.org/10.1016/j.jad.2016.05.022
9. Almeida LS, Moraes Filho IM, Cangussu DDD, Proença MFR, Lisboa RC, Coutinho VF. Consumo de refrigerantes entre adolescentes e o estado nutricional. Rev Inicia Cien Exten. 2018; 1: 342-346.
10. Selfstrom D, Marques AYC, Schlosser KC, Fernandes EJ, Saraiva IC, Ramalho JB. Consumo de bebidas alcoólicas e refrigerantes e perfil nutricional de adolescentes. 2016; v. 8 n. 2: Anais do 8º Salão Internacional de Ensino, Pesquisa e Extensão da UNIPAMPA :Salão de Pesquisa
11. Keller A, Bucher Della Torre S. Sugar-sweetened beverages and obesity among children and adolescents: a review of systematic literature reviews. Child obes. 2015; 11(4): 338-346. Doi: https://doi.org/10.1089/chi.2014.0117
12. Della Torre SB, Keller A, Depeyre JL, Kruseman M. Sugar-sweetened beverages and obesity risk in children and adolescents: a systematic analysis on how methodological quality may influence conclusions. Journal of the Academy of Nutrition and Dietetics. 2016; 116(4): 638-659. Doi: https://doi.org/10.1016/j.jand.2015.05.020

13. Araujo AMD, Brandão SADSM, Araújo MADM, Frota KDMG, Moreira-Araujo RSDR. Overweight and obesity in preschoolers: Prevalence and relation to food consumption. Rev Assoc Med Bras. 2017; 63(2): 124-133. Doi: https://doi.org/10.1590/1806-9282.63.02.124
14. Bezerra IN, Alencar ESD. Association between excess weight and beverage portion size consumed in Brazil. Rev Saude Publica. 2018; 52: 21. Doi: https://doi.org/10.11606/S1518-8787.2018052000082
15. Sánchez L, Quispe E, Medina ML. Consumo de bebidas en niños de cuarto año escolar y su relación con sobrepeso-obesidad. Arch Pediatr Urug. 2018; 89(6): 389-389. Doi: http://dx.doi.org/10.31134/ap.89.s1.3
16. Fontes AS, Pallottini AC, Vieira DADS, Fontanelli MDM, Marchioni DM, Cesar CL, *et al*. Demographic, socioeconomic and lifestyle factors associated with sugar-sweetened beverage intake: a population-based study. Rev bras epidemiol. 2020; 23: e200003. Doi: https://doi.org/10.1590/1980-549720200003
17. International Business Machines Corporation. Statistical Package for Social Sciences. Version 20.0 [software]. Chicago: IBM; 2016.
18. Brasil. Ministério da Saúde (MS). Orientações básicas de atenção integral à saúde de adolescentes nas escolas e unidades básicas de saúde. Brasília: Editora do Ministério da Saúde; 2013.
19. Palla L, Chapman A, Beh E, Pot G, Almiron-Roig E. Where Do Adolescents Eat Less-Healthy Foods? Correspondence Analysis and Logistic Regression Results from the UK National Diet and Nutrition Survey. Nutrients. 2020; 12(8): E2235. Doi: https://doi.org/10.3390/nu12082235
20. Katzmarzyk PT, Broyles ST, Champagne CM, Chaput JP, Fogelholm M, Hu G, *et al*. Relationship between Soft Drink Consumption and Obesity in 9–11 Years Old Children in a Multi-National Study. Nutrients. 2016; 8(12): E770. Doi: https://doi.org/10.3390/nu8120770
21. Perkins JM, Perkins HW, Craig DW. Misperceptions of peer norms as a risk factor for sugar-sweetened beverage consumption among secondary school students. J Am Diet Assoc. 2010; 110: 1916–1921. Doi: 10.1016/j.jada.2010.09.008
22. Branco LM, Hilário MOE, Cintra IP. Percepção e satisfação corporal em adolescentes e a relação com seu estado nutricional. Rev Psiq Clín. 2006; 33(6): 292-6. http://dx.doi.org/10.1590/S0101-60832006000600001
23. Café ACC, Lopes CAO, Novais RLR. Intake of sugar-sweetened beverages, milk and its association with body mass index in adolescence: A Systematic Review. Rev Paul Pediatr. 2018; 36(1): 91-99. Doi:10.1590/1984-0462/;2018;36;1;00010
24. Hwang SB, Park S, Jin GR, Jung JH, Park HJ, Lee SH, *et al*. Trends in Beverage Consumption and Related Demographic Factors and Obesity among Korean Children and Adolescents. Nutrients. 2020; 12(9): E2651. Doi: https://doi.org/10.3390/nu12092651
25. Eseigbe P, Moses LA, Onuoha FM, Ibrahim BY, Eseigbe EE. Risk Factors Associated with Adolescent Obesity in an Urban Area, North-West Nigeria. West Afr J Med. 2020; 37(4): 407-411.
26. Mourão DM, Bressan J. Influência de alimentos líquidos e sólidos no controle do apetite. Rev Nutr. 2009; 22(4): 537-47. Doi: http://dx.doi.org/10.1590/S1415-52732009000400009
27. Pursey K, Burrows TL, Stanwell P, Collins CE. How accurate is web-based self-reported height, weight, and body mass index in young adults? J med Internet Res. 2014; 16(1): e4. Doi: 10.2196/jmir.2909

Recibido: 27/11/2020
Aceptado: 22/03/2021

ARCHIVOS LATINOAMERICANOS DE NUTRICIÓN
Revista de la Sociedad Latinoamericana de Nutrición
Doi: 10.37527/2020.70.4.004

Vol. 70 N° 4, 2020
Artículo Original

Stages of change in the purchase of ultra-processed snacks among university students after the implementation of the chilean food law; a multi-center study

Samuel Durán Agüero[1], Jaime Silva Rojas[2], Astrid Caichac[3], Jacqueline Araneda[4], Waleska Willson Rojas[5], Rodrigo Buhring[6], Viviana Pacheco[7], Claudia Encina[8], Danay Ahumada[9], Marcelo Fernández-Salamanca[10], Ana Maria Neira[11], Paola Aravena Martinovic[12], Pía Villarroel[13], Eloína Fernández[13], Jessica Moya[14].

Summary: Stages of change in the purchase of ultra-processed snacks among university students after the implementation of the Chilean food law; a multi-center study. The Objective is to determine the stages of change in the behavior of university students regarding the purchase of ultra-processed snacks consumed. Multi-center study (14 Chilean universities). The participants (4,807 students) evaluated were applied a survey to determine the stage of change of behavior regarding the purchase of foods with warning signs. The students were evaluated and classified as (a) Nutrition Students, (b) Healthcare-related Students and (c) Other degree Students. More than 90% of the students were aware of the food regulation and knew the warning signs. More than 60% of Healthcare-related and Other degree students are in the stage of pre-contemplation or contemplation regarding purchase intent of sugary drinks, juices, cookies, sweet snacks and potato chips; this value is twice the percentage of Nutrition students in this stages (Chi², p<0.001). In conclusion there is a high proportion of pre-contemplation and contemplation with respect to purchase intent among the students. **Arch Latinoam Nutr 2020; 70(4): 263-268.**

Key words: Ultra-processed, sugary drinks, front-of-package labeling, university students, stages of change.

Resumen: Etapas de cambio en la compra de colaciones ultraprocesadas en estudiantes universitarios posterior a la implementación de la ley chilena de alimentos: estudio multicéntrico. Determinar las etapas de cambio en el comportamiento de los estudiantes universitarios con respecto a la compra de colaciones ultraprocesadas. Estudio Multicéntrico (14 universidades chilenas). A los participantes (4.807 estudiantes) se les aplicó una encuesta para determinar el cambio en el comportamiento con respecto a la compra de alimentos con sellos de advertencia. Los estudiantes se clasificaron como (a) estudiantes de nutrición, (b) estudiantes del área de la salud y (c) estudiantes de otras carreras. Se evaluaron. Más del 90% de los estudiantes conocían la regulación alimentaria y conocían las señales de advertencia. Más del 60% de los estudiantes de la salud y de otras carreras se encuentran en la etapa de pre-contemplación o contemplación con respecto a la intención de compra de bebidas azucaradas, jugos, galletas, bocadillos dulces y papas fritas; Este valor es el doble del porcentaje de estudiantes de nutrición en estas etapas (Chi², p <0,001). Se concluye que existe una alta proporción de pre-contemplación y contemplación con respecto a la intención de compra entre los estudiantes universitarios. **Arch Latinoam Nutr 2020; 70(4): 263-268.**

Palabras clave: Ultraprocesado, bebidas azucaradas, etiquetado frontal, estudiantes universitarios, etapas de cambio.

[1]Escuela de Nutrición y Dietética. Facultad de Ciencias para el Cuidado de la Salud. Universidad San Sebastian. Chile. [2] Carrera de Nutrición y Dietética, Facultad de Ciencias de la Salud, Universidad de Tarapacá. [3]Carrera de Nutrición y Dietética, Universidad Autónoma de Chile, Chile. [4]Departamento de Nutrición y Salud Pública, Facultad de Ciencias de la Salud y de los Alimentos, Universidad del Bío-Bío, Chillán, Chile. [5]Escuela de Nutrición y Dietética. Facultad de Ciencias de la Salud. Universidad de Talca. Chile. [6]Departamento de Salud Pública. Facultad de Medicina. Universidad Católica de la Santísima Concepción. Chile. [7]Departamento Cs. de los Alimentos y Nutrición, Facultad Ciencias de la Salud, Universidad de Antofagasta. Chile. [8]Escuela de Nutrición y Dietética. Facultad de Salud, Universidad Santo Tomás, Sede Viña del Mar. Chile. [9]Departamento de Procesos Diagnósticos y Evaluación, Facultad de Ciencias de la Salud, Universidad Católica de Temuco. Chile. [10]Departamento de Nutrición y Dietética, Facultad de Farmacia, Universidad de Concepción.Chile. [11]Escuela de Nutrición y Dietética, Facultad de Ciencias de la Salud. Universidad Bernardo O´Higgins. Chile. [12]Carrera de Nutrición y Dietética. Facultad de Ciencias de la Salud. Universidad de Magallanes. Chile. [13]Escuela de Nutrición y Dietética, Facultad de Ciencias, Universidad Mayor, Chile.
Autor para la correspondencia: Jessica Moya, email: jessica.moya@uss.cl

Introduction

Chile is one of the largest consumers of ultra-processed foods at the global level, representing 28.6% of total calorie intake and 58% of added sugars (1-2); in addition, Chile ranks first in the world for the consumption of sugary drinks (3). Ultra-processed foods are ready-to-eat or ready-to-drink formulations.These foods consist of refined substances, with carefully combined sugars, salt, fats and various additives. Ultra-processed foods include sugary drinks, snacks and "fast foods" (4).

There is an increasingly higher group of the population of interest; such as university students; this is explained by the size of university population in Chile, being 1 million students in a universe of 17,574,003 inhabitants (5). These students prefer to consume ultra-processed snacks above a different type of food (6).

Consumption of ultra-processed snacks has been related to weight gain and non-communicable diseases (7). During their time at university, students take responsibility for their diet for the first time and usually consume these foods in greater quantities; therefore, this is a critical period for the development of habits that will have an impact on their future health (8).

In response to the high consumption of ultra-processed foods, the Law 20,606 about “Food nutritional composition and food advertising” was formulated in Chile. This law has 3 main concepts: (a) Ban on the sale of ultra-processed foods in schools, (b) Ban on advertising aimed at 14 years old and younger and (c) Mandatory front-of-package warning labels, in accordance with Decree 13/2015 (9). Front-of-package labeling consists of 4 black octagons with white letters; these figures warn about the presence of 4 critical nutrients (calories, saturated fats, sugars and sodium). Despite this law was implemented for the first time more than one year ago, there has not been an assessment of the changes in the behavior of university students regarding the ultra-processed snacks they frequently consume. Therefore, the aim of this study is to determine the stages of change in the behavior of university students regarding the purchase of ultra-processed snacks consumed usually during their study hours.

Methods

For this analytical, cross-sectional and multi-center study, researchers surveyed students using Google Forms; participants belonged to 14 universities with headquarters in Northern, Central and Southern Chile. In order to calculate the sample size, the population of university students in Chile was used as a reference. The confidence level was set at 95% with an error rate of 3%; the result was a sample of 1,067 students (the final sample consisted of 4,807 students) (Table 1). Every participant was asked tosign an informed consent form before the interview. The time of application of the questionnaire was 1 month. This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the Ethics Committee of the Facultad de Ciencias Para el Cuidado de la Salud de la Universidad San Sebastian. Written informed consent was obtained from all subjects.

Inclusion criteria were: university students aged 18 to 40, male or female, Chilean. Exclusion criteria were: people who did not agree to be interviewed, had a visual impairment or were receiving nutritional treatment.

Each subject was asked about his/her gender, age, weight, height and his/her plan of studies, being classified as (a) Nutrition Students, (b) Healthcare-related Students and (c) Other degree Students. During the second part of the interview, participants were asked if they consumed snacks with warning signs; 10 mass consumption foods with 1 or more warning signs were chosen for this item (sugary drinks, juices, sweet cookies, sweet snacks and potato chips). If the person was a consumer of the snacks with warning signs, researchers asked 2 questions related to his will to change his behavior: (a) Having scores ranging from 1 to 10 (being 1 not important at all and 10 very important), Which is the degree of importance for you to stop consuming certain food?; (b) Having scores ranging from 1 to 10 (being 1 not confident at all and 10 very confident). How confident do you feel about stoppingthe consumption of certain food?. Questions a and b were adapted by Fleta Y. and Gimenez J. from the model created by the American College of Sports Medicine and the

Table 1: General Characteristics of the Sample

	Nutrition (n=1028)	Healthcare-related (n=1817)	Other degrees (n=1962)	Total
Age (years)	22.5 ± 3.5	22.5 ± 3.9	21.9 ± 3.0	22.2 ±3.5
Weight (kg)	60.8 ±10.2	68.4 ± 14.1	65.0 ± 12.6	65.4 ±13.1
Height (m)	1.62 ± 0.07	1.67 ± 0.09	1.64 ± 0.08	1.65 ± 0.09
BMI (kg/m^2)	23.1 ± 3.01	24.5 ± 4.2	24.1 ± 4.0	24.0 ± 3.9
	number (%)	number (%)	number (%)	number (%)
Are you aware of the new food law in Chile? (Yes)	1026 (99.8)	1804 (99.2)	1975 (99.1)	4475 (99.3)
Do you know that this law allows the identification of those foods containing a high amount of certain nutrients? (yes)	1024 (99.6)	1769 (97.3)	1915 (97.6)	4708 (97.9)
Do you know the sign that foods with high quantities of saturated fats, sodium, sugars and calories have? (yes)	1014 (98.6)	1733 (95.3)	1889 (96.2)	4636 (96.4)
Do you consume foods with warning signs? (yes)	914 (88.9)	1687 (92.8)	1855 (94.5)	4456 (92.7)

classical Prochaska model to assess the stages of change, using the variables confidence and importance that are part of motivation (10,11). Recently, scales for assessing importance and confidence have been recognized by the American Academy of Nutrition and Dietetics as being very effective in achieving changes in eating behaviors (12). Scores obtained are crossed in a grid to determine the stage of change of the subject. Pre-contemplation: the subject does not intend to change his/her behavior. Contemplation: the person expresses interest in changing his/her behavior and adopting a new habit, but within the next 6 months. Preparation: The person is willing to adopt a habit within the next 30 days and has also incorporated certain habits or isolated actions leading to change his/her behavior. Action: The person adopted a behavior less than 6 months ago. Maintenance: The person has maintained the behavior for more than 6 months. The final classification is obtained by combining the two scales, therefore, the score required to diagnose each stage must reach a minimum in both scales: Pre-contemplation: 1 to 3 points; Contemplation: 3 to 6 points; Preparation: 6 points; Action: 7 points; Maintenance: 9 points.

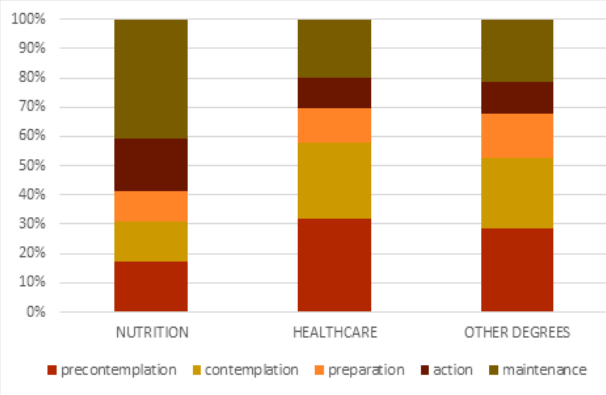
Statistics

The frequency (expressed as percentage) and confidence interval for the parameters and stages of change for each of the components are described in this study. Comparisons were made according to gender and nutritional status; significance for categorical variables was determined using Chi square test. Researchers used SPSS Statistics 22.0 software package and $p < 0.05$ was considered statistically significant.

Results

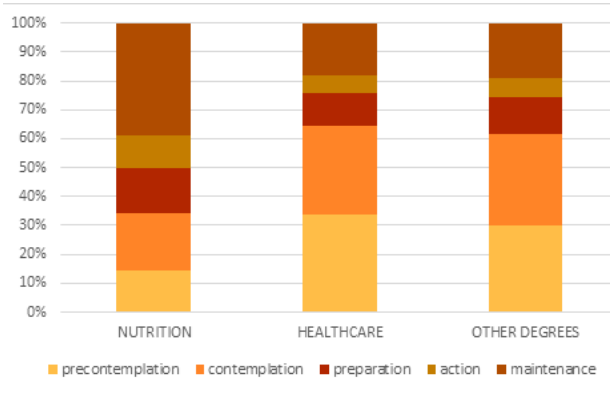
A total of 4,807 students were evaluated (71.6% female); average age was 22.3 ± 3.5 years old. More than 90% of the students were aware of the food regulation and knew the warning signs.

Figures 1 to 5 show the comparison of the stages of change regarding the purchase of sugary drinks, juices, cookies, sweet snacks and potato chips according to the subject's plan of studies. It was noted that more than 60% of the students of Healthcare-related and Other degrees are in the pre-contemplation and contemplation stages; this value is twice the percentage of Nutrition students in this stages (Chi^2, $p<0.001$ for all



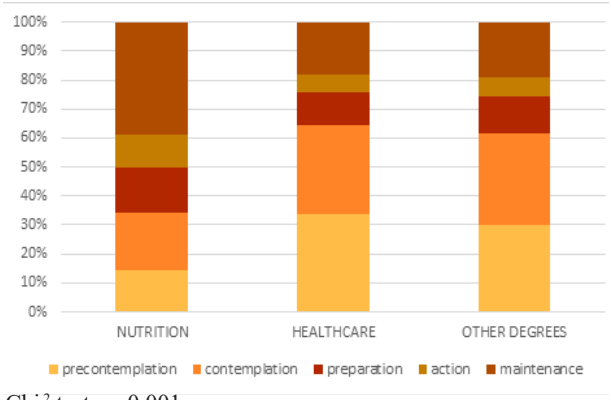
Chi ^{2} test, p=0.001

Figure 1. Comparison of the stages of change in the consumption of sugary drinks, according to the plan of studies.



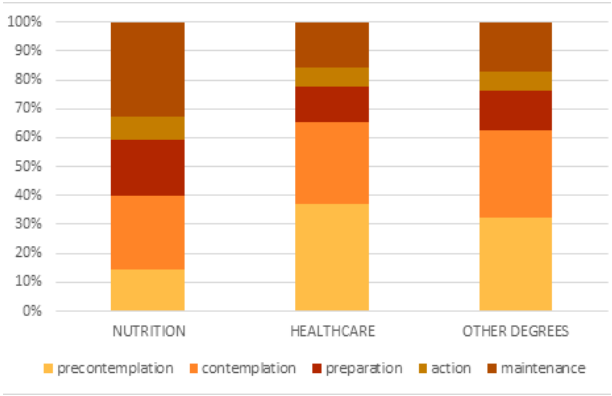
Chi ^{2} test, p=0.001

Figure 2. Comparison of the stages of change in the consumption of juices, according to the plan of studies.



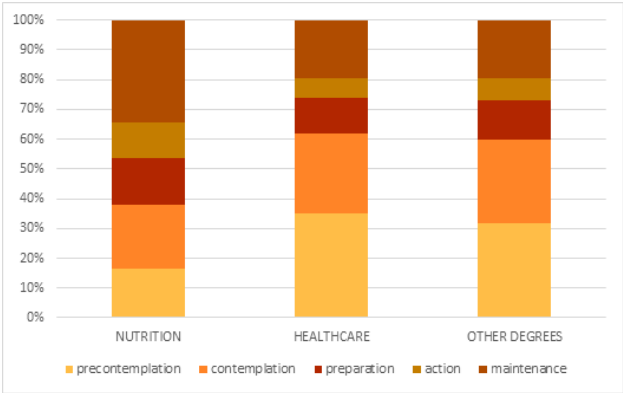
Chi ^{2} test, p=0.001

Figure 3. Comparison of the stages of change in the consumption of cookies, according to the plan of studies.



