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Adolescent eating patterns: an integrative review

Padrões alimentares de adolescentes: uma revisão integrativa

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ABSTRACT
This study aimed to review dietary patterns derived from the food consumption of adolescents using principal component analysis. This integrative review was conducted by searching the Pubmed, Scielo, Lilacs, and Science Direct databases between April and October 2022, using the terms "dietary pattern", "factor analysis", "principal component analysis", "food pattern", and "adolescent". A total of 25 studies were selected, which were published between 2016 and 2022. The most common patterns were characterized by “Traditional”, “Healthy”, and ”Unhealthy” diets; the latter was the most frequent. The analysis of dietary patterns is crucial for nutritional epidemiology and contributes to the understanding of the eating habits of adolescents.

Keywords: Adolescent. Dietary pattern. Factor analysis. Principal component analysis.

RESUMO
O objetivo deste estudo foi revisar padrões alimentares derivados do consumo alimentar de adolescentes por meio da análise de componentes principais. Trata-se de uma revisão integrativa realizada com busca nas bases de dados Pubmed, Scielo, Lilacs e Science Direct, entre os meses de abril a outubro de 2022, utilizando os termos "dietary pattern", "factor analysis", "principal component analysis", "food pattern" e "adolescent". Foram selecionados 25 estudos, publicados no período de 2016 a 2022. Os padrões mais frequentes foram os caracterizados por uma alimentação do tipo tradicional, não saudável e saudável, sendo o tipo não saudável o mais frequente. A análise de padrões alimentares, é uma importante ferramenta utilizada na epidemiologia nutricional, e contribui para a compreensão de hábitos alimentares dos adolescentes.

Palavras-chave: Adolescente. Análise de componente principal. Análise fatorial. Padrão alimentar.

INTRODUCTION

Dietary patterns (DP) are the quantities, proportions, types, or combinations of different foods and beverages and the frequency at which individuals habitually consume them[1]. These patterns have been used as a complementary methodology to studies of isolated nutrients or foods because they allow the development of dietary guidelines for populations based on overall food consumption[2]. Moreover, DP considers the complexity of the diet, the multicollinearity of foods, the interactions between their components, and their cumulative effects[2].

The methodologies for deriving DP are divided into a priori, a posteriori, and hybrid: the first uses pre-established criteria (e.g., dietary indices) to assess adherence to a defined DP, the second uses multivariate analysis based on correlations between dietary survey data, and the third combines both methodologies[3]. The techniques used in the a posteriori method are principal component analysis (PCA), exploratory factor analysis (EFA), and cluster analysis (CA) [3,4]. The PCA and EFA techniques synthesize the choices made by individuals using data reduction to how foods were consumed together[3]. In cluster analysis, the structure of the relationships analyzed occurs between individuals, identifying mutually exclusive groups according to their food consumption[3,5]. Of these techniques, the most used in studies to derive DP are EFA and PCA[4,6]; the latter is considered the best for DP derivation studies[5].

The World Health Organization[7] defines adolescence as the age group between 10 and 19 years old. This period is crucial in human development and it is influenced by eating habits from childhood, which may shape habits that last into adulthood[8]. In this phase of increased independence and experimentation, adolescents can adopt eating habits that may improve or impair their health for their health, including a higher risk for developing chronic non-communicable diseases (CNCD) [8,9].

Studies in Brazil[10] and worldwide[11] aimed at exploring DP in adolescents observed that the most prevalent in this population isthe unhealthy diet, which encompasses ultra-processed food rich in sugar and fat and low in fiber[6].

In this context, identifying and understanding the DP in adolescence is important for developing interventions to promote health and prevent disease[1,6]. Although previous reviews have investigated the association between DP and health outcomes in adolescents[6,12], they did not evaluate the DP identified in this population. Therefore, this study aimed to review the DP derived from the dietary intake of adolescents using PCA, one of the most widely used statistical methods in DP derivation studies[5].

METHODOLOGY

This integrative review aimed to answer the question "What are and how are the DP identified in adolescents using the CPA method?". This exploratory and bibliographical study used integrative review as a methodological procedure to allow for a deeper exploration of the topic[13].

The preparation of this integrative review involved six stages: (1) identification of the topic and selection of the hypothesis or research question; (2) establishment of criteria for inclusion and exclusion of studies, samples, or literature search; (3) definition of the information extracted from the selected studies or categorization of the studies; (4) evaluation of the selected studies; (5) interpretation of the results; and (6) data synthesis[13].