Chi ^{2} test, p=0.001

Figure 4. Comparison of the stages of change in the consumption of sweet snacks, according to the plan of studies.



Chi ^{2} test, p=0.001

Figure 5. Comparison of the stages of change in the consumption of potato chips, according to the plan of studies.

foods), except for sweet snacks and potato chips, with a percentage of 40% in the stages of pre-contemplation and contemplation. Regarding the Preparation stage (Figures 1 to 5) the value is nearly 10%; in Nutrition students is nearly 15%.

Finally, in the Action stage the percentage is lower than 5% in students of Healthcare-related and Other degrees, and in Nutrition students is equal to or greater than 10%. In addition, for all the afore mentioned foods, Nutrition students were in the maintenance stage to a greater extent.

Table 2 shows the reasons for disparity (OR), noting that while being in the stages of action and maintenance, the highest probability of consuming unhealthy snacks and

Table 2. Factors associated with being classified in the stages of Action and Maintenance in the following snacks frequently consumed by non-nutrition university students

	OR Gross	CI 95%	OR Adjusted*	CI 95%
Sugary drinks	2.18	1.89-2.51	1.84**	1.59-2.13
Juices and nectars	2.43	2.11-2.80	2.10**	1.81-2.44
Cookies	1.61	1.35- 1.91	1.42**	1.17-1.71
Sweet snacks	1.82	1.56-2.12	1.72**	1.46-2.03
Potato chips	1.81	1.56- 2.10	1.69**	1.44-1.97

*Adjusted by gender, age and knowledge about warning labels and consumption of food with warnings signs “HIGH IN”.

**p<0.001

belonging to a non-nutrition related degree (OR>2) is related to the intake of juices and nectars (OR=2.10; IC 95%= 1.81-2.44; p<0.001). The rest of the snacks studied are also more likely to be consumed among students of degrees not related to nutrition.

Discussion

The main result of this study shows that students (mainly from Healthcare-related degrees and Other degrees) are in the pre-contemplation or contemplation stages, that is, they are not willing to make a change in the short to medium term in respect of the purchase of the evaluated snacks.

Different studies have showed that Nutrition students have a healthier diet than those studying other degrees (13, 14). It is usually thought that students of healthcare-related degrees would have a similar profile; however, their behavior is similar to the one exhibited by students of other degrees not related to healthcare (Engineering, Education, Law, Architecture, etc.).

It is interesting to note that from all the afore mentioned snacks, only liquid foods offer alternatives without warning signs, because sugar has been replaced by non-caloric sweeteners that are heavily consumed in Chile, as different studies involving university students show (15-18). Instead, solid foods, especially cookies, contain very little moisture and a significant amount of added sugars and fast (therefore, these foods have a higher chance of having three warning signs: high in calories, high in sugars and high in saturated fats). Salty snacks and potato chips are highly consumed among students; these foods are marked with the "high in calories" and "high in sodium" signs. In this case, it is difficult for the industry to reduce the amount of critical nutrients in these foods, thus, they will continue to exhibit warning signs.

People of this group should favor the consumption of healthy snacks like water and fruits; the consumption of these foods has been associated with better nutritional status (19), but, in order to promote their consumption, they should be low cost and readily available in universities and unhealthy snacks consumption should be reduced, since their excessive consumption has been associated with obesity and other chronic diseases (20,21) and poorer academic performance (22).

It is worth mentioning that even though Healthcare-related students handle a large amount of information related to healthy lifestyles, they are not able to make these changes themselves (23). This bears out the fact that changes in behavior involve much more than cognitive aspects, and attitudes related to behavior change must be specifically addressed.

Among the strengths of this research we can mention that the sample was representative of the country; among the weaknesses we can point out we did not separate students according to their plan of studies in healthcare-related degrees and non-healthcare degrees, there must probably be some differences. In addition, we could evaluate according to gender and current year of study. Other weakness is that groups were not homogeneous concerning gender, due to the fact thatabout 90% of Nutrition students are female.

Conclusion

A high proportion of Healthcare-related and Other degree students are in the stages of pre-contemplation or contemplation. It is necessary to conduct educational work, especially among

Healthcare students, since in the future they will be responsible for giving advice about healthy lifestyles. However, it is interesting to note that Nutrition students, unlike other degree students, are mostly classified in the action and maintenance stages.

Furthermore, they should be trained in knowing the food law, since so far the efforts of the Ministry of Health have been focused on structural measures but there have not been educational measures aimed at generating changes in eating patterns.

Finally, it is necessary to perform follow-up studiesin order to assess the impact of the food law and to know if it has helped in the reduction of ultra-processed foods.

References

1. Cediel G, Reyes M, da Costa Louzada ML, Martinez Steele E, Monteiro CA, Corvalán C, *et al* .Ultra-processed foods and added sugars in the Chilean diet (2010). Public Health Nutr. 2018; 21:125-133.
2. Crovetto M, Uauy R.Changes in the consumption of dairy products, sugary drinks and processed juices in the Chilean population. Rev Med Chile. 2014:142;1530-1539.
3. Popkin BM, Reardon T.Obesity and the food system transformation in Latin America. Obes Rev. 2018;19(8):1028-1064.
4. The Pan American Health Organization (PAHO).Consumo de alimentos y bebidas ultra-procesados en América Latina: Tendencias, impacto en obesidad e implicaciones de política pública https://www.paho.org/hq/dmdocuments/2014/alimentos-bebidas-ultra-procesados-ops-e-obesidad-america-latina-2014.pdf. UpdatedApril 21, 2014. Accessedjune 20, 2019.
5. Consejo Nacional de Educación. Índices tendencias educación superior 2017 https://www.cned.cl/sites/default/files/tendencias_matricula_pregrado_2017.pdfUpdated June 21, 2017. Accessed May 5, 2019.
6. Rodríguez F, Palma X, Romo A, Escobar D, Aragú B, Espinoza L, *et al*. Eating habits, physical activity and socioeconomic level in university students of Chile. Nutr Hosp.2013;28:447-455.
7. IRIS-PAHO.Ultra-processed food and drink products in Latin America: Trends, impact on obesity, policy implications http://iris.paho.org/xmlui/bitstream/handle/123456789/7699/9789275118641_eng.pdf(Accessed on march 19 2019)Updated 2015. Accessed March 20, 2019.¿
8. UNICEF.Adolescencia una etapa fundamental https://www.unicef.org/ecuador/pub_adolescence_sp.pdfUpdated 2012. Accessed May 5, 2019.
9. Biblioteca del Congreso nacional de Chile/BCN.Modifica Decreto Supremo Nº 977, de 1996, Reglamento Sanitario de los Alimentos https://www.leychile.cl/Navegar?idNorma=1078836. UpdatedJune 27, 2016. Accessed May 5, 2019.
10. Fleta Y., Giménez J. Coaching Nutricional. Primera Edición. Barcelona; 2015
11. Moore M. Coaching Psycology Manual. Second Edition. Lippincott Williams&Wilki; 2016.
12. Nigg, C. eds. LWW. ACSM's Behavioral Aspects of Physical Activity and Exercise. Vol 2. Philadelphia, PA: 2013. P. 39-69.
13. Durán Agüero S, Fernández Godoy E, Fuentes Fuentes J, Hidalgo Fernández A, Quintana Muñoz C, Yunge Hidalgo W, *et al*.Food patterns associated with a healty body weight in Chilean students of Nutrition and Dietetics. Nutr Hosp 2015;32:1780-1785.
14. Durán Agüero S, Bazaez Díaz G, Figueroa Velásquez K, Berlanga Zúñiga Mdel R, Encina Vega C, Rodríguez Noel MP. Comparison between the quality of life and nutritional status of nutrition students and those of other university careers at the Santo Thomas University in Chile. Nutr Hosp2012;27:739-746.
15. Durán Agúero S, Blanco Batten E, Rodríguez Noel M del P, Cordón Arrivillaga K, Salazar de Ariza J, *et al*. Association between non-nutritive sweeteners and obesity risk among university students in Latin America. Rev Med Chile 2015;143,367-373.
16. Durán Agüero S, Rodríguez Noel MP, Cordón Arrivillaga K,Salazar de Ariza J, Record Cornwall J, Cereceda Bujaicon MP, *et al*. Comparison of non-nutritive artificial sweetener consumption among university students in Latin American: Multicentric Study. ALAN 2017;67:178-186.
17. Crovetto M, Valladares M, Espinoza V, Mena F, Oñate G, Fernández M, Durán-Agüero S. Effect of healthy and unhealthy habits on obesity: a multicentric study. Nutrition 2018;54:7-1
18. Fiolet T, Srour B, Sellem L, Kesse-Guyot E, Allès B, Méjean C, *et al*.Consumption of ultra-processed foods and cancer risk: results from NutriNet-Santé prospective cohort. BMJ 2018;360.k322.
19. Poti JM, Braga B, Qin B. Ultra-processed Food Intake and Obesity: What Really Matters for Health-Processing or Nutrient Content? Curr Obes Rep 2017;6:420-431.
20. Gibney MJ, Forde CG, Mullally D, Gibney ER. Ultra-processed foods in human health: a critical appraisal. Am J Clin Nutr 2017;106:717-724.
21. Asigbee FM, Whitney SD, Peterson CE.The Link Between Nutrition and Physical Activity in Increasing Academic Achievement. J Sch Health 2018;88:407-415.
22. Correa-Burrows P, Rodríguez Y, Blanco E, Gahagan S, Burrows R.Snacking Quality Is Associated with Secondary School Academic Achievement and the Intention to Enroll in Higher Education: A Cross-Sectional Study in Adolescents from Santiago, Chile. Nutrients. 2017 ;9(5):433. doi: 10.3390/nu9050433
23. Montero Bravo A, Úbeda Martín A, García González A.Evaluación de los hábitos alimentarios de una población de estudiantes universitarios en relación con sus conocimientos nutricionales. Nutr Hosp 2006;21:466-473.

Recibido: 11/11/2021
Aceptado: 10/03/2021

ARCHIVOS LATINOAMERICANOS DE NUTRICIÓN
Revista de la Sociedad Latinoamericana de Nutrición
Doi: 10.37527/2020.70.4.005

Vol. 70 N° 4, 2020
Artículo Original

Main changes on the polyphenols profile and antioxidant capacity in Manila mango (*Mangifera indica L.*)

Dulce María Soria-Lara[1], Sandra Neli Jiménez-García[2], José Enrique Botello-Álvarez[1], Rita Miranda-López[1].

Summary: Main changes on the polyphenols profile and antioxidant capacity in Manila mango (*Mangifera indica* L.) Mango is the second most commercialized tropical fruit in the world, and Mexico is the major exporter. In terms of mango production, Manila´s variety represents a quarter of the total mangoes production in Mexico. However, the changes that occur on the phenolic compounds during the Manila mango ripening process are unknown. Quantitative analysis of the major phenolic compounds was conducted at different maturity stages, using several spectrophotometric measurements and by high-performance liquid chromatography (HPLC). At the late ripening stage was observed the biggest content in pulp and peel of total phenols (577 and 10547 mg EAG /100 g), flavonoids (95.33 and 537 mg EQ/100 g), and antioxidant capacity by DPPH (25 and 347 mmol TE/100 g). Some bioactive compounds achieve their highest values at optimal consumption ripening. Although they diminish when the fruit reaches a senescence appearance. This is the first study to prove that mangiferin by itself shows a higher correlation in antioxidant capacity compared to other phenolic compounds in mango peel, and this suggest that phenolic compounds may have an important role in the postharvest antioxidant metabolism in Manila mango fruit. On the other hand, the results show that the peel compared to the pulp contains higher amounts of total phenols, flavonoids, gallic acid, mangiferin and antioxidant capacity, so its use as an ingredient in the preparation of functional food products is recommended. More studies are needed to go in-depth in the changes of the content of phytochemicals during the ripening process in the peel and pulp mango, which ones could be caused by the hormones responsible for ripening in the fruit, such as ethylene, and bioavailability of these compounds at different stages of maturation. **Arch Latinoam Nutr 2020; 70(4): 269-281.**

Key words: Antioxidant capacity, bioactive compounds, by-products of mango, *Mangifera indica* L., phytochemicals, and ripening.

Resumen: Principales cambios en el perfil de polifenoles y capacidad antioxidante del mango Manila (*Mangifera indica* L.). El mango es la segunda fruta tropical más comercializada del mundo y México es el principal exportador. En términos de producción de mango, la variedad Manila representa una cuarta parte de la producción total de mangos en México. Sin embargo, se desconocen los cambios que ocurren en los compuestos fenólicos durante el proceso de maduración del mango Manila. El análisis cuantitativo de los principales compuestos fenólicos se realizó en diferentes etapas de madurez, utilizando varias medidas espectrofotométricas y mediante cromatografía líquida de alta resolución (HPLC). En la etapa de madurez tardía se observó el mayor contenido en pulpa y cáscara de fenoles totales (577 y 10547 mg EAG / 100 g), flavonoides (95.33 y 537 mg EQ / 100 g) y capacidad antioxidante por DPPH (25 y 347 mmol TE / 100 g). Algunos compuestos bioactivos alcanzan sus valores más altos en el punto de madurez óptima. Aunque disminuyen cuando el fruto adquiere una apariencia de senescencia. Este es el primer estudio que demuestra que la mangiferina por sí misma presenta una alta correlación con la capacidad antioxidante en comparación con otros compuestos fenólicos de la cáscara de mango, y esto sugiere que los compuestos fenólicos pueden tener un papel importante en el metabolismo antioxidante postcosecha en el mango Manila. Por otro lado, los resultados muestran que la cáscara comparada con la pulpa contiene mayores cantidades de fenoles totales, flavonoides, ácido gálico, mangiferin y capacidad antioxidante por DPPH, por lo que se recomienda su uso como ingrediente en la elaboración de productos alimenticios fucionales. Se necesitan más estudios para profundizar en los cambios del contenido de fitoquímicos durante el proceso de maduración en la cáscara y pulpa del mango, los cuáles podrían ser provocados por las hormonas responsables de la maduración en el fruto, como el etileno, y la biodisponibilidad de estos compuestos en diferentes etapas de maduración. **Arch Latinoam Nutr 2020; 70(4): 269-281.**

Palabras clave: Capacidad antioxidante, compuestos bioactivos, subproductos del mango, *Mangifera indica* L., fitoquímicos y maduración.

Introduction

In Mexico, mango is a fruit with high economic impact since worldwide ranks first as an exporter, with an annual average of 12-15% of its total production. In 2019 the profit from its export increased to 422 million dollars (1).

[1]Departamento de Ingeniería Bioquímica, Tecnológico Nacional de México en Celaya, Guanajuato, México. [2] División de Ciencias de la Salud e Ingeniería, Campus Celaya-Salvatierra, C.A. Enfermedades no transmisibles, Universidad de Guanajuato; México.
Autor para la correspondencia: Rita Miranda-López, email: rita.miranda@itcelaya.edu.mx.

Mango is consumed either fresh or processed in several food products, which generates large amounts of residual material that cannot be incorporated into food. These residues, also called by-products, compromise around 20% of the mango's weight, represented by seed and peel (pericarp). Therefore, food science has focused on the search for new ingredients derived from fruits and vegetables, emphasizing foods with abundant bioactive compounds that have potential health benefits. Per example, gallic, hydroxybenzoic, hydroxycinnamic and vanillic acids are present in mango; these acids can be easily absorbed in the small intestine and act as potential antioxidant (2). Mangiferin has a positive effect on lipids metabolism and in glycemic control specially in diabetic persons (3).

In this context, several studies have begun to show the health benefits of mango consumption. According to Abbasi (4) several types of mango peel extract grown in China inhibited proliferation of hepatocellular carcinoma in vitro (HepG2 cell line). Rodríguez-González (5) showed that fiber mango pulp (0.5 g per kilogram of weight per day in a DM1 rat model) increased serum insulin secretion levels, and also reduces hepatic steatosis. Moreover, in overweight subjects, mango pulp consumption can reduce oxidative stress and triglyceride levels in serum (6). Considering the previous scientific evidence, it can be said that mango pulp and peel are foods with functional potential, since in addition to its high vitamin content, mango has a significant concentration of bioactive compounds such as total phenols, flavonoids, carotenes, tannins and acids phenolic compounds compared to other "tropical" fruits such as grape, guava and pineapple pulp (7).

On the other hand, in Mexico all commercial mango varieties belong to the *Mangifera indica* L. species; consequently, there is a wide fruit diversity, among them are Keitt, Kent, Ataulfo, Paraiso, Palmer, Tommy Atkins and Manila (8). This last variety represents 26% of the total production of mango fruit in Mexico (9). The mango is considered a climatic type of fruit. There is very limited information in the scientific literature regarding changes on the content of the polyphenols present in its pulp and peel during the ripening process. Hence the present study aims to provide essential information to favor and encourage agricultural innovation initiatives focused for the use of this fruit, which is of great importance for the development of biotechnological strategies designed to utilize mango's peel and pulp.

Material and methods

Chemical and apparatus

All the reagents utilized, in the different analysis in this study, were of analytical and HPLC grades. They were provided by a commercial brand.

Spectrophotometric measurements were performed on a UV-Vis double beam GENESYS 10S single cell holder spectrometer (Thermo Fisher Scientific TM, USA). An HP 1200 series HPLC system (Hewlett-Packard, Palo Alto, USA) equipped with a diode array detector (DAD) and Discovery HSC C18 column Sigma-Aldrich (St. Luis, MO) reverse-phase column (250 mm x 4.6 mm) with a spherical particle size of 5 µm was used in the High-performance liquid chromatography assay.

Samples and preparation of extracts

The Manila mango was acquired during the months of April (harvest time 1) and May (harvest time 2), from the municipality of Alcozauca, Guerrero, Mexico. Once the fruit arrived at Celaya, Guanajuato, it was selected according to its color and external appearance, considering the mangoes with physiological ripening stage according to the Mexican standard "NMX-FF-058-SCFI-2006" (10) and in conjunction to Palafox-Carlos (11) having a ripening stage of R1 (0-10 % of yellow pigmentation on the surface of the fruit). Those fruits with defects or some visible physiological irregularity were discarded from the study.

Once in the laboratory, the fruits were sanitized with sodium hypochlorite (NaClO) at a concentration of 200 ppm, dried carefully with absorbent paper, and then stored during 30 days at a temperature of 16 °C and relative humidity of 50 %, to resemble the marketing conditions that occur at the "Bajio" region from Mexico. The fruits were sampled in the following days: day zero (D0), five (D5), fifteen (D15), twenty-five (D25), and thirteen (D30). It is worth mentioning that D0 was considered the day of the arrival of the fruit at

Celaya, Gto, and therefore at the laboratory (18 h after being harvested).

Pulp and peel were removed by hand from the mango and separately were freeze-dried LabconcoFreeZone® 4.5 model 10404A 7750000 (LABCONCO, Kansas City, MO). Preparation extract was determined according to a modified method described by Ajila (12). Mango pulp and peel freeze-dried samples (0.5 g) were macerated in 10 mL of methanol for 24 h at 40 °C in 1500 rpm using a shaking incubator Shel Lab (Sheldon manufacturing, Oregon, USA), centrifuged at 6000 rpm for 15 min at 25 °C in a Hermle centrifuge model Z200-A (Labortechnik Technologies, Wehingen, Germany), and then filtered through number 1 Whatman paper. The supernatant was collected, and this was used to quantify polyphenols.

Determination of polyphenolic compounds

The total phenolic content of the mango samples (pulp and peel) was determined using the Folin-Ciocalteu colorimetric method, as described by Singleton (13). The absorbance was measured at 765 nm using a spectrophotometer. The total phenolic content of the extract was calculated from the gallic acid standard curve and was expressed as milligrams equivalent of gallic acid per one hundred dry weight (mg EAG/100 g).

The aluminum chloride method was used for flavonoid determination following the method described by Papoti (14). The total flavonoid content was calculated from the quercetin standard curve and was expressed as milligrams equivalent of quercetin per one hundred dry weight (mg EQ/100 g).

Condensed tannin determination is based on the reaction of condensed tannins with vanillin under acid conditions, using catechin as standard. A 2 mL aliquot of freshly prepared vanillin solution (1 g/100 mL) in sulfuric acid 70% was added to 500 µL of mango extract. The mixture was incubated at 20 °C for 15 min and its absorbance was read at 500 nm; (+)-catechin was used for the reference curve, and the results were expressed as mg catechin/g dry weight (mg EC/g) (15).

The anthocyanin content was measurement by the pH differential method (16). The total monomeric anthocyanin was calculated using the molecular weight of cyanidin-3-glucoside (449.2 g mol-1) and peonidin-3-galactoside (498.9 g mol-1), which are the main anthocyanins found in mango, and whose molecular absorptivity are 25 740 mol L-1 at 520 nm wavelength and 48 400 mol L-1 at 532 nm in acidified ethanol buffer. The content in the sample solution was calculated using the equation below:

$$\textit{Monomeric anthocyanin pigment (mg/L)} = (A \times MW \times DF \times 1000)/(\varepsilon \times 1)$$

where A is absorbance in the sample, MW is the molecular weight, DF is the dilution factor, and ε is the molar absorptivity; it is important to mention that the equation presented above assumes a pathlength of 1 cm. The results were expressed as mg anthocyanin/100 g dry weight (mg/100 g).

HPLC analysis was performed according to Palafox-Carlos (17). Samples containing phenols were injected automatically into an HP 1200 series HPLC system with a DAD. Absorption spectra for the main peaks were recorded at 280 nm. The HPLC system was equipped with a Discovery HS C18, which was kept at 30 °C. The mobile phase was composed of water and 1% acetic acid (A) and methanol (B), and the elution gradient was 2–100% (B) in 40 min at a flow rate of 0.8 mL min-1 and 30 °C. The injection volume was 20 µL, and the concentration of each compound of interest was calculated with a calibration curve for the following standards: (+)-catechin, (−)-epigallocatechin, mangiferin, gallic acid, and vanillic acid.

To gauge the antioxidant activity, three methods were used: 1) DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging assay, where absorbance values were measured on a spectrophotometer at 517 nm, and results were expressed as mmol Trolox equivalent (TE)/100 g of dry sample (18). 2) ABTS (2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid)) radical cation (ABTS+*) scavenging activity assay (19), absorbance values were measured on a spectrophotometer at 734 nm, and the results were expressed as mmol Trolox equivalent (TE)/100 g of dry sample. 3) Ferric reducing antioxidant power (FRAP), methodology described by Griffin (20), the FRAP values were measured on a spectrophotometer at 510 nm and the results estimated in mmol Trolox equivalents (TE)/100 g of dry sample.

Statistical analysis

Data were statistically analyzed following a

randomized design. Results were expressed as means ± SD of six replicates for each experiment, considering both harvest time 1 and harvest time 2 per each evaluation day. Data were analyzed using the one-way ANOVA procedure. The Tukey–Kramer multiple comparison tests were used. Standard deviation and variance coefficient between data groups were used to determine significant differences between them at $p< 0.05$. Multiple linear regression evaluates the influence that predictors (X1, X2, X3, ..., Xn) have on a variable response (Y); in these models, R2 (R-squared) provides an estimate of the strength of the relationship between a model and the response variable, the overall F-test compares multiple coefficients simultaneously of different linear models, and together with p-value indicates the level of significance of the model. In the present study, the independent variables were each polyphenol evaluated and the dependent variable was the antioxidant capacity. It should be noted that, all the statistical analyses in this study were achieved by using the software IBM, SPSS v. 23 for Windows.

Results

Effect of ripening on the polyphenol content

Figure 1 contains the phenolic compounds that were evaluated in Manila mango pulp and peel at different ripening stages, from D0 to D30. In regards to the total phenolic content at day D0 the values were 236.9 and 3154.8 mg de EAG/100g in pulp and peel, respectively; although increases as ripening does (D25), and the total phenolic content in both pulp and peel decreases as senescence is reached (D30) (Figure 1.A and 1.B). The flavonoids values in Manila mango pulp varied from 84.2 to 94.6 mg EQ/100 g, and in the peel from 306.3 to 537.2 mg EQ/100 g (Figure 1.C and 1.D). In all the ripening stages, flavonoids were lower in pulp (4-5 times) than in peel. At the same time, tannin content was also reduced as mango accomplishes higher maturity, the tannin content in pulp and peel were 2.7±0.2 and 12.6±1.5 mg EC/g, respectively (Figure 1.E and 1.F). With regards to the anthocyanin content in pulp and peel of Manila mango (Table 1), this phytochemical decreases during ripening by up to 60 % in pulp and 52 % in the peel. The anthocyanin content was also estimated to be higher in the peel samples than in the pulp.

Content of more important phenolic compounds by HPLC

The quantification of phenolic compounds by HPLC is shown in Table 2. Being gallic acid the most abundant polyphenol compound found in the mango samples, followed by catechin. Mangiferin values increases as ripeness does, in both pulp (0.36 – 2.58 mg/100 mg) and peels (2.10 -3.27 mg/100 mg), as well as, the content of catechin and epicatechin gallate in peel was 7-10 times higher compared to the content of its pulp. Although vanillic acid was detected in all the samples, in many of them the concentrations were less than the quantifiable limit established (<L.Q.) in the calibration standard curve.

Changes in antioxidant capacity

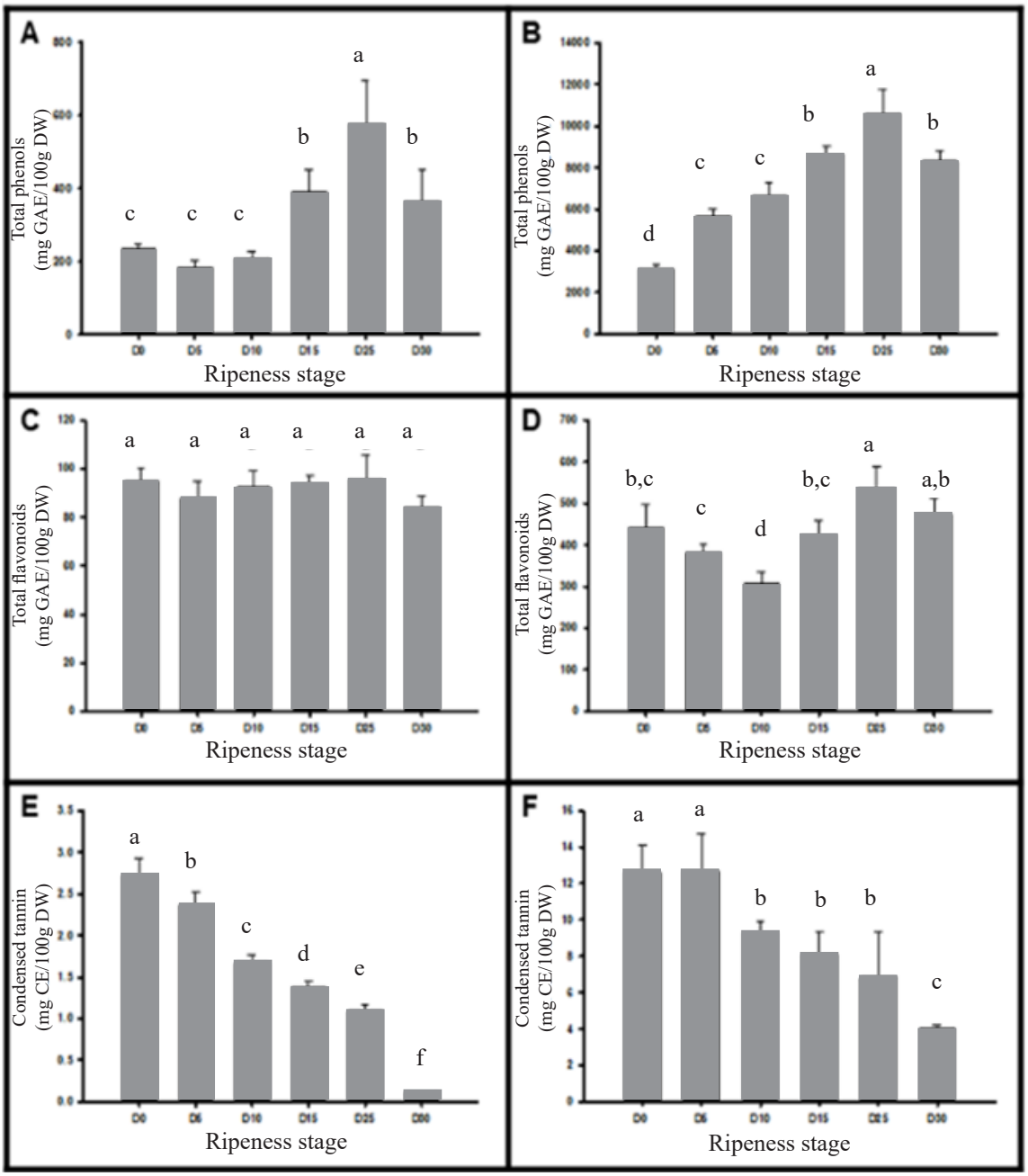
The results of the three antiradical assays are shown in Figure 2, which was observed as the ripening increase the antioxidant capacity increases too. The values in the peel was 4–10 times higher than in the pulp. Figure 2.A shows electron donation of antioxidants to neutralize the DPPH radical in the pulp and peel of Manila mango, whose maximum values were 25.0±1.2 mmol/100 g and 347.4±56.6 mmol/100 g respectively. Figure 2.B shows the low oxidation of ABTS+ by the increase of antioxidant capacity during fruit ripening in mango, peel having values between 82.7±12.7 to 140±2.7 mmol TE per 100 g DW. Finally, at D25 Manila mango holding the highest scavenging activity of $Fe3+$ in peel with 40.8±1.6 mmol/100 g and 3.5±0.1 mmol/100g in the pulp.

Influence of polyphenols on antioxidant capacity

The influence of each polyphenol evaluated was weighed on the antioxidant capacity by using the simple and multiple linear regression model (Table 3). In the case of mango peel, it can be observed that by employing simple linear regression all the polyphenols evaluated participate significantly ($p <0.05$) by themselves except for vanillin acid, which only showed a significant correlation ($p <0.05$) for the antioxidant capacity evaluated by the ABTS method. The single phenolic acids are the ones with the greatest contribution.

Moreover, mangiferin contributes to a majority way on the antioxidant capacity evaluated by the DPPH and FRAP method, with standardized Beta coefficients of 2.1% and 0.5%, respectively (data no show), and in the pulp of this variety, mangiferin was profiled within multiple regression

models to explain the antioxidant capacity evaluated by the different methods. Furthermore, the interaction between catechin, epicatechin, and total phenols explains in 80% the value of the antioxidant capacity in pulp by the FRAP method.



Different letters per column indicate statistical difference ($p < 0.05$) as a result of Anova with Tukey's post hoc. 1.A: Total phenols in pulp; 1.B: Total phenols in peel; 1.C: Total flavonoids in pulp; 1.D: Total flavonoids in peel; 1.E: Condensed tannin in pulp; 1.F: Condensed tannin in peel; GAE: gallic acid equivalent of dry weight; QE: quercetin equivalent of dry weight; CE: catechin equivalent of dry weight.

Figure 1. Polyphenol content in Manila mango.

Table 1. Variations of anthocyanin content in Manila mango.

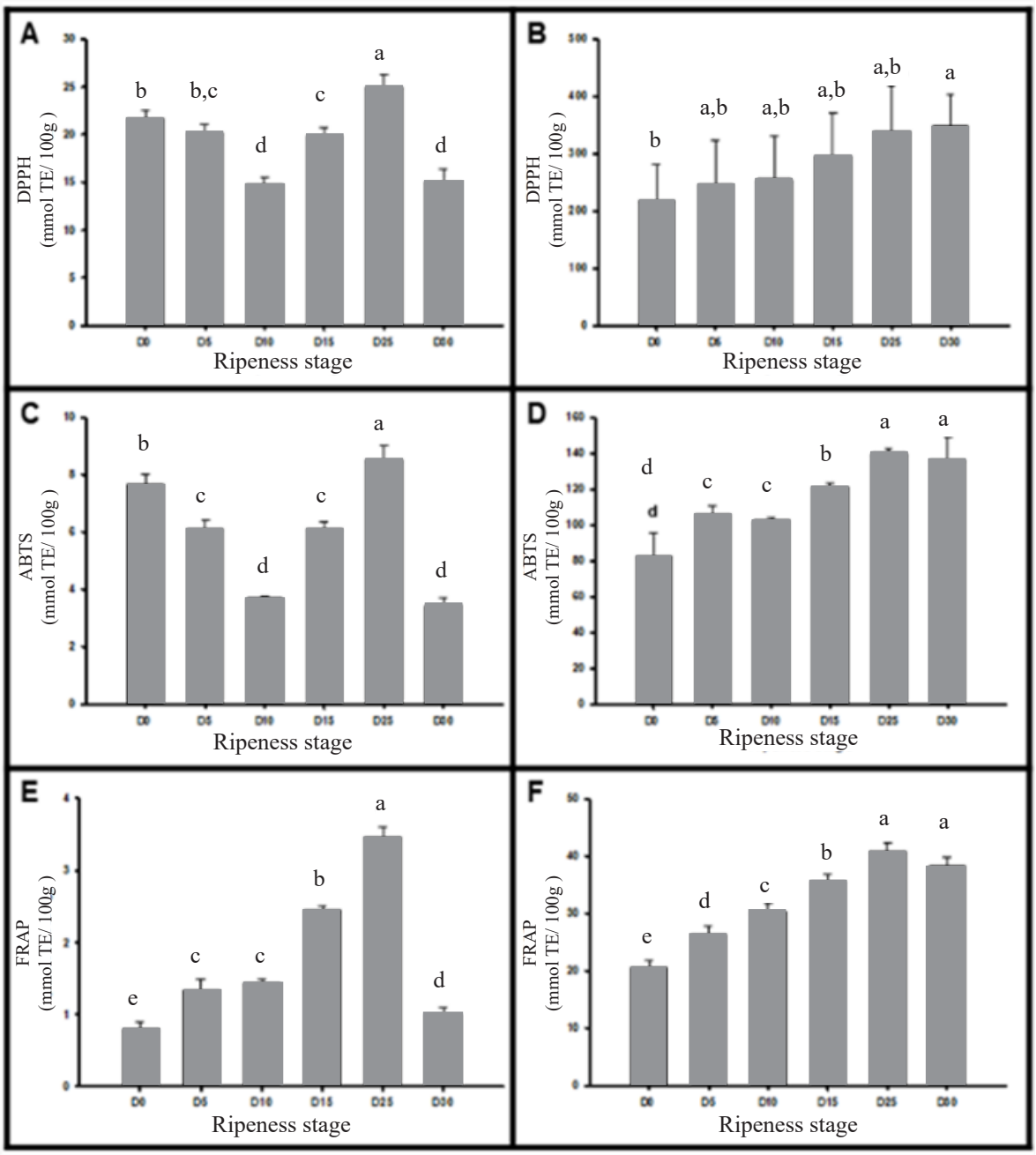
Portion	Anthocyanin (mg/100 g)	Ripeness stage					
		D0	D5	D10	D15	D25	D30
Pulp	Cyn-3-glu	1.53±0.19^{a}	1.44±0.14^{a}	0.92±0.08^{c}	1.19±0.11^{b}	0.83±0.04^{c}	0.88±0.05^{c}
	Pnd-3-gal	2.42±0.08^{a}	2.27±0.11^{a}	1.63±0.05^{b}	2.22±0.18^{a}	1.56±0.15^{b}	1.60±0.09^{b}
	total	3.95±0.21^{a}	3.71±0.17^{a,b}	2.55±0.10^{c}	3.41±0.28^{b}	2.39±0.16^{c}	2.47±0.10^{c}
Peel	Cyn-3-glu	3.08±0.15^{a}	2.62±0.17^{b}	2.25±0.13^{c}	2.02±0.11^{d}	1.79±0.12^{e}	1.49±0.09^{f}
	Pnd-3-gal	2.04±0.20^{b}	1.88±0.12^{b,c}	2.42±0.25^{a}	2.05±0.19^{b}	1.68±0.19^{c}	1.18±0.10^{d}
	total	5.12±0.25^{a}	4.51±0.29^{b,c}	4.66±0.37^{a,b}	4.06±0.30^{c}	3.46±0.31^{d}	2.67±0.16^{e}

Anova with Tukey's post hoc, different letters per row indicate statistical difference ($p < 0.05$); Cyn-3-glu: cyanidin-3-glucoside; Pnd-3-gal: peonidin-3-galactoside.

Table 2. Changes in most important polyphenols by HPLC in Manila mango.

Portion	Compound (mg/100 g)	Ripeness stage					
		D0	D5	D10	D15	D25	D30
Pulp	Mangiferin	0.36±0.02^{c}	0.50±0.03^{c}	1.74±0.12^{b}	1.76±0.11^{b}	1.78±0.10^{b}	2.58±0.17^{a}
	(+)-Catechin	6.13±0.14^{a}	4.21±0.49^{b}	2.81±0.09^{c}	2.68±0.14^{c}	2.55±0.19^{c}	0.48±0.09^{d}
	(−)-Epigallocatechin	1.79±0.22^{a}	0.54±0.04^{b}	0.43±0.03^{b,c}	0.39±0.03^{b,c}	0.34±0.02^{c}	0.38±0.03^{b,c}
Peel	Gallic acid	10.94±0.26^{f}	18.98±2.05^{e}	31.34±1.56^{d}	38.68±1.70^{c}	46.02±1.86^{b}	69.16±8.06^{a}
	Vanillic acid	<Q.L.	0.20±0.01^{b}	0.42±0.03^{a}	<Q.L.	<Q.L.	<Q.L.
	Mangiferin	2.10±0.02^{f}	2.47±0.06^{e}	2.68±0.07^{d}	2.84±0.03^{c}	3.01±0.04^{b}	3.27±0.07^{a}
	(+)-Catechin	38.85±2.64^{a}	37.66±2.55^{a}	33.69±2.30^{b}	29.21±1.97^{c}	24.73±1.66^{d}	20.31±1.50^{e}
	(−)-Epigallocatechin	2.20±0.16^{a}	1.73±0.13^{b}	1.63±0.12^{b,c}	1.43±0.10^{c,d}	1.22±0.09^{d}	1.26±0.11^{d}
	Gallic acid	59.33±4.85^{e}	74.94±2.88^{d}	79.51±5.70^{d}	101.63±5.98^{c}	123.76±6.39^{b}	133.84±6.90^{a}
	Vanillic acid	<Q.L.	<Q.L.	<Q.L.	<Q.L.	0.62±0.07a	0.12±0.02^{b}

Anova with Tukey's post hoc, different letters per row indicate statistical difference ($p < 0.05$); <Q.L.: Less than the quantifiable limit.



Different letters per column indicate statistical difference ($p < 0.05$) as a result of Anova with Tukey's post hoc. 2.A: DPPH antioxidant capacity in pulp; 2.B: DPPH antioxidant capacity in peel; 2.C: ABTS antioxidant capacity in pulp; 2.D: ABTS antioxidant capacity in peel; 2.E: FRAP antioxidant capacity in pulp; 2.F: FRAP antioxidant capacity in peel; DPPH: 2,2-diphenyl-1-picrylhydrazyl; ABTS: (2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid)); FRAP: Ferric reducing antioxidant power; TE: trolox (6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid) equivalent of dry weight.

Figure 2. Antioxidant profile of Manila mango.