The search and selection of studies were performed between April and October 2022 in the databases Pubmed, Scientific Electronic Library Online (Scielo), Science Direct, and Latin American and Caribbean Health Sciences Literature (Lilacs); studies published between 2016 and 2022 were included. The search terms were found in the lists of Medical Subject Headings (MeSH) and Health Sciences Descriptors (DeCS); the latter is available on the Virtual Health Library (VHL) portal. The studies were selected using the following search terms in English and Portuguese: Dietary pattern; Factor analysis; Principal component analysis; Food pattern; "Padrão Alimentar", and "adolescente". The search terms were connected by the Boolean operators "OR" and "AND", generating the expression ("Dietary pattern" OR "Food pattern") AND ("adolescent" OR "Principal component analysis, Factor analysis"), another expression

used was ("eating patterns teenagers" OR "Dietary pattern adolescent") AND ("Principal component analysis"), with their respective translations into Portuguese.

Inclusion criteria considered full-text, open-access studies in Portuguese or English on adolescents aged 10 to 19 years that used the PCA method to identify DP. Studies in languages other than English or Portuguese; which were case reports, systematic reviews, experimental animal studies, dissertations, theses, book chapters; or duplicates were excluded.

Of the 5,217 studies found, 205 were selected after excluding duplicates and filter applications (period, human research, open access, and type of study). Then, studies were exported to Excel spreadsheets for analysis. During selection, titles and abstracts were examined, followed by a reading in full text. The data extraction was organized in Excel tables. Two authors independently reviewed the data to confirm suitability for the inclusion criteria; the decision is documented in Figure 1.

After reading the abstracts, 205 studies were selected. Of these, 25 met the inclusion criteria and were chosen to read the full texts to confirm their relevance to the review and qualitative synthesis; 180 studies were excluded. The details of the exclusions are shown in the selection flowchart. Thus, 25 studies were included in the review. The data extracted included information on authors, year of publication, location, study design, sample size, dietary survey method, and DP identified and their percentage of individual variance. The data was synthesized using a narrative approach.

RESULTS

A total of 5,217 studies were identified in the databases, and after applying screening criteria, 205 were selected to be read in full. Of these, 179 studies were excluded after assessing the inclusion and exclusion criteria resulting in 25 studies included (Figure 1).

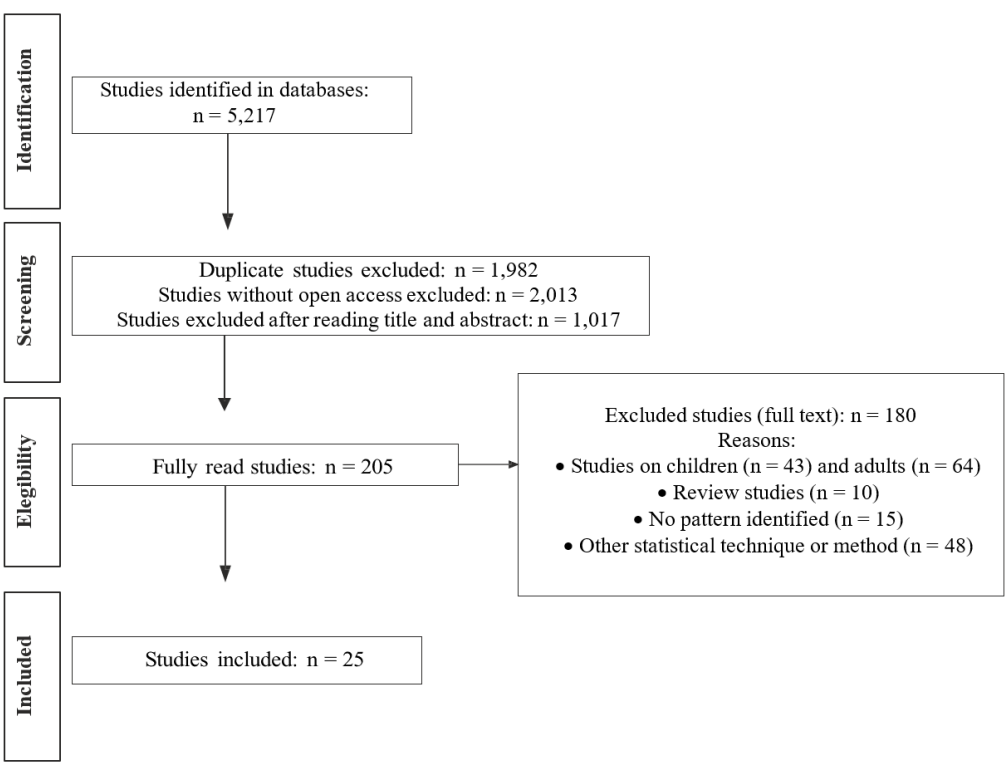

Figure 1. Flowchart of the study selection process. Blumenau - SC, 2023.
Source: Authors, 2023.