Table 3. Linear and multiple regression between polyphenols and antioxidant capacity in of Manila mango

	Assay of ACA	Type regression	Regression equation	R	R2	F	p-level
PULP	DPPH	Linear	DPPH= 21.484 -0.058 X1	0.298	0.062	3.322	0.077
			DPPH=16.416 +0.952 X2	0.443	0.173	8.314	0.077
			DPPH=22.252-1.958 X3	0.413	0.146	6.977	0.012
			DPPH=18.182+1.904 X4	0.267	0.044	2.609	0.115
			DPPH= 19.022-3.672X5	0.343	0.092	4.547	0.040
			DPPH=15.314+0.012X6	0.497	0.225	11.134	0.002
			DPPH=17.287+1.367X7	0.314	0.072	3.725	0.062
			DPPH=5.577+0.152X8	0.300	0.063	3.351	0.076
			DPPH=15.660+3.316X9	0.262	0.041	2.506	0.123
			DPPH=14.030+2.759X10	0.278	0.050	2.842	0.101
		Multiple	DPPH =9.882+0.022X6+0.086X7-3.878X3	0.912	0.815	52.428	>0.001
	ABTS	Linear	ABTS=7.423-0.042X1	0.421	0.153	7.322	0.011
			ABTS=4.010+0.0611X2	0.560	0.293	15.503	>0.001
			ABTS= 7.746-1.249X3	0.517	0.246	12.409	0.001
			ABTS=5.014+1.426X4	0.393	0.129	6.205	0.018
			ABTS=5.728-1.936X5	0.356	0.101	4.926	0.033
			ABTS=4.278+0.005X6	0.394	0.131	6.262	0.017
			ABTS=4.426+0.970X7	0.439	0.169	8.095	0.007
			ABTS=-3.082+0.099X8	0.384	0.122	5.868	0.021
			ABTS=3.553+2.105X9	0.327	0.081	4.065	0.052
			ABTS=2.698+1.659X10	0.328	0.081	4.105	0.051
		Multiple	ABTS=-0.901+0.196X2+0.010X6+0.058X7-1.7X3	0.933	0.854	52.194	>0.001
	FRAP	Linear	FRAP=1.311+0.012X1	0.250	0.035	2.267	0.141
			FRAP= 2.204 -0.145X2	0.268	0.044	2.627	0.114
			FRAP=1.239+0.351X3	0.294	0.060	3.219	0.082
			FRAP=2.329-0.901X4	0.502	0.230	11.448	0.002
			FRAP=0.026+31.639 X5	0.028	-0.029	0.028	0.869
			FRAP=0.170+0.005X6	0.761	0.567	46.884	>0.001
			FRAP=2.218-0.302X7	0.276	0.049	2.804	0.103
			FRAP=-1.686+0.038X8	0.296	0.061	3.256	0.080
			FRAP=3.253-1.331 X9	0.418	0.150	7.190	0.011
			FRAP=3.406-0.850X10	0.340	0.090	4.444	0.042
		Multiple	FRAP=-0.141+0.385X2+0.005X6-1.449X4	0.898	0.806	44.323	>0.001
			DPPH= 120.497+1.710 X1	0.577	0.314	16.992	>0.001
			DPPH= 409.394-4.083 X2	0.353	0.099	4.852	0.034
			DPPH=-61.380+126.518 X3	0.592	0.332	18.370	>0.001
			DPPH=394.874-70.384 X4	0.306	0.067	3.521	0.069
	DPPH	Linear	DPPH=331.072-83.680 X5	0.238	0.029	2.049	0.161
			DPPH= 171.041+0.016 X6	0.475	0.203	9.927	0.003
			DPPH=411.308-14.291 X7	0.601	0.342	19.220	>0.001
			DPPH=151.296 X8	0.312	0.071	3.661	0.064
			DPPH=425.589-64.211 X9	0.430	0.161	7.709	0.009

Table 3. Linear and multiple regression between polyphenols and antioxidant capacity in of Manila mango. (cont)

	Assay of ACA	Type regression	Regression equation	R	R2	F	p-level
PEEL			DPPH=371.874-46.974 X10	0.243	0.031	2.138	0.153
		Multiple	DPPH= -1770.540+449.030 X3+13.526X2+152.415X4+0.405X8	0.869	0.723	23.863	>0.001
			ABTS=45.859+0.721 X1	0.924	0.850	199.296	>0.001
			ABTS=190.302-2.458 X2	0.808	0.642	63.799	>0.001
			ABTS=-21.070+49.770 X3	0.885	0.776	122.464	>0.001
			ABTS=197.102-52.216 X4	0.863	0.737	99.138	>0.001
	ABTS	Linear	ABTS= 132.483-31.447 X5	0.340	0.090	4.451	0.042
			ABTS=60.786+0.008 X6	0.863	0.738	99.514	>0.001
			ABTS=159.166-4.981 X7	0.795	0.622	58.573	>0.001
			ABTS= 64.634+0.117 X8	0.447	0.177	8.513	0.006
			ABTS=188.961-33.626 X9	0.855	0.723	92.341	>0.001
			ABTS=171.630-30.361 X10	0.597	0.338	18.830	>0.001
		Multiple	ABTS=29.390+0.794 X1+16.836X5	0.937	0.871	119.530	>0.001
			FRAP=9.057+0.240 X1	0.923	0.847	194.647	>0.001
			FRAP=58.278-0.854 X2	0.841	0.699	82.205	>0.001
			FRAP=-15.483+17.405 X3	0.927	0.855	207.086	>0.001
			FRAP=60.305-17.938 X4	0.888	0.782	126.863	>0.001
	FRAP	Linear	FRAP=36.995-8.835 X5	0.286	0.055	3.037	0.090
			FRAP=12.696+0.003 X6	0.926	0.853	204.074	>0.001
			FRAP=47.220-1.705 X7	0.816	0.656	67.655	>0.001
			FRAP=16.128+0.037 X8	0.425	0.156	7.491	0.010
			FRAP=58.178-11.855 X9	0.903	0.810	150.053	>0.001
			FRAP=46.253-7.601 X10	0.448	0.177	8.525	0.006
		Multiple	FRAP=-4.236+9.474 X3+0.001X6	0.964	0.925	215.333	>0.001

ACA: antioxidantcapacityassay; GAE: gallicacidequivalents; CE: catechin equivalents: QE: quercetinequivalents; X1: gallicacid (mg/100 g); X2: catechin (mg/100 g);: X3: mangiferin (mg/100 g); X4: epicatechingallato (mg/100 g); X5: vanillicacid (mg/100 g); X6: total phenols (mg GAE/100 g); X7: tannincondensaded (mg CE/ g); X8: total flavonoids (mg QE/100 g); X9: cyanidin-3-glucoside (mg/100g); X10: peonidin-3-galactoside (mg/100g).

Discussion

The content of total phenolic in the present study are according to Maldonado-Astudillo (21), who reported similar results (544 to 416 mg EAG/100g) in the pulp of this variety grown in another state of Mexico. The changes in total phenolic is triggered by the loss of water during the ripening of the climatic fruits and it is denoted by its softness increment, perhaps it can be explained by the progressive structural rearrangement of the cell wall, loss of pectin and hemicelluloses interconnection, which is important because some phenolic compounds are trapped in the pectin chains of the cell wall (22).

The values of flavonoids in the peel are consistent with Foluso (23), who indicate that the total flavonoid content in mango peel is 449 mg EQ/100 g. In contrast, the pulp of several citrus flavonoid productions decreases or even stops during cell elongation and subsequent of leaves and ripening (11), which could explain why in Manila mango the content remains constant during the ripening of the pulp; additionally, flavonoids are great antioxidants with health benefit effects; there are known to hold antiproliferative and antitumor growth properties, making them a potential anticancer agent (24).

The values of tannin or proanthocyanidin in Manila mango are similar to those stated by Rashmi (25), who reported content of 3.5-10.6 mg/g and 8-14 mg/g in pulp and peel, respectively in seven Indian mango varieties (Banganapaglli, Alphonso, Totapuri, Mylupilian, Dusheri, Langra, and EC-95862). Unripe fruits usually have high tannin content that helps to protect them from environmental factors and to prevent them from herbivores animals. It appears that the degree of polymerization changes during fruit ripening; however, the content varies based on the type of fruit and the environmental factors, like temperature and humidity, among others (26).

The anthocyanin content in Manila mango is in agreement with López-Cobo (27), who reported a concentration range of 1.1 to 5.3 mg/100 g in mango peel, and in pulp is approximately about half to ten times less compared to its peel. The peonidin content has a higher concentration than cyanidin because the cyanidin contain the o-diphenol structure on the B ring, which is more sensitive to oxidation than other flavonoids. Anthocyanins have also been seeming to protect flavonoids from oxidation, which play a greater role in plants to attract insects in order to spread pollen and seeds, encouraging the survival and reproduction of the plants (28).

Regarding to HPLC quantification, this study concur with other studies finding gallic acid as the major polyphenol present in mango varieties such as the “Keiit” (47 mg/100 g) and “Kensington pride” (906 mg/100 g) in peel (29). The importance of gallic acid in human health is that it can exert its cytotoxic and antitumor effect because of modulation in antioxidant/pro-oxidant balance (30).

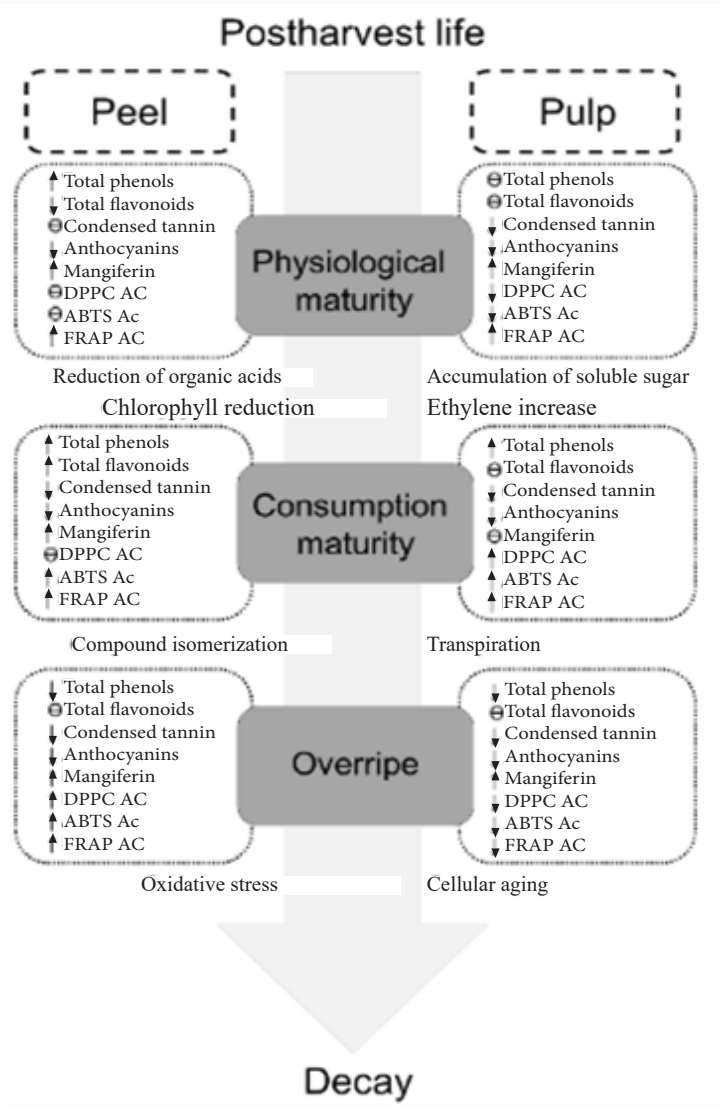
Mangiferin content is agree with 11 varieties of mango reported from China, it was found between 0.2-20 mg/100 g in pulp and 4-749 mg/100 g in the peel (31). Some authors suggest that mangiferin increases as fruit mature, perhaps due to the xanthophylls generation, as products of the condensation of flavanols with glyoxylic acid, lactone, and xanthylium structures during ripening (24). Studies have suggested that mangiferin ameliorates insulin resistance by the inhibition of both glucose uptake and insulin signaling, which facilitates the translocation of glucose transporter type 4 and stimulates glucose uptake (32).

The content of catechin in peel are similar to the ones reported by Da Silva Sauthier (33) which indicates a value of 22.4 mg/100 g in peel and 7.71 mg/100 g in the pulp of "Rosa" and "Espada" mangos, respectively. The decrement of catechin and epicatechin during ripening, could be because the corresponding quinone methide is catalyzed by the enzyme PPO (polyphenol oxidase), which is known to increase significantly as the mango fruit matures (26). Regarding the health benefits associated with these compounds, some authors have pointed its cardioprotective effect, such as reducing levels of cholesterol and very-low-density lipoprotein (VLDL) (34).

In addition, the particular case of vanillic acid presents a similar pattern with other mango varieties, this phenomenon has been reported by Da Silva Sauthier (33). In other studies, the concentration of this compound is 1.59 mg/100 g, 0.59 mg/100 g, and 2.67 mg/100 g for Keiit, Osteen, and Sensación variety, respectively (27). Variations regarding the concentrations of the quantified compounds can be attributed to ontogenetic factors, that can modify the production of secondary metabolites by directly influencing the expression of the fruit genes (35).

The fact of a higher antioxidant capacity in the peel of mango which agrees with the hypothesis of the peel of mango has a role in defense (delay, control or inhibit) against various biotic and abiotic stress conditions during fruit development. It can be seen that the antioxidant potential by DPPH assay in the pulp of the Manila mango is within the ranges of 20-75 mmol/100 g reported in six different flesh of Thailand mango cultivars (36). In contrast, the antioxidant potential in the peel is lower compared to Blancas-Benitez (2), who report concentrations of 790 mmol/100 g. These differences may be due to the maturity stage of the plant tissue or exposure to biotic and abiotic stresses can directly influence the genes that express the metabolic enzymes which are required for the synthesis of several compounds that directly influence the antioxidant potential.

The antioxidant capacity measurement by ABTS assay were comparable to the ones described by Blancas-Benitez (2), with concentrations of 116.01 mmol/100 g in the peel of Mexican mango Ataulfo variety, and pulp presented ranges



Θ: without changes; ↑: increase; ↓: lowering; AC: antioxidant capacity

Figure 3. Biochemical adaptation of polyphenols in Manila mango.

between 3.4±0.3 to 8.5±0.5 mmol/100 g DW. The increase in antioxidant power may be exposed to high storage since this process exhibit elevated levels of oxidation in itself; before disrupting cellular membranes and release naturally sequestered oxidants during fruit respiration process. In parallel, the result of FRAP assay in the present study is smaller than that reported in Australian mangos peel (concentrations of 2-25.5 mg/g of ascorbic acid equivalents), which can be explained by the type of standard used to quantify it.

Lastly, the greater correlation between vanillic acid and antioxidant capacity in linear regression may be due to the fact that the major polyphenols in Manila mango are phenolic acids, which are small molecules, and therefore can react with the radical and be more reactive, resulting in higher antioxidant capacity by FRAP assay. Other reason for the FRAP assay may be promoted principally by flavonoid content in multiple regression is that only quercetin and myricetin found to chelate Fe2+, even though others flavonoids like kaempferol, quercetin, myricetin, luteolin, naringenin, and catechin are capable of complexing Fe3+ (37).

The results indicate that the mechanism of action by phenols in pulp and peel of Manila mango is variable and, including electron-donating ability, hydrogen atom transfer, and the chelation of catalytic metals; it´s important to consider that the effect of antioxidant concentration depends on many intrinsic factors, including the structure of the antioxidant, and oxidation conditions during mango ripening process. The mechanism by which antioxidants exert their effects may vary depending on the polyphenolic compositional of the food, including its minor components in response to the initiation of ripening as described in Figure 3.

Furthermore, the health benefit effects of eating plant foods have been ascribed, in part, to the presence of phenolics, which are associated with other mechanisms of action in addition to its antioxidant capacity, such as apoptosis of cancerous cells, effects on cell differentiation, blocking the formation of N- nitrosamine, and affecting enzyme activity, among others (35); thus, the action mechanism by which beneficial health effects of phenolics are rendered may follow one or more mechanisms.

Conclusions

The first profile of phytochemical compounds in mango Manila during several ripeness stages was obtained. Likewise, this study confirm mango peel is considered a major location of polyphenols within the whole fruit, which gives the possibility of the mango peel will be able to integrate in the

food industry. Also, Manila mango peel and pulp has a high bioactive potential due to its mangiferin content and to the antioxidant expression of the other functional compounds like flavonoids and tannins, in as much as the aforementioned phytochemicals showed a significant correlation with antioxidant capacity.

It should be noted, that the knowledge of the concentration of bioactive structures in the peel of Manila mango allows us to obtain information to implement extraction and drying techniques to give it greater added value as a functional food and to compete in the international market with high-quality products.

Conflict of interest

The authors declare that they have not conflicts of interest with the contents of this paper.

Acknowledgement

The authors thank CONACyT (Consejo Nacional de Ciencia y Tecnologia) for the graduate scholarship number 291236, and also to the National Technological from Mexico (Tecnologico Nacional de Mexico) for its support to this research (grant 7668.20-P).

References

1. SIAP-SAGARPA. Panorama agroalimentario 2020. Disponible: https://www.inforural.com.mx/wp-content/uploads/2020/11/Atlas-Agroalimentario-2020.pdf
2. Blancas-Benitez FJ, Mercado-Mercado G, Quirós-Sauceda AE, Montalvo-González E, González-Aguilar GA, Sáyago-Ayerdi SG. Bioaccessibility of polyphenols associated with dietary fiber and in vitro kinetics release of polyphenols in Mexican 'Ataulfo' mango (*Mangifera indica* L.) by-products. Food Funct 2015;6:859–68.
3. Soria-Lara D, Gaitan-Velez BV, Jiménez-Islas H, Miranda-Lopez R. El Sistema de Endocannabinoides como regulador de la lipogénesis y su posible modulación por la mangiferina. Revista Biomédica 2019; 30:2:83-102.
4. Abbasi AM, Liu F, Guo X, Fu X, Li T, Liu RH. Phytochemical composition, cellular antioxidant capacity and antiproliferative activity in mango (*Mangifera indica* L.) pulp and peel. Int J Food Sci Technol 2017;52:817–26.
5. Rodríguez-González S, Gutiérrez-Ruíz IM, Pérez-Ramírez IF, Mora O, Ramos-Gomez M, Reynoso-Camacho R. Mechanisms related to the anti-diabetic properties of mango (*Mangifera indica* L.) juice by-product. J. ofFunct. Foods 2017;37:190–9.
6. Robles-Sánchez M, Astiazarán-García H, Martín-Belloso O, Gorinstein S, Alvarez-Parrilla E, de la Rosa LA, *et al*. Influence of whole and fresh-cut mango intake on plasma lipids and antioxidant capacity of healthy adults. Food Res. Int. 2011;44:1386–91.
7. Kuskoski EM, Asuero AG, Morales MT, Fett R. Frutos tropicais silvestres e polpas de frutas congeladas: atividade antioxidante, polifenóis e antocianinas. Cienc Rural 2006;36:1283–7.
8. Santoyo-Juárez JA, Martínez-Alvarado CO. Nuevas variedades de mango con potencial para el sur de Sinaloa. Fundación Produce Sinaloa AC. 2008.
9. Consejo Nacional del Sistema Producto Mango. Plan Rector Nacional de Sistema Producto Mango. Comité Nacional Sistema Producto Mango, 2012.
10. Secretaría del Gobierno de México-Secretaria de Economía. Norma Mexicana para Productos alimenticios no industrializados para consumo humano – fruta fresca – mango (*Mangifera indica* L.) – especificaciones (NMX-FF-058-SCFI-2006). 2006.
11. Palafox-Carlos H, Yahia E, Islas-Osuna MA, Gutierrez-Martinez P, Robles-Sánchez M, González-Aguilar GA. Effect of ripeness stage of mango fruit (*Mangifera indica* L., cv. Ataulfo) on physiological parameters and antioxidant activity. Sci. Hortic. 2012;135:7–13.
12. Ajila C, Naidu K, Bhat S, Rao U. Bioactive compounds and antioxidant potential of mango peel extract. Food Chem. 2007;105:982–8.
13. Singleton VL, Orthofer R, Lamuela-Raventós RM. Analysis of total phenols and other oxidation substrates and antioxidants by means of folin-ciocalteu reagent. Meth. Enzymol, 1999, p. 152–78.
14. Papoti VT, Xystouris S, Papagianni G, Tsimidou MZ. "Total flavonoid" content assessment via aluminum [Al (III)] complexation reactions. What we really measure? Ital. J. Food Sci. 2011;23:252–9.
15. Butler LG, Price ML, Brotherton JE. Vanillin assay for proanthocyanidins (condensed tannins): modification of the solvent for estimation of the degree of polymerization. J Agric. Food Chem. 1982;30:1087–9.
16. Lao F, Giusti MM. Quantification of Purple Corn (*Zea mays* L.) Anthocyanins Using Spectrophotometric and HPLC Approaches: Method Comparison and Correlation. Food Anal Methods 2016;9:1367–80.
17. Palafox-Carlos H, Yahia EM, González-Aguilar GA. Identification and quantification of major phenolic compounds from mango (*Mangifera indica*, cv. Ataulfo) fruit by HPLC–DAD–MS/MS-ESI and their individual contribution to the antioxidant activity during ripening. Food Chem. 2012;135:105–11.
18. Xie J, Schaich KM. Re-evaluation of the 2,2-Diphenyl-1-picrylhydrazyl Free Radical (DPPH) Assay for Antioxidant Activity. J Agric Food Chem 2014;62:4251–60.

19. Re R, Pellegrini N, Proteggente A, Pannala A, Yang M, Rice-Evans C. Antioxidant activity applying an improved ABTS radical cation decolorization assay. Free Radic. Biol. Med. 1999;26:1231–7.
20. Griffin SP, Bhagooli R. Measuring antioxidant potential in corals using the FRAP assay. J. Exp. Mar. Biol. Ecol. 2004;302:201–11.
21. Maldonado-Astudillo YI, Navarrete-García HA, Ortiz-Morales ÓD, Jiménez-Hernández J, Salazar-López R, Alia-Tejacal I, *et al*. Propiedades físicas, químicas y antioxidantes de variedades de mango crecidas en la costa de Guerrero. Rev. Fitotec 2016;39:207–2014.
22. Cárdenas-Coronel WG, Velez-De la Rocha R, Siller-Cepeda JH, Osuna-Enciso T, Muy-Rangel MD, Sañudo-Barajas JA. Cambios en la composición de almidón, pectinas y hemicelulosas durante la maduración de mango (*Mangifera indica* cv. Kent). Rev. Chapingo 2012;18:5–19.
23. Foluso AO, Makinde A, Adeyemi I, Timothy V. Bioactive components, antioxidative properties and inhibition of Fe2+-induced lipid peroxidation of mango peel as affected by the storage of mango fruit. IJFS 2016;5:131–45.
24. Barreca D, Mandalari G, Calderaro A, Smeriglio A, Trombetta D, Felice MR, *et al*. Citrus Flavones: An Update on Sources, Biological Functions, and Health Promoting Properties. Plants 2020;9:288.
25. Rashmi MA, Abraham V, Shivashankar S, Chakravarthy AK, Sumathi M, Subhash K. Does change in tannin content in mango (*Mangifera indica*) fruits influence the extent of fruit fly (Bactrocera dorsalis Hendel) herbivory? J. Entomol. Zool. Stud. 2017;54:381–385.
26. Oliveira J, Mateus N, de Freitas V. Flavanols: Catechins and Proanthocyanidins. In: Ramawat KG, Mérillon J-M, editors. Natural Products. 2013, p. 1753–1801.
27. López-Cobo A, Verardo V, Diaz-de-Cerio E, Segura-Carretero A, Fernández-Gutiérrez A, Gómez-Caravaca AM. Use of HPLC- and GC-QTOF to determine hydrophilic and lipophilic phenols in mango fruit (*Mangifera indica* L.) and its by-products. Food Res Int. 2017;100:423-434.
28. Zhao C, Wang F, Lian Y, Xiao H, Zheng J. Biosynthesis of citrus flavonoids and their health effects. Crit Rev Food Sci Nutr.2018, p. 1–18.
29. Peng D, Zahid HF, Ajlouni S, Dunshea FR, Suleria HAR. LC-ESI-QTOF/MS Profiling of Australian Mango Peel By-Product Polyphenols and Their Potential Antioxidant Activities. Processes Biochem. 2019;7:764.
30. Kahkeshani N, Farzaei F, Fotouhi M, Alavi SS, Bahramsoltani R, Naseri R, *et al*. Pharmacological effects of gallic acid in health and disease: A mechanistic review. Iran J Basic Med Sci. 2019;22(3):225-237.
31. Luo F, Lv Q, Zhao Y, Hu G, Huang G, Zhang J, *et al*. Quantification and Purification of Mangiferin from Chinese Mango (*Mangifera indica* L.) Cultivars and Its Protective Effect on Human Umbilical Vein Endothelial Cells under H2O2-induced Stress. IJMS 2012;13:11260–11274.
32. Qian Q, Tang M, Li X, Cao Q, Zhu Z. Mangiferin ameliorates insulin resistance in a rat model of polycystic ovary syndrome via inhibition of inflammation. Trop. J. Pharm. Res. 2020;19:89–94.
33. Da Silva Sauthier MC, da Silva EGP, da Silva Santos BR, Silva EFR, da Cruz Caldas J, CavalcanteMinho LA, *et al*.Screening of *Mangifera indica* L. functional content using PCA and neural networks (ANN). Food Chem. 2019;273:115-123.
34. Feng J, Yang J, Chang Y, Qiao L, Dang H, Luo K, *et al*. Caffeine-free hawk tea lowers cholesterol by reducing free cholesterol uptake and the production of very-low-density lipoprotein. Commun. Biol. 2019;2:173. https://doi.org/10.1038/s42003-019-0396-4
35. Ruiz-Montañez G, Ragazzo-Sánchez JA, Calderón-Santoyo M, Velázquez-de la Cruz G, Ramírez de León JA, Navarro-Ocaña A. Evaluation of extraction methods for preparative scale obtention of mangiferin and lupeol from mango peels (*Mangifera indica* L.). Food Chem. 2014;159:267–272.
36. Rumainum IM, Worarad K, Srilaong V, Yamane K. Fruit quality and antioxidant capacity of six Thai mango cultivars. Agric. Nat. Resour. 2018;52:208-214.
37. Fernandez MT, Mira ML, Florêncio MH, Jennings KR. Iron and copper chelation by flavonoids: an electrospray mass spectrometry study. J. Inorg. Biochem. 2002;92:105-111.

Recibido: 05/10/2020
Aceptado: 10/03/2021

ARCHIVOS LATINOAMERICANOS DE NUTRICIÓN
Revista de la Sociedad Latinoamericana de Nutrición
Doi: 10.37527/2020.70.4.006

Vol. 70 N° 4, 2020
Artículo de Revisión

Desarrollo de preferencias alimentarias saludables en etapas tempranas de la vida

Mónica Mazariegos[1]

Resumen: Desarrollo de preferencias alimentarias saludables en etapas tempranas de la vida. El deterioro de la calidad de la dieta está afectando la salud de los niños menores de dos años. Por tal motivo, es de vital importancia la identificación de factores relacionados con el desarrollo y establecimiento de preferencias alimentarias en etapas tempranas de la vida y brindar recomendaciones que faciliten su adopción. Esta revisión sistemática de la literatura tiene como objetivo resumir la evidencia existente sobre los factores asociados a formar y modelar las preferencias alimentarias en etapas tempranas de la vida. Para esto se realizó una búsqueda en PubMed de estudios que evaluaran la asociación entre la exposición prenatal y posnatal de sabores, introducción temprana de alimentos y habituación al sabor dulce, alimentación complementaria y diversidad dietética. Se incluyeron artículos publicados desde el 2000 hasta el 2019. Resultados de 39 artículos sugieren que la alimentación durante los primeros dos años de vida y el desarrollo de preferencias alimentarias en etapas tempranas de la vida tiene el potencial de modificar los patrones de alimentación y establecerse en etapas posteriores de la vida, por lo que, los primeros mil días de vida constituyen una ventana de oportunidad para formar preferencias alimentarias saludables y mejorar la calidad de dieta de los niños. **Arch Latinoam Nutr 2020; 70(4): 282-289.**

Palabras clave: Preferencias alimentarias, lactancia humana, alimentación complementaria, dieta

Summary: Development of healty food preferences early in life. Poor diets are damaging children's health. Therefore, it is urgent to identify factors related to the development and establishment of healthy food preferences early in life and to provide recommendations to enable their adoption. This systematic literature review aims to summarize the existing evidence on the factors identified on shaping food preferences early in life. For this, a search was conducted on PubMed about studies evaluating the association between prenatal and postnatal exposure of flavors and the development of food preferences, early food introduction, innate preference to sweet taste, complementary feeding and dietary diversity with the development of food preferences. Articles published from 2000 to 2019 were included. Results from 39 manuscripts suggest that the first 2 years of life are critical for the development of food preferences early in life. These food preferences have the potential to modify children's eating patterns and persist later in life. Therefore, the first 1000 days of life are a key window of opportunity to establish healthy food preferences and shape the quality of children's diet. **Arch Latinoam Nutr 2020; 70(4): 282-289.**

Key words: Food preferences, breastfeeding, human lactation, complementary feeding, diet.

Introducción

Los niños presentan una mayor vulnerabilidad a la oferta actual del sistema alimentario debido a que están creciendo en un ambiente obesogénico que promueve agresivamente los sucedáneos de la leche materna y el consumo de productos ultraprocesados ricos en azúcares añadidos, sodio y grasas saturadas, los cuales promueven la ganancia de peso y el deterioro de la calidad de la dieta (1). Las respuestas biológicas y de comportamiento con que los niños responden a este ambiente obesogénico son formadas incluso desde antes del nacimiento, durante la lactancia y los primeros años de vida (2).

Frente al deterioro de la calidad de la dieta de los niños es de vital importancia la identificación de factores relacionados con el desarrollo y establecimiento de preferencias alimentarias en etapas tempranas de la vida y brindar recomendaciones que faciliten su adopción. Por tal motivo, se realizó una revisión sistemática de literatura con el objetivo de resumir la evidencia

[1]Centro de Investigación del INCAP para la Prevención de Enfermedades Crónicas (CIIPEC). Instituto de Nutrición de Centro América y Panamá (INCAP)
Autor para la correspondencia: Mónica Mazariegos, email: momazariegos@incap.int

existente sobre los principales factores asociados a modelar y formar las preferencias alimentarias y la calidad de la dieta en los niños a etapas tempranas de la vida –incluso en la vida uterina-.

Materiales y métodos

Se realizó una revisión sistemática de la literatura siguiendo las directrices PRISMA (3). Se realizó una búsqueda en la base de datos de PubMed de estudios que evaluaran la asociación entre la exposición prenatal y postnatal de sabores y el desarrollo de preferencias alimentarias, la introducción temprana de alimentos y habituación al sabor dulce, la alimentación complementaria y diversidad dietética en el desarrollo de las preferencias alimentarias en los niños menores de dos años publicados entre el 2000 y el 2019. La estrategia de búsqueda electrónica se realizó haciendo combinaciones de términos relacionados con las preferencias alimentarias (*food preferences*) con palabras clave para las cada uno de los siguientes términos: dieta materna: *diet AND pregnancy*; lactancia materna: *breastfeeding, breast-feeding, human milk, breast-milk, lactation*; introducción temprana de alimentos y habituación al sabor dulce: *early food introduction, taste preferences, early preferences*; y alimentación complementaria y diversidad dietética: *complementary feeding, food diversity*.

Los criterios de inclusión considerados para esta revisión fueron: 1. Especificación de tamaño de muestra, tipo de estudio, tiempo de seguimiento (si aplica), definición de variables de estudio, fuentes de información, ajuste por variables confusoras, país y año donde se llevó a cabo y resultados detallados. Se excluyeron aquellos artículos que no cumplieran con los requisitos anteriores y que proporcionaran información incompleta.

Se identificaron 118 artículos, de estos 79 fueron eliminados y 39 cumplieron con los criterios de inclusión. De cada artículo se extrajeron los siguientes datos: autor, tipo de estudio, tamaño de la muestra, variables de estudio clave y resultados principales. Para presentar y resumir los resultados, se utilizó la síntesis narrativa debido a que la revisión incluyó una amplia gama de diseños de investigación, tipos de datos y medidas, que no se pudieron resumir utilizando métodos cuantitativos (4). Los resultados se agruparon en tres grupos: 1) exposición prenatal y postnatal a sabores y su influencia en el desarrollo de preferencias alimentarias, 2) implicaciones de la habituación al sabor dulce en el establecimiento de preferencias alimentaria y el deterioro de la calidad de la dieta y 3) alimentación complementaria y diversidad dietética como factores clave para formar preferencias y hábitos alimentarios saludables.

Resultados

Exposición prenatal y postnatal a sabores y su influencia en el desarrollo de preferencias alimentarias

La dieta de la madre durante el embarazo y la lactancia tienen el potencial de modificar los patrones de alimentación y establecerse en etapas posteriores a lo largo de la vida (2, 5). Se ha observado que los niños hijos de madres que mantuvieron una dieta saludable y variada durante el embarazo tienen una mayor aceptación a ciertos alimentos en la etapa de alimentación complementaria y posteriores, condición que no se presenta en niños que fueron alimentados con fórmula ya que han sido expuestos a un sabor monótono (2, 6). También, aunque existe escasa evidencia se ha documentado que los hijos de madres que durante el embarazo y lactancia tuvieron un alto consumo de productos ultraprocesados, presentan un mayor consumo de estos en etapas posteriores de la vida (7, 8). La explicación biológica de como la dieta de la madre modela las preferencias alimentarias en los niños es que hay transmisión de sabores de los alimentos ingeridos (ej.: frutas, verduras y especies) por la madre al niño vía líquido amniótico en la vida uterina y por la leche materna durante la etapa de lactancia (2, 9, 10). Por lo tanto, debido a que tanto el líquido amniótico como la leche materna contienen partículas volátiles derivadas de los alimentos que forman parte de la dieta de la madre, los lactantes reciben y aprenden sabores antes de iniciar a recibir alimentos sólidos (11). Lo anterior, puede hacer que acepten una mayor cantidad de alimentos en la etapa de alimentación complementaria debido a que han tenido una exposición repetida a estos incluso antes de nacer (9). Por el contrario, los sucedáneos de la leche materna ofrecen un sabor monótono, ya que solamente ofrecen el sabor característico del tipo y marca de fórmula con la que se

alimente al lactante. En general, las fórmulas pueden variar en sabor según el tipo y grado de procesamiento. Por ejemplo, las fórmulas con proteína hidrolizada se caracterizan por tener un sabor amargo debido a un alto contenido de glutamato y compuestos sulfurados, y existe evidencia de que los lactantes alimentados con este tipo de fórmula han demostrado mayor aceptación de alimentos con sabor amargo y de vegetales crucíferos como el brócoli y la coliflor (12-14).

Entre los alimentos y especies que transmiten su sabor vía líquido amniótico y que se refuerzan a través de la lactancia materna después del nacimiento son la zanahoria, el queso azul, ajo, menta, anís, vainilla, curri y ciertas frutas (15). Otra explicación desde una perspectiva evolutiva indica que a través de la transmisión y familiarización de sabores a etapas tempranas la madre le está indicando al lactante que alimentos son seguros para su consumo (16). Por lo anterior, se puede decir que la leche materna expone al lactante a los sabores de los alimentos que son parte de la dieta de la madre y de su cultura alimentaria. Mientras que los bebés alimentados con fórmula solamente pueden diferenciar sabores entre los tipos y marcas de la misma (13).

Por otro lado, la genética también influye en la aceptación de sabores. Por ejemplo, el polimorfismo del gen TAS2R38 ha sido asociado con el aumento a la sensibilidad del sabor amargo (17, 18). Existe evidencia que sugiere que la mayor sensibilidad a cierto sabor puede influir en las preferencias alimentarias, ya que niños y adultos con este polimorfismo han reportado un menor consumo de alimentos con sabor amargo en comparación con sus pares que no lo tienen y han reportado mayor consumo de alimentos dulces y bebidas azucaradas. Sin embargo, la etnicidad tiene una asociación más fuerte con el gusto por el sabor dulce que el polimorfismo del gen TAS2R38 por lo que se ha sugerido que las experiencias previas y la cultura alimentaria podrían invalidar los efectos de este sobre las preferencias alimentarias a lo largo de la vida (18, 19).

En general, la intensidad de los sabores en la leche materna es alta en las horas posteriores a la alimentación y este va disminuyendo progresivamente (20). El tipo e intensidad del sabor en la leche materna dependerá del alimento consumido y será diferente entre los tiempos de comida ya que dependerá de la dieta usual de la madre (20). La leche materna ayudará a aumentar la aceptación y consumo de alimentos saludables como frutas y verduras, solamente si estos son parte de la dieta usual de la madre durante el embarazo y el periodo de lactancia (10, 21). Se ha sugerido que la leche materna es el vínculo entre las experiencias sensoriales en la vida uterina y aquellas dadas por los alimentos sólidos (20). La evidencia sugiere que las experiencias sensoriales que los niños tienen con la transmisión y exposición a sabores por medio del líquido amniótico y la leche materna explica el que los niños sean menos selectivos y sean más abiertos a probar diferentes alimentos (2). La importancia de esto radica en que es muy probable que los niños lleven estas preferencias a etapas posteriores de la vida, contribuyendo al establecimiento de hábitos alimentarios saludables y mejorando la calidad de la dieta en la edad adulta (2, 9, 11). También, es importante mencionar que independientemente de la forma de alimentación en los primeros meses de vida (leche materna o fórmula láctea), se puede promover y fomentar que el niño desarrolle preferencias alimentarias saludables mediante la exposición repetida a alimentos con diferentes sabores y texturas (2).

Implicaciones de la habituación al sabor dulce en el establecimiento de preferencias alimentarias y el deterioro de la calidad de la dieta

El sabor es uno de los determinantes del consumo de alimentos, es el resultado de sistemas organolépticos como el gusto y el olor (6, 22). Tanto el sentido del gusto como el del olfato están bien desarrollados en el tercer trimestre del embarazo y para las 35 semanas de gestación el feto ya puede percibir sabores básicos como el dulce (23). A las pocas horas de nacer, los bebés demuestran rápidamente una fuerte preferencia por los sabores dulce y umami, y aversión por los sabores ácido y amargo (6, 24). Se ha descrito que los seres humanos tienen un gusto innato por el sabor dulce, esto quiere decir que no es un gusto aprendido (2).

El gusto por el sabor dulce es universal y se ha demostrado que es consistente en niños de todas partes del mundo, al disminuir el llanto y reacciones de dolor cuando estos están pasando por situaciones incómodas como la aplicación de inyecciones. Por tal motivo, se ha relacionado el sabor dulce como un mecanismo de recompensa (2, 25). También, se ha sugerido que los niños tienen preferencia por

los alimentos dulces debido a una condición de supervivencia, ya que este tipo de alimentos suelen tener mayor contenido de calorías en periodos de crecimiento acelerado en comparación con los alimentos amargos, por los cuales presentan naturalmente un rechazo (26, 27).

El gusto innato por los sabores dulce y salado puede ser magnificado durante los primeros años de vida al tener una exposición temprana y repetida a este, aumentado la respuesta hedónica (28). Se ha sugerido que exposiciones tempranas a azúcares, sodio y grasas pueden aumentar el riesgo de obesidad por sus características sensoriales que los hacen particularmente palatables y de fácil consumo (2, 29). Sin embargo, las experiencias relacionadas con la transmisión de sabores a edades tempranas de la vida y la exposición repetida a estos junto con una dieta adecuada pueden desarrollar, modelar y establecer preferencias de alimentos saludables y disminuir el gusto innato a ciertos sabores y nutrientes críticos (2).

Alimentación complementaria y diversidad dietética: factores clave para formar preferencias y hábitos alimentarios saludables

La alimentación complementaria adecuada para los lactantes se refiere a la introducción de alimentos seguros y ricos nutricionalmente, además de la lactancia materna, a los seis meses de edad, y que se proporciona generalmente de los 6 a los 23 meses (30). La etapa más importante para formar hábitos y preferencias saludables es la etapa de alimentación complementaria, ya que es en esta donde los niños tienen la experiencia y reciben el contacto a un sin número de texturas y sabores. Los mayores predictores de la aceptación de alimentos son el sabor de los alimentos, la duración de la lactancia y si la madre incluyó en su dieta esos alimentos durante el embarazo, y la exposición repetida a estos alimentos durante el periodo de introducción de alimentos (en promedio de 8 a 10 días) (2, 31). El exponer repetidamente a cierto alimento no significa que no deban incluirse otros alimentos en ese periodo, es más, resultados de estudios indican que el aumentar la variedad de exposición a diferentes sabores facilitan su posterior aceptación (32, 33).

Algunos de los sabores que han sido mayormente documentados en estudios controlados aleatorizados que se aceptan con mayor facilidad tras una exposición repetida son entre las frutas, el melocotón, banano y pera; algunas verduras, como la zanahoria, espinaca y arvejas; cereales como la papa; y algunas especias como vainilla, menta, anís y ajo (2, 10, 21, 34-36). También se ha documentado que el preparar alimentos como cereales y papillas con leche materna aumentan la aceptación y el consumo de los mismos, probablemente porque mejoran su palatabilidad al tener sabores que le resultan familiares (20, 37).

Existe evidencia que sugiere que, al dar alimentos nuevos a los niños, las madres suelen fijarse más en las expresiones faciales que ellos hacen más que en la cantidad de alimento consumida (20). Por tal motivo, se sugiere que las madres no presten tanta atención a las expresiones faciales ya que estas pueden hacer que la madre ceda con mayor facilidad y no le continúe brindando un determinado alimento (20). También, es importante enfatizar que una vez desarrollada la preferencia a cierto alimento, se procure que este sea parte de la dieta familiar para aumentar la exposición al mismo y mantener la preferencia alimentaria a lo largo de la vida (2).

Además de la exposición repetida a un alimento, el contexto social es un factor importante en la formación de preferencias alimentarias saludables, se han observado resultados positivos en la aceptación de alimentos cuando el ambiente es positivo y calmado. Particularmente en el periodo de los dos a los cinco años la influencia de los padres, cuidadores, hermanos, compañeros y niños más grandes pueden influir en sus preferencias (12). Por ejemplo, hay evidencia que muestra que niños a los que no les gustaban las frutas y verduras y que observaron a otros niños consumirlas, posteriormente prefirieron comer dichos alimentos (38, 39). Los niños de entre dos y cinco años incrementan su atención al ambiente, son conscientes del lugar donde se llevan a cabo las comidas e interactúan con otros niños y adultos de su entorno, como resultado de esta interacción se forman hábitos alimentarios y de estilo de vida influenciados por el ambiente en el que se desarrollan (39, 40).

Las preferencias alimentarias cambiaran a lo largo de la vida y a medida que tanto la edad como el nivel de desarrollo avance. También, es importante considerar que otros factores

Fuente: Elaboración propia con base en evidencia científica y conocimiento experto.

Figura 1. Factores individuales y contextuales con el potencial de formar preferencias alimentarias saludables y mejorar la calidad de la dieta desde etapas tempranas de la vida

más complejos como el nivel educativo, estado de salud, tipo de actividad, creencias y cultura, nivel socioeconómico y el contexto ambiental y social entrarán en juego para modelar las preferencias y hábitos alimentarios. Por lo que desarrollar hábitos saludables en etapas tempranas será fundamental para facilitar su persistencia a lo largo del curso de vida (33). En la Figura 1 se presentan los factores individuales y contextuales que con su interacción tienen el potencial de formar preferencias alimentarias saludables y mejorar la calidad de la dieta desde etapas tempranas de la vida. En el Cuadro 1 se presentan mensajes claves y recomendaciones derivadas de esta revisión de literatura.

Cuadro 1. Mensajes clave y recomendaciones para formar preferencias alimentarias saludables en etapas tempranas de la vida

- Los primeros mil días de vida constituyen una ventana de oportunidad para formar las preferencias alimentarias y mejorar la calidad de la dieta del niño pequeño.
- Debido a que los niños aceptan y consumen con mayor facilidad los alimentos que tienen sabores con los que se encuentran familiarizados, se recomienda que la alimentación de la madre durante el embarazo sea saludable y variada para que estén expuestos a una amplia variedad de sabores vía líquido amniótico y posteriormente vía la leche materna.
- Apoyar a las madres para lograr un establecimiento exitoso de la lactancia materna exclusiva durante los primeros seis meses de vida y para que la continúen hasta los dos años de edad (si la madre y el niño así lo desean) para que la exposición repetida a diferentes sabores por medio de la leche materna sea lo más prolongado posible.
- Después de los seis meses de edad, al inicio de la alimentación complementaria se recomienda una exposición repetida a alimentos sólidos saludables de diferentes sabores y texturas para fomentar y optimizar las preferencias y la calidad de la dieta del niño pequeño.
- Evitar la introducción temprana de líquidos diferentes a la leche materna, especialmente bebidas azucaradas y limitar su consumo durante todo el ciclo de vida.
- Evitar la introducción temprana (antes de los seis meses de edad) y el consumo de alimentos con alto contenido de azúcares añadidos y sodio ya que se puede magnificar el gusto innato que se tiene a estos sabores.
- Promover la diversidad dietética y evitar alimentos ultraprocesados con alto contenido de azúcares añadidos, grasas saturadas y sodio durante el periodo de alimentación complementaria y etapas posteriores de la vida.
- Establecer y monitorear las regulaciones sobre las estrategias de publicidad y mercadeo inapropiado y no ético de los sucedáneos de la leche materna y alimentos ultraprocesados dirigidos a niños.

Fuente: Elaboración propia con base en evidencia científica y conocimiento experto.

Discusión

La alimentación sana y variada durante el embarazo y la lactancia materna tienen el potencial de formar preferencias alimentarias saludables en etapas posteriores de la vida al exponer a los niños a una amplia variedad de sabores que los prepara para una alimentación saludable y más diversa. Sin embargo, la exposición prenatal y postnatal a diversos sabores por medio de la lecha materna puede verse afectada debido a las prácticas subóptimas de lactancia en la región (41, 42). Entre varios factores, la promoción agresiva de sucedáneos de la leche materna y fórmulas de crecimiento están socavando los esfuerzos para el adecuado establecimiento de lactancia (43, 44). Por otro lado, la habituación al sabor dulce tendrá implicaciones para la selección, consumo de alimentos y bebidas y posterior riesgo de sobrepeso y obesidad (28). La habituación al sabor dulce, el bajo costo y fácil disponibilidad de alimentos con alto contenido de azúcares añadidos ha aumentado la ingesta de snacks, galletas, dulces y bebidas azucaradas (45). A nivel mundial, el 43 % de los niños menores de seis meses reciben líquidos diferentes a la leche materna como agua azucarada, refrescos, café, té, miel o jugos artificiales magnificando el gusto por el sabor dulce y desplazando espacio gástrico para la leche materna (46, 47). La etapa más importante para formar hábitos y preferencias alimentarias saludables es la etapa de alimentación complementaria. Sin embargo, el alto consumo de snacks, dulces, jugos industriales y galletas están empeorando la calidad de las dietas y aumentando el riesgo de malnutrición tanto por déficit como por exceso (43). El ambiente obesogénico y el mercadeo no ético de sucedáneos de la leche materna y alimentos para niños pequeños, entre otros factores, dificulta la toma de decisiones de las madres o encargados de los niños y socaba los esfuerzos de apegarse a una alimentación saludable y variada.

Los resultados de esta revisión de literatura son relevantes para la salud pública y la práctica clínica por varios factores. Primero, a nivel poblacional es urgente establecer regulaciones sobre las estrategias de publicidad y mercadeo inapropiado y no ético de los sucedáneos de la leche materna (incluyendo fórmulas de seguimiento y crecimiento) y otros alimentos y bebidas comercializados para lactantes y niños. Segundo, sancionar las violaciones al Código Internacional de Sucedáneos de Leche Materna ya que, de no regularse, se promueve un ambiente obesogénico temprano y la ganancia acelerada de peso en niños de 0 a 36 meses. Tercero, mejorar la promoción y sostenimiento de la lactancia materna, por medio de una consejería guiada en nuevos aspectos de esta. Y, por último, promover la diversidad dietética e incluir en la consejería recomendaciones para evitar alimentos ultraprocesados (incluidas las fórmulas de seguimiento y crecimiento) con alto contenido de azúcares añadidos, grasas saturadas y sodio durante el embarazo, lactancia y el periodo de alimentación complementaria.

Conclusión

Los primeros mil días de vida son una ventana de oportunidad para formar y modelar las preferencias alimentarias y mejorar la calidad de dieta de los niños. La alimentación saludable y variada durante el embarazo y la lactancia materna tienen el potencial de formar preferencias alimentarias saludables en etapas posteriores de la vida al familiarizar a los niños con una amplia variedad de sabores que los prepara para una alimentación saludable y más diversa a medida que crecen. Lo anterior, junto con la implementación de medidas regulatorias necesarias para lograr ambientes alimentarios saludables es necesario para mejorar las prácticas de lactancia y la calidad de la dieta de los menores. Es necesario trasladar esta evidencia a la práctica clínica y a los tomadores de decisiones no solamente para mejorar la calidad de la dieta de los niños y sus preferencias alimentarias sino para reducir el riesgo de la malnutrición en todas sus formas.

Agradecimientos

La autora agradece a Andrea Sandoval por el redibujo de la figura 1.

Conflictos of interés:

El autor no tiene ningún conflicto de interés que declarar.

References

1. Baker P, Santos T, Neves PA, Machado P, Smith J, Piwoz E, *et al*. First-food systems transformations and the ultra-processing of infant and young child diets: The determinants, dynamics and consequences of the global rise in commercial milk formula consumption. Mater Child Nutr.n/a(n/a):e13097.
2. Mennella JA. Ontogeny of taste preferences: basic biology and implications for health. Am J Clin Nutr. 2014;99(3):704s-711s.
3. Moher D, Liberati A, Tetzlaff J, Altman DG, The PG. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLOS Medicine. 2009;6(7):e1000097.
4. Popay J, Roberts H, Sowden A, Petticrew M, Arai L, Rodgers M, *et al*., editors. Guidance on the conduct of narrative synthesis in systematic Reviews. A Product from the ESRC Methods Programme. Version 12006.
5. Cooke L, Fildes A. The impact of flavour exposure in utero and during milk feeding on food acceptance at weaning and beyond. Appetite. 2011;57(3):808-811.
6. Forestell CA, Mennella JA. The Ontogeny of Taste Perception and Preference Throughout Childhood. Handbook of Olfaction and Gustation: John Wiley & Sons, Inc; 2015. p. 795-828.
7. Bayol SA, Macharia R, Farrington SJ, Simbi BH, Stickland NC. Evidence that a maternal "junk food" diet during pregnancy and lactation can reduce muscle force in offspring. Eur J Nutr. 2009;48(1):62-65.
8. Bayol SA, Simbi BH, Bertrand JA, Stickland NC. Offspring from mothers fed a 'junk food' diet in pregnancy and lactation exhibit exacerbated adiposity that is more pronounced in females. J Physiol. 2008;586(13):3219-3230.
9. Beauchamp GK, Mennella JA. Early flavor learning and its impact on later feeding behavior. J Pediatr Gastroenterol Nutr. 2009;48 Suppl 1:S25-30.
10. Mennella JA, Jagnow CP, Beauchamp GK. Prenatal and postnatal flavor learning by human infants. Pediatrics. 2001;107(6):E88.
11. Ventura AK, Worobey J. Early influences on the development of food preferences. Curr Biol. 2013;23(9):R401-408.
12. Mennella JA, Beauchamp GK. Developmental changes in the acceptance of protein hydrolysate formula. Journal of developmental and behavioral pediatrics : JDBP. 1996;17(6):386-391.
13. Mennella JA, Forestell CA, Morgan LK, Beauchamp GK. Early milk feeding influences taste acceptance and liking during infancy. Am J Clin Nutr. 2009;90(3):780s-788s.
14. Mennella JA, Kennedy JM, Beauchamp GK. Vegetable acceptance by infants: effects of formula flavors. Early Hum Dev. 2006;82(7):463-468.
15. Mennella JA. Ontogeny of taste preferences: basic biology and implications for health. Am J Clin Nutr 2014;99(3):704s-711s.
16. Breslin Paul AS. An Evolutionary Perspective on Food and Human Taste. Current Biology. 2013;23(9):R409-R418.
17. Feeney E, O'Brien S, Scannell A, Markey A, Gibney ER. Genetic variation in taste perception: does it have a role in healthy eating? Proc Nutr Soc. 2011;70(1):135-143.
18. Mennella JA, Pepino MY, Reed DR. Genetic and environmental determinants of bitter perception and sweet preferences. Pediatrics. 2005;115(2):e216-222.
19. Ariza AC, Sánchez-Pimienta TG, Rivera JA. Percepción del gusto como factor de riesgo para obesidad infantil. Salud Pública Mex. 2018;60:472-478.
20. Mennella JA, Trabulsi JC. Complementary foods and flavor experiences: setting the foundation. Ann Nutr Metab. 2012;60 Suppl 2:40-50.
21. Forestell CA, Mennella JA. Early determinants of fruit and vegetable acceptance. Pediatrics. 2007;120(6):1247-1254.
22. Schwartz C, Chabanet C, Lange C, Issanchou S, Nicklaus S. The role of taste in food acceptance at the beginning of complementary feeding. Physiol Behav. 2011;104(4):646-652.
23. Mistretta CM, Bradley RM. Development of the Sense of Taste. In: Blass EM, editor. Developmental Psychobiology and Developmental Neurobiology. Boston, MA: Springer US; 1986. p. 205-236.
24. Rosenstein D, Oster H. Differential facial responses to four basic tastes in newborns. Child Dev. 1988;59(6):1555-68.
25. Stevens B, Yamada J, Ohlsson A, Haliburton S, Shorkey A. Sucrose for analgesia in newborn infants undergoing painful procedures. Cochrane Database Syst Rev. 2016;7(7):Cd001069.
26. Mennella JA, Ventura AK. Early feeding: setting the stage for healthy eating habits. Nestle Nutr Workshop Ser Paediatr Programme. 2011;68:153-163.
27. Drewnowski A. Sensory control of energy density at different life stages. Proc Nutr Soc. 2000;59(2):239-244.
28. Ventura AK, Mennella JA. Innate and learned preferences for sweet taste during childhood. Curr Opin Clin Nutr Metab Care. 2011;14(4):379-384.
29. Adair LS. How could complementary feeding patterns affect the susceptibility to NCD later in life? Nutr Metab Cardiovasc Dis. 2012;22(10):765-769.
30. Organización Mundial de la Salud. Indicadores para evaluar las prácticas de alimentación del lactante y del niño pequeño. Parte I definiciones. Washington, DC. 2009.
31. Maier A, Chabanet C, Schaal B, Issanchou S, Leathwood P. Effects of repeated exposure on acceptance of initially disliked vegetables in 7-month old infants. Food Quality and Preference. 2007;18(8):1023-1032.
32. Maier AS, Chabanet C, Schaal B, Leathwood PD, Issanchou SN. Breastfeeding and experience with variety early in weaning increase infants' acceptance of new foods for up to two months. Clin Nutr. 2008;27(6):849-857.
33. Maier-Nöth A, Schaal B, Leathwood P, Issanchou S. The Lasting Influences of Early Food-Related Variety Experience: A Longitudinal Study of Vegetable Acceptance from 5 Months to 6 Years in Two Populations. PLoS One. 2016;11(3):e0151356.
34. Mennella JA, Nicklaus S, Jagolino AL, Yourshaw LM. Variety is the spice of life: strategies for promoting fruit and vegetable acceptance during infancy. Physiol Behav. 2008;94(1):29-38.
35. Mennella JA, Daniels LM, Reiter AR. Learning to like vegetables during breastfeeding: a randomized

clinical trial of lactating mothers and infants. Am J Clin Nutr. 2017;106(1):67-76.
36. Caton SJ, Ahern SM, Remy E, Nicklaus S, Blundell P, Hetherington MM. Repetition counts: repeated exposure increases intake of a novel vegetable in UK pre-school children compared to flavour-flavour and flavour-nutrient learning. Br J Nutr. 2013;109(11):2089-2097.
37. Mennella JA, Beauchamp GK. Mothers' milk enhances the acceptance of cereal during weaning. Pediatr Res. 1997;41(2):188-192.
38. Hendy HM. Effectiveness of trained peer models to encourage food acceptance in preschool children. Appetite. 2002;39(3):217-225.
39. Ward S, Bélanger M, Donovan D, Boudreau J, Vatanparast H, Muhajarine N, *et al*. "Monkey see, monkey do": Peers' behaviors predict preschoolers' physical activity and dietary intake in childcare centers. Prev Med. 2017;97:33-9.
40. Birch LL, Doub AE. Learning to eat: birth to age 2 y. Am J Clin Nutr. 2014;99(3):723s-728s.
41. Victora CG, Bahl R, Barros AJ, França GV, Horton S, Krasevec J, *et al*. Breastfeeding in the 21st century: epidemiology, mechanisms, and lifelong effect. Lancet. 2016;387(10017):475-490.
42. Neves PAR, Barros AJD, Gatica-Domínguez G, Vaz JS, Baker P, Lutter CK. Maternal education and equity in breastfeeding: trends and patterns in 81 low- and middle-income countries between 2000 and 2019. Int J Equity Health. 2021;20(1):20. doi: 10.1186/s12939-020-01357-3
43. Harris JL, Pomeranz JL. Infant formula and toddler milk marketing: opportunities to address harmful practices and improve young children's diets. Nutr Rev. 2020;78(10):866-883.
44. Neves PAR, Barros AJD, Baker P, Piwoz E, Santos TM, Gatica-Domínguez G, *et al*. Consumption of breast milk, formula and other non-human milk by children aged under 2 years: analysis of eighty-six low- and middle-income countries. Public Health Nutr. 2020:1-9.
45. Drewnowski A, Mennella JA, Johnson SL, Bellisle F. Sweetness and food preference. J Nutr. 2012;142(6):1142s-1148s.
46. Krasevec J, An X, Kumapley R, Bégin F, Frongillo EA. Diet quality and risk of stunting among infants and young children in low- and middle-income countries. Matern Child Nutr. 2017;13 Suppl 2(Suppl 2). doi: 10.1186/s12939-020-01357-3
47. Mazariegos M, Slater C, Ramirez-Zea M. Validity of Guatemalan Mother's Self-Reported Breast-Feeding Practices of 3-Month-Old Infants. Food Nutr Bull. 2016;37(4):494-503.

Recibido: 29/05/2020
Aceptado: 18/12/2020

ARCHIVOS LATINOAMERICANOS DE NUTRICIÓN
Revista de la Sociedad Latinoamericana de Nutrición
Doi: 10.37527/2020.70.4.007

Vol. 70 N° 4, 2020
Artículo de Revisión

Effectiveness training type on body composition and metabolic parameters in adolescents with obesity: review

Thalles Guilarducci Costa[1], *Louise Rodrigues*[2], *Carlos Ramos-Urrea*[3].

Summary: Effectiveness training type on body composition and metabolic parameters in adolescents with obesity: review. No systematic reviews had analyzedthe most effective training for adolescents with obesity, thus, the aim of our review was to understand whether aerobic, resistance, or combinate, is appropriate for improving body composition, and factors associated with obesity in adolescents. We followed PRISMA methods, in the Pubmed, SCOPUS, and Web of Science databases, using the terms Obesity, teenager, fat mass, body mass index, body mass, intervention, aerobic, resistance, training and physical activity. Subsequently, titles and abstracts were read to filter the articles. Of the 3585 results found, 10 articles were selected with protocols of 3 to 4 weekly training sessions of 15 to 60 minutes, with interventions of 4 to 12 weeks. All types of training were beneficial for anthropometric and biochemical improvement, only resistance training (RT) has a significant difference for muscle mass compared to aerobic training (AT). Even though of the small number of studies with this type of comparison, it is still unclear which type of training is better or whether the two done concurrently would be a better alternative. According to our findings adolescents who want to maximize the effect of exercise on anthropometric variables should ideally perform aerobic and endurance exercises, but significant benefit can be achieved through any type of exercise, and if it were to have a significant differentiation within muscle mass the resistance exercise may be ideal to achieve this goal. **Arch Latinoam Nutr 2020; 70(4): 290-299.**

Key words: Exercise, obesity, adolescents, intervention.

Resumen: Efectividad de diferentes tipos de ejercicios sobre la composición corporal y parámetros metabólicos en adolescentes con obesidad: revisión. En este artículo de revisión, fue analizado cual es el método de entrenamiento que es más efectivo para adolescentes con obesidad, de allí, a que nuestro objetivo en esta revisión es definir cual de los protocolos de entrenamiento (aeróbico, de resistenciao combinado) es mas apropiado para mejorar la composición corporal y otros factores asociados con la obesidad en adolescentes. Siguiendo los métodos de PRISMA se realizóla búsqueda en las bases de datos de, Pubmed, SCOPUS, y Web os Science, utilizando términos de obesidad, adolescentes, masa grasa, índice de masa corporal, masa corporal, intervención, ejercicio aeróbico, ejercicio de resistencia, ejercicio combinado y actividad física, subsecuentemente se leyeron títulos y resúmenes para filtrar los artículos. De los 3585 artículos encontrados, 10 artículos fueron seleccionados con protocolos de 3 a 4 días a la semana, donde cada sesión era de 15 a 60 minutos, con intervenciones entre 4 y 12 semanas. Todos los tipos de entrenamiento fueron beneficiosos para mejorar composición corporal y parámetros bioquímicos, el ejercicio de resistencia demuestra tener diferencia con relación a los otros dos protocolos de entrenamiento donde post-intervención consiguen mejorar la masa muscular. Debido al número pequeño de estudios aun la información es poco clara sobre cual protocolo es más efectivo y así poder elegir una alternativa mas adecuada. De acuerdo con los hallazgos realizar ejercicios aeróbicos y/o combinados mejoran la composición corporal a nivel de masa grasa, y el ejerciciode resistenciademuestra mejorar musculatura en adolescentes con obesidad. **Arch Latinoam Nutr 2020; 70(4): 290-299.**

Palabras clave: Ejercicio, obesidad, adolescentes, intervención.

Introduction

Obesity is known as the major challenge on world's public health in the 21° century (1), obese teenagers exhibit diseases that were observed only on adults, such as insulin resistance (IR), type 2 diabetes (T2B), hypertension (HTA), metabolic syndrome (MS), sleep apnea, non-alcoholic fatty liver disease (NAFD), among others (2,3). Obesity affects 13% - 20% of the adolescents in occidental countries, and these numbers had presented

[1]Sector of Human and Exercise Physiology, Faculty of Physical Education and Dance, Federal University of Goiás, Goiânia, GO, Brazil. [2]Universidade Federal de São Paulo - UNIFESP - Campus Baixada Santista, Santos (SP) Brasil. [3]Scientific Research Departament, Instituto Universitario Vive Sano, CEP: 04147100. São Paulo, Brasil.
Autor para la correspondencia: Carlos Ramos-Urrea, email: carlosramos2690@gmail.com

growth in the last three decades (4), if the growing persists the world will have more obese teenagers than with moderate and severeundernutritionon 2022 (5). Weight excess affects 340 million children and adolescents worldwide, in addition to thedeleterious effects on health, weight excess is associated with a high financial impact on the health system. Obesity is difficult to reverse, and multi-professional strategies are recommended, including dietary, lifestyle changes and the practice differenttypes of physical exercise (6). Only in 2016, an estimated 41 million children under the age of 5 years were overweight or obese (7); in Brazil, recent data showed that approximately 50% of adults and 30% of adolescents present some obesity degree (8), and although the prevalence of malnutrition has decreased considerably in Brazil, it continues to be an important public health problem, especially in some "foci" both in economic abundance as well as in poverty, which are found in large cities. The role of excess weight among children from less privileged social classes is of utmost importance, since these children are not only deprived of a healthy diet, but are also often deprived of culture, education and affection, which causes even greater damage (9).

The weight gain can induce important physical and psychosocial threats toteens' population, because, in this age occurs great changes in body composition, besides that, physical inactivity and poor nutrition can increase the risk of depression and anxiety (2). Physical exercise can improve body composition, metabolic profile and inflammatory state on teenagers with obesity, thus, an important nonpharmacological approach (10), traditionally, two strategies (aerobic and resistance training) had been proposed to obesity damage control, which can improve quality of life, those strategies consist on protocols of resistance and aerobic training (8,11,12).

Both types of training had benefits on multiples valences associated with obesity (11,13–15), however, to the best of our knowledge, few studies on teenagers had compared the two, separated or combinate, and no systematic review had analyzed the effects of both on body composition on obese adolescents. Thus, our aim was to demonstrate, on a systematic review, the effects of the resistance and aerobic training on body composition on adolescents with obesity, as to identify which one is more effective for the analyzed outcomes, to improve the knowledge in this subject, we include studies that combine the two types to compare.

Materials and methods

This systematic review is registered on International Prospective Register of Systematic Reviews (PROSPERO) on identification number 146021. We use PICO strategy for eligibility criteria. PEDRo scale was used to bias and quality evaluation. The article selection was on PubMed, SCOPUS e Web of Science databases, using the following descriptors: Obesity, child adolescent, fat mass, body mass index, body mass, intervention, aerobic training, resistance training, physical activity. Posteriorly, the peer review was made by tittle and resumes reading, for this matter, we used Rayyan online platform (https://rayyan.qcri.org/), where also were excluded the duplicates.

The database research was made in July 2019, with the following inclusion criteria: original articles, disponible on English, Portuguese and Spanish, and that compare the resistance and/or aerobic training in adolescents on the proposed outcomes. As exclusion criteria: systematic reviews and articles without training comparison. Thus, 10 articles were selected to complete reading, all of them were included on the systematic review and meta-analyses.

The resume of the data was exposed on a synoptic chart, in which presents the information about the review outcomes. The comparison between articles were dispose on topics.

Results

Were found 3585 articles on our descriptors analysis, on PubMed (2438), SCOPUS (360) and Web of Science (916), 129 articles were excluded as duplicates. Through the titles and resumes Reading, 10 articles were selected for a complete reading.

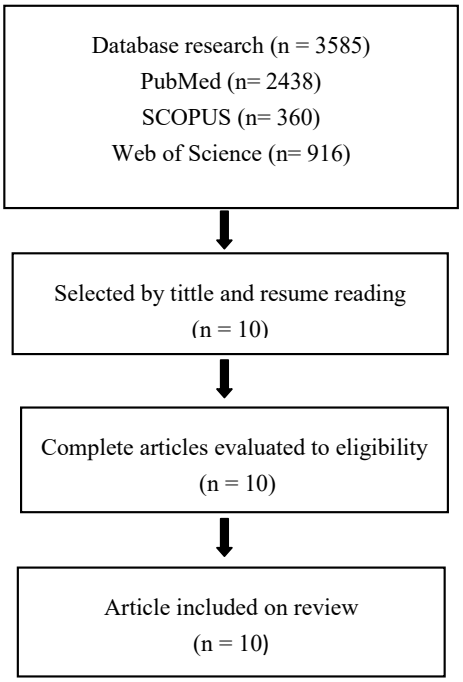


Figure 1. Flowchart of article selection on systematic review

Table 1. Search strategy.

Stage	Descriptors
(1)	Obesity in Adolescence [Title/Abstract]
(2)	Physical activity [Title/Abstract]
(3)	Physical activity [Title/Abstract] OR Obesity in Adolescence [Title/Abstract]
(4)	Obesity in Adolescence [Title/Abstract] AND aerobic training [Title/Abstract]
(5)	Obesity in Adolescence [Title/Abstract] AND resistance training [Title/Abstract]

Table 2. List of variables and units of measurement of the studies.

Variable	Unit of measurement
Body mass index	kg/m^2
Body mass	kg
Fat mass Index	%
Fat mass	kg
Muscle	kg
Waist circumference	cm

Table 3. Characteristics of studies included by body composition and factors associated with obesity on obese adolescents

Author (year)	Participants	Intervention	Results
Walsh *et al*(2018)	n= 202 Female 136 Male 66	CG (n=50) (Caloric restriction, 250 kcal/day), the exact number in which intervention was not mentioned AT (n=152): treadmill, elliptical machines or cycle ergometers, the participants progressed in exercise duration, from 20 to 45 minutes and intensity, from 65% to 85% of MHR. RT (n=152): 7 exercises, progressing from 2x15 at 3x8 sets, on 8RM load, 2x per week, lower body training, and 2x per week, upper body training. Six months, 4 days/week.	In the training group, increases in BDNF was associated with fasting glucose reduction (β=6.57, SE=3.37, p= 0.05), increases on HOMA-B (β=0.093, SE=0.03, p=0.004). They did not find associations between diabetes risk factors and BDNF on CG.

Table 3. Characteristics of studies included by body composition and factors associated with obesity on obese adolescents

Author (year)	Participants	Intervention	Results
Wong *et al*(2018)	n= 30 Female 30	GC (n=15) (without caloric restriction) AT + RT (n=15): treadmill, 30 minutes progressing, from 40% to 70% of HRR. 10 exercises of resistance band, 5 for upper body and 5 for lower body, progressing from 15 to 20 repetitions. 12 weeks, 3 days/week	There were significant reductions on Body weight (Δ=-6.2 kg), BMI (Δ=-2.8 kg/m^2), BF (Δ=-3.6%), WC (Δ=-4.1 cm) and waist to height ratio (Δ=-0.03) ($p<0.05$) on the training group, compared with control. Training group also decrease fasting glucose (Δ= -1.2 mmol/L), insulin (Δ=-17.1μU/mL), HOMA-IR (Δ=-4.8) and HR in resting (Δ=-4 bpm) ($p<0.05$), compared to control group.
De Groote, 2018	n= 14 Male 6 Female 8	AT+RT+hypoxia(n=7) AT+RT+normoxia(n=7) AT: cycloergometer, 50-60 minutes (session 1: 2 min at 50% MAP and 10 min at 70% MAP; session 2: 2 min at 50% MAP and 5 repetitions of 1 min 80%–1 min 50% MAP; session 3: incremental training started at 40% MAP with an increase of 10% MAP each 2 min) RT: Exercises to abdominal, quadriceps and biceps, 15 repetitions at 50% 1RM and 4x6 at 70% 1RM, with resting time of 2 minutes Six weeks, 3 days/week	Body mass, BMI, umbilical perimeter, fat mass and % Fat mass decreased on both types of training, with no difference between ($p>0.01$), compare to baseline. Fasting insulin levels decrease after normoxic training (-45 %; $p<0.05$) but not after hypoxic training ($p=0.1$), however, fasting glucose levels did not decrease after either conditions, compare to baseline. HOMA-IR decreased on normoxic (-45%; $p<0.05$), but not on hypoxic training, whereas HOMA-βcell (normoxic: -29%; hypoxic: -30%) and cholesterol decreased on both conditions (both: -14%$p<0.05$), with no difference between, compare to baseline. QUICKI values were increased on both groups (normoxic: +6%; hypoxic: +7%; $p<0.05$).
Son, 2017	n= 40 Feminine 40	CG (n=20) AT+RT (n=20): a series of combined resistance and aerobic exercises, including jump, cross-jump, box jump, weighted squat jump and jump rope, following 20 min of playing badminton 12 weeks, 3 days/week	Blood pressure (Δ= -7.3 ± 2.67 mmHg), baPWV (Δ= -1.23 ± 0.49 m/s), HOMA-IR (Δ= -1.4 ± 0.07), percentual body fat (Δ= -1,35 ± 0,9%), body lean mass (Δ= 0.75 ± 2.22%), and waist circumference (Δ= -2.2 ± 1.4 cm) were significantly improved on training group, compare to CG ($P < 0,05$).
Da Silveira Campos, 2017	n = 148 Female 84 Male 64	AT(n=51): 60 minutes on treadmill, the intensity of AT was not mentioned on the article AT + RT (n=97): 30 minutes of AT on bicycle or treadmill and 30 minutes of RT, the intensity varies weekly, divided into high loads (6 to 8 reps), moderated loads (10 to 12 reps) and light loads (15 to 20 reps). 18 sets per session, 3 for each muscular group (pectoralis, deltoid and triceps; back and biceps, quadriceps; hamstrings and abdominal), the exercises were not specified. 12 months, 3 days/week	Both types of training decrease Body mass (AT: Δ=-8.2 kg; AT+RT Δ=-8.5 kg; $p<0.05$), BMI (AT: Δ=-3.1 kg/m^2; AT+RT Δ=-3.7 kg/m^2 ; $p<0.05$), visceral fat (AT: Δ= -1.3 cm; AT+RT Δ=-1.7 cm; $p<0.05$) and subcutaneous fat (AT: Δ=-0.7 cm; AT+RT Δ=-0.9 cm; $p<0.05$), after one year, compare to baseline. Only AT+RT group decrease insulin (Δ=-5 μU/mL; $p<0.05$), HOMA-IR(Δ=-1; $p<0.05$) , HOMA-AD (Δ=-12.5; $p<0.05$) and increase on QUICKI (Δ=0.02; $p<0.05$), after one year, compare with baseline. Besides both groups had significant decreases on fat mass (AT Δ= -5 %;-7 kg vs AT+RT Δ= -7.6 %; -10.9 kg; $p<0.05$) after one year, compare to baseline, the AT+RT group had greater decrease compare with AT only. For lean mass and lean tissue (AT Δ= 5%; -1 kg vs AT+RT Δ= 7.6%; 2.6 kg; $p<0.05$), AT+RT had greater increase, compare with AT.

Table 3. Characteristics of studies included by body composition and factors associated with obesity on obese adolescents

Author (year)	Participants	Intervention	Results
Alberga, 2015	n= 304 Female 213 Male 91	AT (n=75): Treadmill, elliptical or bicycle ergometers. Progressing exercise duration, from 20 to 45 minutes, and intensity from 65% to 85% MHR RT (n=78): 7 exercises, progressing from 2x15 at moderate intensity from 3x8 at maximum intensity AT+RT (n=75): AT plus RT training CG (n=76) 22 weeks, 4 days/week	Changes in SAT on L4-L5 were significantly different between AT (Δ=-21.8 cm^2 [-42.9; -0.7]; p<0.05), RT(Δ=-28.3 cm^2 [-49.3; -7.3]) and combined (Δ=-24.3 cm^2 [-45.3; -3.3]) groups, compare to CG. Changes in superficial SAT occurs only on RT (Δ=-14.7 cm^2 [-28.2; -1.2]) and combined (Δ=-14.9 cm^2 [-28.3; -1.4]), but not on AT, compare to CG. Changes in deep SAT were significant only on AT (Δ=-15.3 cm^2 [-29.6; -1]), but not on RT and combined groups, compare to CG. VAT at L4-l5 did not differ on any groups. There was no difference among intervention groups on any variables.
Dâmaso, 2014	n= 139 Female 82 Male 57	AT: (n=61): Treadmill. 60 minutes, intensity not mentioned in the article. AT+RT (n=55): 30 minutes of AT on bicycle or treadmill and 30 minutes of RT, the intensity varies weekly, divided into high loads (6 to 8 reps), moderated loads (10 to 12 reps) and light loads (15 to 20 reps). 18 sets per session, 3 for each muscular group (pectoralis, deltoid and triceps; back and biceps, quadriceps; hamstrings and abdominal), the exercises were not specified. 23 dropouts. 12 months, 3 days/week	Both types of training decrease Body mass (AT: Δ=-8.8 kg; AT+RT Δ=-12.3 kg; p<0.05), BMI (AT: Δ=-3.1 kg/m2; AT+RT Δ=-4.8 kg/m2 ; p<0.05), visceral fat (AT: Δ=-1.4 cm; AT+RT Δ=-1.6 cm; p<0.05) and subcutaneous fat (AT: Δ=-0.5 cm; AT+RT Δ=-0.9 cm; p<0.05), insulin (AT: Δ=-3.9 μU/mL; AT+RT Δ=-5.5 μU/mL; p<0.05), HOMA-IR (AT: Δ=-0.9; AT+RT Δ=-1.2; p<0.05), QUICKI (AT: Δ=-0.2; AT+RT Δ=-0.2; p<0.05), and total cholesterol (AT: Δ=-8.1 mg/dL; AT+RT Δ=-13.5 mg/dL; p<0.05), after one year, compare to baseline. Both types of training increase lean mass (AT Δ=5.4%; 1 kg vs AT+RT Δ= 9.4%; 2.2 kg; p<0.05), but only AT+RT intervention had body fat mass decreased (Δ= -9.4%; -14.2 kg; p<0.05), after one year compare to baseline.
Sigal, 2014	n= 304 Female 213 Male 91	AT (n=75): Treadmill, elliptical or bicycle ergometers. Progressing exercise duration, from 20 to 45 minutes, and intensity from 65% to 85% MHR RT (n=78): 7 exercises, progressing from 2x15 at moderate intensity from 3x8 at maximum intensity AT+RT (n=75): AT plus RT training CG (n=76) 22 weeks, 4 days/week	The body fat percentage did not change on CG (p>0.05), but decreased on intervention groups (Δ AT: -1.1 [-1.7 a -0.5]; Δ RT: -1.6 [-2.2 a -1.0]; Δ RT+AT: -1.4 [-2.0 a -0.8]; p< 0.001), compare to CG, there was not difference between groups of intervention. Waist circumference did not change in CG (p>0.05), but decreases on AT, RT and combined training (Δ AT: -3.0 [-4.4 a -1.6 cm]; Δ RT: -2.2 [-3.7 a -0.8 cm]; Δ RT+AT: -4.1 [-5.5 a -2.7]; p<0.05). Waist circumference decrease were greater in the combine group than the AT. BMI decreases were greater in the combined group, compare to AT and RT groups.
Lee, 2013	n=44 Female 44	AT (n=16): Treadmills or bicycles. Progressing in duration, from 40 min at 50% V Ό2peak to 60 min at 60-75% V Ό2peak RT (n= 16): 10 whole body exercises (Leg press, leg extension, leg flexion, chest press, latissimus pulldown, seated row, bicep curl, triceps extension. In addition, one set of pushups and situps), progressing from 1-2x12 at 60% 1RM (weeks 1-4), to 2x8-12 reaching failure (weeks 4-12) CG (n=12) 3 months, 3 days/week	There were differences on total body fat (Δ AT: -1.7%; ΔRT: 1.63%; p<0.05) and IMAT (Δ AT: -13.5 cm^2; ΔRT: 10.9 cm^2; p<0.05), on both interventions, compare to CG. Only AT decreased intrahepatic lipid (Δ=-1.7; p<0.05), compare to CG. Only RT increase muscular strength index (Δ=0.45; p<0.001). Only AT had improvement on insulin sensitivity (Δ= 0.92 mg/kg/min per μU/mL; p<0.05).

Table 3. Characteristics of studies included by body composition and factors associated with obesity on obese adolescents

Author (year)	Participants	Intervention	Results
Lee, 2012	N= 45 Male 45	AT (n=16): Treadmills or bicycles. Progressing in duration, from 40 min at 50% V Ό2peak to 60 min at 60-75% V Ό2peak RT (n= 16): 10 whole body exercises (Leg press, leg extension, leg flexion, chest press, latissimus pulldown, seated row, bicep curl, triceps extension. In addition, one set of pushups and situps), progressing from 1-2x12 at 60% 1RM (weeks 1-4), to 2x8-12 reaching failure (weeks 4-12) CG (n=13) 3 months, 3 days/week	There were differences on total adiposity tissue (Δ AT: -3 kg; ΔRT: -2.5 kg; $p<0.05$) and visceral fat Δ AT: -0.1; ΔRT: 0.2; $p<0.001$), on both interventions, compare to CG. Only RT had improvement on insulin sensitivity (Δ:0.8 mg/kg/min per μU/mL; $p<0.05$).

AT: Aerobic Training; RT: Resistance Training; CG: Control Group; MHR: Maximum Heart Rate; RM: Repetition Maximum BDNF: Brain-Derived Neurotrophic Factor; HOMA-B: Homeostatic Model Assessment Beta Cell Secretory Capacity; HRR: Heart Rate Reserve; HOMA-IR: Homeostatic Model Assessment of Insulin Resistance; HOMA-AD: Homeostasis Model Assessment-adiponectin; QUICKI: Quantitative Insulin Sensitivity Check Index; BMI: Body Mass Index; BF: Body Fat; WC: Waist Circumference; baPWV: brachial-ankle pulse wave velocity; SAT: Subcutaneous Adipose Tissue; VAT: Visceral Adipose Tissue: IMAT: Intermuscular Adipose Tissue;

Discussion

To the best of our knowledge this is the first systematic review comparing effects of RT and TA on body composition and obesity outcomes on obese teenagers.

The primary finding was to show that resistance training has significant improvements in muscle mass than aerobic training (SMD= 0.68 vs. 1.37), one of the explanations may be because resistance training can have positive effects on muscle mass, improving hypertrophy, due to a greater stimulation within the cellular activity in the muscle, through a higher volume of exercises, quantitative changes in skeletal muscle mass or fiber diameter and increased muscle strength (16) when compared to aerobic training (improvement in the energy system dependent on oxidative metabolism, qualitative changes in the type of skeletal muscle fiber, metabolic capacity and cardiorespiratory fitness) (17). In addition to our work, we have shown that interventions smaller than 12 weeks by almost 30 minutes composed with aerobic training and resistance training can bring benefits for the improvement of body composition.

The physical activity guides recommend the combination of AT and RT to optimize the health of the individual, and for other benefits in general (18). Recently the American College of Sport Medicine confirmed that there is evidence to assert that AT and/or RT may promote weight loss (19). Our review study suggests that there are no differences between these two types of training for the decrease of anthropometric parameters such as BMI, fat mass (in percentage and kilograms), PCT, and waist circumference, but itis important to mention that both types of training help decrease these parameters in both sexes and that individuals who underwent resistance training have the same tendency to decrease the percentage of BMI, fat mass and waist circumference as those who underwent aerobic training with a p value < 0.05. Just doing some kind of training can bring benefits within the body composition of an obese individual (20).

According to the World Health Organization (21), for significant weight loss (between 5 and 7 kg per month), it is necessary to practice 225 to 420 min of aerobic exercisesto adolescents, of moderate intensity, per week. In addition, according to the institution mentioned, resistance physical

exercise can potentiate the loss of fat mass, when associated with aerobic physical exercises, because it increases or promotes the maintenance of lean mass during the weight loss process, contributing to the increase in resting metabolic rate and daily caloric expenditure; improves functional capacity, facilitating the practice of daily physical activities, and increases lipid oxidation during and especially after physical exercise (22).

Some of the studies cited also used nutritional interventions within the sports interventions in adolescents where (23,24) had a diet regimen based on caloric restriction (55-60% carbohydrates, 15-20% proteins and 20-25% lipids). Another research group (25) also did caloric restriction (Deficit of 250 kcal/day (1.0467kJ), interventions only with caloric restriction seem to lead to greater reductions in BMI when accompanied by some type of training, but changes in BMI may reflect a reduction in BMI dependent on muscle mass rather than fat mass, especially in children involved in physical activity interventions (26). A meta-analysis reported that diet-only interventions resulted in greater BMI reductions than exercise-only interventions among obese children and adolescents. However, without information on changes in lean mass, it is not possible to compare the effectiveness of these interventions, because we do not know if this occurs because the exercise group was gaining lean mass, the group only with diet was losing lean mass, or both (27). Finally, as evidence suggests that exercise-induced changes in energy balance can stimulate compensatory adjustments that alter daily food intake (28), diet control is required during physical activity interventions.

All studies analyzed describe a decrease in waist circumference, which is frequent within interventions that relate abdominal fat to aerobic training and resistance training (23), decreased abdominal fat during adolescence may confer important cardiometabolic protection due to which in an individual each year with abdominal obesity may have a 4% risk for developing diabetes mellitus (23).

Adolescents with obesity have a high adherent to training protocols in both aerobic activities ($99.7 \pm 0.8\%$) as in the resistance training group ($99.0 \pm 2.1\%$) (23). This observation confirms that the exercise regimen (three times/week or 180 min/week) is feasible and effective for obese adolescents.

Some studies have also been able to measure insulin sensitivity,showing that both aerobic exercise and resistance exercise improve insulin sensitivity, but to present differences between them when compared to the control group (25). Other researchers (23) have achieved that aerobic training maintained insulin sensitivity, and that it is demonstrate that resistance exercise sessions 2 to 3 times a week can increase insulin sensitivity by a 27% (29).

None of the study's findings report on the prevention of weight recovery, in none there was monitoring of weight after studies, and it is that some research shows that the maintenance of the new weight acquired is as arduous a task as the weight loss process itself (22), more studies that elude the volume, intensity and the best types of physical exercise are essential. According to other measured parameters, we have that both AT and RT can improve BDNF being an effective strategy for brain health (30), the TA shows to be more effective for the improvement of the HOMA-IR index (8)when compared to TA, TR, and combined training we believe that the three improve abdominal adiposity in the population studied (28) although we do not compare different types of training when the combined exercises were studied in isolation, we have that they can show improvement in arterial stiffness, nitric oxide values and inflammatory markers, these findings were only evaluated in obese girls (31). When this type of exercise (Combined) and performed in hypoxia shows that it can be an interesting strategy against IR and development of DM2 in both sexes (32). Combined exercise proves to be a useful therapeutic treatment for high BP, IR, central and visceral adiposity, hepatic markers at ApoB / ApoA-1 ratio (12,15,31,33). Aerobic and resistance exercises performed with protocols of 3 to 4 weekly trainings, with sessions of 15 to 60 minutes in interventions from 4 to 12 weeks with caloric restriction resulted in reductions in the parameters analyzed, the two types of training allow greater use of fat stocks as an energetic substrate and preserves lean mass (34).

There is already consensus in the literature that strategies involving physical exercise, food reeducation and behavioral

changes jointly are more effective in the treatment of obesity than such practices performed in isolation(35,36), although not included in any guide, it is necessary that the members of the obesity treatment teams are well trained and have specific competencies, especially during the practical approach of patients (37).

It is relevant to mention the sex differences, which six of ten studies analyzed both sexes, but only one compared them, reveling that gender did not moderate the effects of exercise on BDNF or diabetes risk factor, and did not function as confounder by the BDNF, fasting glucose and HOMA-B changes in the exercise group, as well as, there was no difference between sex on adherence in exercise programs (30). Howsoever, two of the studies selected (Table 3), had both sex in the sample, but they did not analyzed difference among them (31,38).

It would be important to develop others study of this type with combined exercise, since the most frequent recommendations within physical exercise for the treatment of obesity have to be composed of strength training, with a large number of repetitions in conjunction with moderate intensity aerobic training, showing to be more efficient in improving the body composition of adolescents with obesity (39,40). The main limitation of this work was the small number of articles obtained, demonstrating once again the need to study the effect of different types of training in adolescents with obesity.

Conclusion

It is important that the adolescent with obesity who craves weight loss, maintenance of new body weight and incorporation of a healthy life find and practice pleasurable physical activities, which facilitate adherence to a more active life.

The treatment of obesity should address lifestyle changes that include:

Food reeducation, increased practice of physical exercise, behavioral changes, pharmacological intervention (when necessary) and environmental changes.

Adolescents who want to maximize the effect of exercise on anthropometric variables should ideally perform aerobic and endurance exercises, but significant benefit can be achieved through any type of exercise, and if it were to have a significant differentiation within muscle mass the resistance exercise may be ideal to achieve this goal.

It would be of great importance to evaluate variables related to the pubertal stretch stage (Tanner's stage) for this target population so that from there we can make more accurate decisions regarding exercise protocols and thus optimize transdisciplinary work, this due to the endocrine-metabolic influence, which has a fundamental role, which will set the pattern of development according to the levels of maturation, early, average and late. In none of the studies analyzed has it been documented about the influence of obesity within the development period, considering the distribution of fat and lean mass.

Acknowledgments

We are grateful to Prof. Thatiane Ostolin for helping us and for her generous support and all the education help.

Financial Support

This research was not funded by any agency.

Conflict of Interest

The authors declare that there are no conflicts of interest in this paper.

Authorship

The authors' contributions are as follows: T.G.C, L.R. and C.R.U. designed the study. C.R.U. and T.G.C. performed all data collection. L.R. completed all tables, and interpreted the data, C.R.U. and T.G.C. wrote the paper. T.G.C. contributed to revision of the paper. T.G.C. and C.R.U. contributed to the writing and discussion of the paper. All authors were responsible for the critical revisions of the paper and approved the final version.

References

1. WHO. The double burden of malnutrition, Policy Brief. Who/Nmh/Nhd/173. 2017;21(4):402–4.
2. Narciso J, Silva AJ, Rodrigues V, Monteiro MJ, Almeida A, Saavedra R, *et al*. Behavioral, contextual and biological factors associated with obesity during adolescence: A systematic review. PLoS One [Internet]. 2019 [cited 2019 Jul 12];14(4). Available from: https://doi.org/10.1371/journal.pone.0214941
3. Güngör NK. Overweight and obesity in children and adolescents. JCRPE J Clin Res Pediatr Endocrinol. 2014;6(3):129–43.
4. Ogden CL, Flegal KM, Carroll MD, Johnson CL. Prevalence and Trends in Overweight Among US Children and Adolescents, 1999-2000. JAMA [Internet]. 2002 Oct 9 [cited 2018 Aug 29];288(14):1728. Available from: http://jama.jamanetwork.com/article.aspx?doi=10.1001/jama.288.14.1728
5. OPAS/OMS Brasil [Internet]. 2018 [cited 2019 Jul 15]. Available from: https://www.paho.org/bra/
6. Martins VJB, Filgueiras AR, Almeida VBP, de Moraes RCS, Sawaya AL. Changes in thyroid and glycemic status and food intake in children with excess weight who were submitted for a multi-component school intervention for 16 months. Int J Environ Res Public Health. 2020;17(11):3825. doi:10.3390/ijerph17113825
7. UNICEF, WHO, World Bank Group. LEVELS AND TRENDS IN CHILD MALNUTRITION Worldwide. World Heal Organ [Internet]. 2017 [cited 2019 Feb 1];16. Available from: https://www.who.int/nutgrowthdb/jme_brochoure2017.pdf?ua=1
8. Da Silveira Campos RM, Masquio DCL, Corgosinho FC, De Lima Sanches P, De Piano A, Carnier J, *et al*. Homeostasis Model Assessment-Adiponectin: The role of different types of physical exercise in obese adolescents. J Sports Med Phys Fitness. 2017;57(6):831–8.
9. Vieira KA, Rosa-Júnior LS, Souza MAV, Santos NB, Florêncio TMMT, Bussadori SK. Chronic malnutrition and oral health status in children aged 1 to 5 years: An observational study. Medicine (Baltimore). 2020;99(18):e19595.
10. García-Hermoso A, Ramírez-Vélez R, Ramírez-Campillo R, Peterson MD, Martínez-Vizcaíno V. Concurrent aerobic plus resistance exercise versus aerobic exercise alone to improve health outcomes in paediatric obesity: a systematic review and meta-analysis. Br J Sports Med [Internet]. 2018;52(3):161–6. Available from: http://bjsm.bmj.com/
11. Bea JW, Blew RM, Hetherington-Rauth CHM, Going SB. Resistance Training Effects on Metabolic Function Among Youth: A Systematic Review. Pediatr Exerc Sci. 2017;29(3):297–315.
12. Dâmaso AR, da Silveira Campos RM, Caranti DA, de Piano A, Fisberg M, Foschini D, *et al*. Aerobic plus resistance training was more effective in improving the visceral adiposity, metabolic profile and inflammatory markers than aerobic training in obese adolescents. J Sports Sci. 2014;32(15):1435–45.
13. Cockcroft EJ, Williams CA, Weaver H, O'Connor A, Jackman SR, Armstrong N, *et al*. Acute Exercise and Insulin Sensitivity in Boys: A Time-Course Study. Int J Sports Med. 2017;38(13):967–74.
14. Costigan SA, Eather N, Plotnikoff RC, Taaffe DR, Lubans DR. High-intensity interval training for improving health-related fitness in adolescents: A systematic review and meta-analysis. Br J Sports Med. 2015;49(19):1253–61.
15. Son WM, Sung KD, Bharath LP, Choi KJ, Park SY. Combined exercise training reduces blood pressure, arterial stiffness, and insulin resistance in obese prehypertensive adolescent girls. Clin Exp Hypertens [Internet]. 2017;39(6):546–52. Available from: https://doi.org/10.1080/10641963.2017.1288742
16. Kraus W, Levine B. Annals of Internal Medicine Editorial Exercise Training for Diabetes : The " Strength " of the Evidence. Ann Intern Med. 2007;147(6):243–425.
17. McArdle W, Katch F, Energy V. Energy transfer in the body. In: Exercise Physiology: Energy Nutrition and Human Performance. 5th ed. Baltimore; 2001. p. 131–56.
18. Organization WH. Global recommendations on physical activity for health. In: WHO. 2010.
19. Donnelly JE, Greene JL, Gibson CA, Smith BK, Washburn RA, Sullivan DK, *et al*. Physical Activity Across the Curriculum (PAAC): A randomized controlled trial to promote physical activity and diminish overweight and obesity in elementary school children. Prev Med (Baltim) [Internet]. 2009;49(4):336–41. Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-70349982732&doi=10.1016%2Fj.ypmed.2009.07.022&partnerID=40&md5=63084514bb3379e676073d5b675e0608
20. García-Hermoso A, Ramírez-Vélez R, Saavedra JM. Exercise, health outcomes, and pædiatric obesity: A systematic review of meta-analyses. J Sci Med Sport [Internet]. 2019;22(1):76–84. Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85050271664&doi=10.1016%2Fj.jsams.2018.07.006&partnerID=40&md5=406ee63ba98a7792cfb7666cb9e90d48
21. World Health Organization (WHO). Recomendaciones mundiales sobre actividad fisica. WHO. 2010.
22. Donnelly JE, Blair SN, Jakicic JM, Manore MM, Rankin JW, Smith BK. Appropriate physical activity intervention strategies for weight loss and prevention of weight regain for adults. Med Sci Sports Exerc. 2009;41(2):459–71.
23. Lee SJ, Bacha F, Hannon T, Kuk JL, Boesch C, Arslanian S. Effects of aerobic versus resistance exercise without caloric restriction on abdominal fat, intrahepatic lipid, and insulin sensitivity in obese adolescent boys a randomized, controlled trial. Diabetes. 2012;61(11):2787–95.
24. Lee SJ, Deldin AR, White D, Kim YM, Libman I, Rivera-Vega M, *et al*. Aerobic exercise but not resistance exercise reduces intrahepatic lipid content and visceral fat and improves insulin sensitivity in obese adolescent girls: A randomized controlled trial. Am J Physiol Endocrinol Metab. 2013;305(10):E1222-E1229. doi:10.1152/ajpendo.00285.2013
25. Sigal RJ, Alberga AS, Goldfield GS, Prud'homme D, Hadjiyannakis S, Gougeon R, *et al*. Effects of

aerobic training, resistance training, or both on percentage body fat and cardiometabolic risk markers in obese adolescents: The healthy eating aerobic and resistance training in youth randomized clinical trial. JAMA Pediatr. 2014;168(11):1006–14.
26. Martínez Vizcaíno V, Salcedo Aguilar F, Franquelo Gutiérrez R, Solera Martínez M, Sánchez López M, Serrano Martínez S, *et al*. Assessment of an after-school physical activity program to prevent obesity among 9- to 10-year-old children: A cluster randomized trial. Int J Obes. 2008;32(1):12–22.
27. Ho M, Garnett SP, Baur LA, Burrows T, Stewart L, Neve M, *et al*. Impact of dietary and exercise interventions onweight change andmetabolic outcomes in obese children and adolescents a systematic review and meta-analysis of randomized trials. JAMA Pediatr. 2013;167(8):759–68.
28. King NA, Caudwell P, Hopkins M, Byrne NM, Colley R, Hills AP, *et al*. Metabolic and behavioral compensatory responses to exercise interventions: Barriers to weight loss. Obesity. 2007;15(6):1373–83.
29. Shaibi GQ, Cruz ML, Ball GDC, Weigensberg MJ, Salem GJ, Crespo NC, *et al*. Effects of resistance training on insulin sensitivity in overweight Latino adolescent males. Med Sci Sports Exerc. 2006;38(7):1208–15.
30. Walsh JJ, D'Angiulli A, Cameron JD, Sigal RJ, Kenny GP, Holcik M, *et al*. Changes in the brain-derived neurotrophic factor are associated with improvements in diabetes risk factors after exercise training in adolescents with obesity: The Hearty randomized controlled trial. Neural Plast [Internet]. 2018 [cited 2020 Mar 8];2018. Available from: https://doi.org/10.1155/2018/7169583
31. Alberga AS, Prud'homme D, Kenny GP, Goldfield GS, Hadjiyannakis S, Gougeon R, *et al*. Effects of aerobic and resistance training on abdominal fat, apolipoproteins and high-sensitivity C-reactive protein in adolescents with obesity: The HEARTY randomized clinical trial. Int J Obes [Internet]. 2015 [cited 2020 Mar 9];39(10):1494–500. Available from: www.nature.com/ijo
32. Wong A, Sanchez-Gonzalez MA, Son W-M, Kwak Y-S, Park S-Y. The Effects of a 12-Week Combined Exercise Training Program on Arterial Stiffness, Vasoactive Substances, Inflammatory Markers, Metabolic Profile, and Body Composition in Obese Adolescent Girls. Pediatr Exerc Sci. 2018;30(4):480–6.
33. De Piano A, De Mello MT, Sanches PDL, Da Silva PL, Campos RMS, Carnier J, *et al*. Long-term effects of aerobic plus resistance training on the adipokines and neuropeptides in nonalcoholic fatty liver disease obese adolescents. Eur J Gastroenterol Hepatol. 2012;24(11):1313–24.
34. Hainer V, Toplak H, Mitrakou A. Treatment modalities of obesity: what fits whom? Diabetes Care. 2008;31 Suppl 2(2):269–77.
35. Caranti DA, de Mello MT, Prado WL, Tock L, Siqueira KO, de Piano A, *et al*. Short- and long-term beneficial effects of a multidisciplinary therapy for the control of metabolic syndrome in obese adolescents. Metabolism. 2007;56(9):1293–300.
36. Foschini D, Arajo RC, Bacurau RFP, De Piano A, De Almeida SS, Carnier J, *et al*. Treatment of obese adolescents: The influence of periodization models and ACE genotype. Obesity [Internet]. 2010;18(4):766–72. Available from: http://dx.doi.org/10.1038/oby.2009.247
37. NICE. Obesity prevention. Nice Guidel. 2006; (December 2006).
38. De Groote E, Britto FA, Bullock L, François M, De Buck C, Nielens H, *et al*. Hypoxic Training Improves Normoxic Glucose Tolerance in Adolescents with Obesity. Med Sci Sports Exerc. 2018;50(11):2200–8.
39. Sothern M, von ALMEN TK. Clinical Management. In: Handbook of Pediatric Obesity. Taylor & F. Boca Raton; 2005.
40. Strong WB, Malina RM, Blimkie CJR, Daniels SR, Dishman RK, Gutin B, *et al*. Evidence based physical activity for school-age youth. J Pediatr. 2005;146(6):732–7.

Recibido: 05/10/2020
Aceptado: 10/03/2021

INFORMACIÓN PARA LOS AUTORES

En 1950 el Instituto Nacional de Nutrición de Venezuela edita su revista Archivos Venezolanos de Nutrición la cual en 1966 es donada a la recién creada Sociedad Latinoamericana de Nutrición, SLAN, para convertirse en su órgano oficial de divulgación Archivos Latinoamericanos de Nutrición, ALAN.

ALAN acoge en sus páginas trabajos de investigación originales sobre temas relacionados con alimentación y nutrición, entre ellos, nutrición humana y animal, bioquímica nutricional aplicada, nutrición clínica y comunitaria, educación en nutrición, ciencia y tecnología de alimentos, microbiología de alimentos, revisiones científicas críticas, Editoriales y Cartas al Editor.

Todos los artículos que se publican pasan por un proceso de arbitraje externo. El Comité Editorial no se hace responsable de los conceptos emitidos en los artículos aceptados. No se mantendrá correspondencia sobre aquellos que no sean publicados.

Requisitos para la presentación de manuscritos vía electrónica

Resumen de requisitos:

- Todas las partes del manuscrito estarán presentadas en versión Word a doble espacio, con letra Times New Roman (tamaño 12) en páginas tamaño carta. El trabajo debe tener una extensión no mayor de 23 páginas, incluyendo las Tablas, Figuras e ilustraciones si la hubiere, las cuales deben estar incorporadas al final del texto. Todas las páginas deben estar numeradas.
- Revise la secuencia general: Título del manuscrito y autores, Resumen y palabras clave, Introducción, Materiales y Métodos, Resultados, Discusión, Conclusiones, Agradecimientos, Referencias, Tablas y Figuras.
- Adjunte carta de presentación y aceptación de autoría firmada por los investigadores involucrados. Los autores podrán sugerir los nombres de tres posibles árbitros con sus respectivas direcciones electrónicas.
- Envíe el manuscrito junto con la carta de presentación, a la siguiente dirección electrónica: info@alanrevista.org

Portada

Debe contener: Título del manuscrito. Nombres, apellidos y la afiliación institucional de los autores. Nombre, dirección postal, número de teléfono y dirección de correo electrónico del autor encargado de la correspondencia.

Resumen y palabras clave

Escrito en forma corrida y no en secciones, que no sobre pasará las 250 palabras de extensión. Agréguense de 3 a 6 palabras clave que ayuden a los indizadores a clasificar el artículo. ALAN exige que si el trabajo original es en español o en inglés, deberá acompañarse de un resumen en inglés o en español o alternativamente en portugués con sus palabras clave.

Introducción

Enuncie la finalidad o el objetivo de investigación específico del estudio u observaciones, o bien la hipótesis que se ha puesto a prueba. Cite las referencias estrictamente pertinentes.

Materiales y métodos

Identifique los métodos, los aparatos y equipos (nombre y dirección del fabricante) y los procedimientos realizados. Identifique los reactivos y productos químicos utilizados.

Describa los métodos estadísticos con detalles e indique el método y modelo estadístico.

Resultados

Limite las Tablas y las Figuras al número necesario para explicar el argumento y resultados de la investigación y evaluar los datos en que se apoya. Se sugiere un máximo de 5 Tablas y 3 Figuras.

Discusión

Breve y concisa, contrastada con observaciones realizadas en otros estudios. Proponga nuevas hipótesis cuando haya justificación para ello, pero identificándolas claramente como tales.

Conclusiones

Refiérase a las más relevantes y oriente sobre posibles vías para continuar la investigación o el estudio emprendido. No cite referencias bibliográficas en esta sección.

Agradecimientos

Mencione la procedencia del apoyo recibido en forma de subvenciones (equipos, reactivos, medicamentos) y a las instituciones financiadoras del estudio, dependencia e instituciones que apoyaron su ejecución, así como a personas y colaboradores.

Tablas y figuras

Numérelas consecutivamente en arábigos siguiendo el orden en que se citan por primera vez en el texto. Cerciórese de que cada Tabla y Figura aparezca citada en el manuscrito.

Referencias

En el texto numere las referencias consecutivamente siguiendo el orden en que se mencionan por primera vez y se identificarán mediante números arábigos entre paréntesis.

Las Referencias serán listadas al final del manuscrito en orden numérico, no en orden alfabético. La veracidad de la información contenida en esta sección es responsabilidad del autor (de los autores). Se sugiere que los autores consulten: http://www.icmje.org

ÍNDICE DE AUTORES DEL VOLUMEN 70, 2020

ÍNDICE POR MATERIAS DEL VOLUMEN 70, 2020

LA SOCIEDAD LATINOAMERICANA DE NUTRICIÓN (SLAN)

La Sociedad Latinoamericana de Nutrición (SLAN) fue creada el 10 de Noviembre de 1965 en ocasión de celebrarse el Primer Congreso de Nutrición del Hemisferio Occidental. El actual Consejo Directivo de la SLAN (2019 – 2021) está constituido por los siguientes miembros:

Presidente	Rafael Figueredo Grijalba
Vicepresidente	Wilma Freire
Secretaria	Ana Ferreira Saguier
Secretaria Adjunta	Claudia Bordón Riveros
Tesorera	Cristina Jimenez Bazzano
Tesorera Adjunta	Rocio Arguello Ayala

DIRECTORIO DE ARCHIVOS LATINOAMERICANOS DE NUTRICION

Editor General	Maritza Landaeta-Jiménez
Editor Asociado	Yaritza Sifontes

COMITE EDITORIAL. PERÍODO 2019 – 2021

Elizabeth Dini Golding	Elba Sangronis
Betty Méndez Pérez	Pilar Hernández Serrano
Cristina Palacios Alzuru	Alexia Torres
Liseti Solano R.	Andrés Carmona

MIEMBROS DEL CUERPO EDITORIAL. PERÍODO 2019 – 2021

Juan de Dios Alvarado - Ecuador
Hugo Amigo A. - Chile
Marianella Anzola - Venezuela
Marián Araujo Yasselli - Venezuela
Marcela A. Araya Bannout - Chile
María Laura Arias E. - Costa Rica
Linda Arturo - Ecuador
Eduardo Atalah Samur – Chile
Omar T. Barrionuevo - Argentina
Luis A. Bello Pérez – México
Odilia Bermúdez - E.E.U.U.
David Betancur-Ancona - México
Adriana Blanco Metzler - Costa Rica
Erick Boy - E.E.U.U.
Jesús Bulux - Guatemala
Ana M. Calderón de la Barca - México
Fernando Carrasco Naranjo - Chile
Louella Cuningham - Costa Rica
Marcia Erazo – Chile
Patricia R. de Ferrer - Argentina
María A. González Stäger - Chile
Marisela Granito - Venezuela
Marisa Guerra M. - Venezuela
Marianella Herrera Cuenca - Venezuela
Hector A. Herrera M. - Venezuela
Ileana Holst Schumacher - Costa Rica
Marta Kaufer Horwitz - México
Aurelio López Malo - México
Iñigo Verdalet Guzman – México
Laura B. López de Bellesi - Argentina
Laura B. López de Ventades - Argentina
Mariane Lutz Riquelme - Chile
María Elena Maldonado Celis - Colombia
Marbella Marcano Martell - Venezuela
Julio Sergio Marchini - Brasil
Mariana Mariño Elizondo - Venezuela
María L. P. Martín de Portela – Argentina
Luis Antonio Mejia - Mexico
Josefina Morales de León - México
Laura Moreno Altamirano - México
Alvaro Ojeda - Venezuela
Manuel Olivares - Chile
Giovannina Orsini Velásquez - Venezuela
Saturnino de Pablo - Chile
Ingrid Rached Paoli - Venezuela
Sandra Restrepo Mesa - Colombia
Delia Rodríguez Amaya - Brasil
Gaspar Ros Berruezo - España
Manuel Ruz Ortiz - Chile
Alba Morón de Salim - Venezuela
Norma Sammán - Argentina
Sonia G. Sáyago Ayerdi - México
Teresa Shamah Levi – México
Ingrid Soto de Sanabria - Venezuela
Coromoto M. Tomei - Venezuela
Elio Vannucchi – Brasil
Maura Vásquez Ramírez - Venezuela

Archivos Latinoamericanos de Nutrición

Volumen 70. N° 4, Diciembre 2020

Contenido

Páginas