Chart 1 shows the characteristics of the studies reviewed, including 11 conducted in Brazil[10,14-23], 2 in Iran[24,25], 1 in China[26], and 1 in each of the following territories: Mexico[27], Chile[28];

Ghana[29]; Greece[30]; Israel[31]; Spain[32]; Italy[33]; Tanzania[34]; Greece and France[35]; Europe and Brazil[36]; and New Caledonia[37]. The sample size ranged from 153 to 71,298 individuals, and one study included only female adolescents[25]. Most studies were cross-sectional (n = 24)[10,14-16,18-26,29-37], followed by cohort studies (n = 3) [27,28,35], and longitudinal study (n = 1)[17]. The food frequency questionnaire was the most used method to identify food consumption (n = 15)[19,21,24-27,29-34,37].

Chart 1. Characteristics of the studies included. Blumenau- SC, 2023.

Author, year, location	Population	Study design / Dietary survey	Dietary patterns identified (% of variance explained)
Yang et al., 2016[26], China	N = 1,590 (age 11.0 to 17.0), both sexes.	Cross-sectional / FFQ	Chinese and western (26.3); Westernization (22.2); Meat diet (17.1).
Cunha et al., 2018[22], Brazil	N = 5,266 (age 10.0 to 19.0), both sexes.	Cross-sectional / 2-day FR	At home: Traditional (9.6); Bread and butter (6.4); Western (5.8). Away from home: Traditional (14.8); Bread and butter (8.0); Western (7.2).
Borges et al., 2018[36], Europe and Brazil	N = 2,330 (age 12.5 to 17.5), both sexes, from 10 European cities. N = 3,194 (age 12.5 to 17.5), both sexes, Brazilians.	Cross-sectional / 2-day FR	European boys: Western (7.3); Traditional European (7.2); Breakfast (6.4). European girls: Breakfast (6.8); Western (5.5); Traditional European (5.7); Monotonous (5.4). Brazilian boys: Traditional Brazilian (6.8); Western (6.2); Snacks (5.4); Healthy (4.8). Brazilian girls: Western (6.4); Breakfast (6.3); Sweets and fried food (5.4); Traditional Brazilian (5.2).
Borges et al., 2018b[18], Brazil	N = 6,784 (age 10.0 to 18.0), both sexes.	Cross-sectional / 24HR	Traditional Brazilian (8.40); Snacks (8.14); Fast food (8.12); Milk, fruit, and breakfast cereals (6.78).
Abizari; Ali, 2019[29], Ghana	N = 336 (age 10.0 to 19.0), both sexes.	Cross-sectional / FFQ	Sweet (32.5); Traditional (17.1).
Khayyatzadeh et al., 2019[25], Iran	N = 750 (age 12.0 to 18.0), female sex.	Cross-sectional / FFQ	Healthy (8.6); Traditional (5.5); Western (4.1).
Barchitta et al., 2019[33], Italy	N = 213 (age 15.0 to 18.0), both sexes.	Cross-sectional / FFQ	Prudent; Western; Energy-dense food[¥].
Alves et al., 2019[15], Brazil	N = 71,298 (age 12.0 to 17.0), both sexes.	Cross-sectional / 24HR	North: Traditional; Bread and coffee; Unhealthy; Traditional North. Northeast: Bread and coffee; Unhealthy; Traditional. Southeast: Traditional; Bread and coffee; Unhealthy. South: Traditional; Bread and coffee; Unhealthy. Midwest: Traditional; Bread and coffee; Unhealthy.
Bodega et al., 2019[32], Spain	N = 1,324 (age 12.0 to 16.0), both sexes.	Cross-sectional / FFQ	Processed; Traditional; Healthy[¥].
de Almeida Alves et al.,2020[16], Brazil	N = 52,038 (age 12.0 to 17.0), both sexes.	Cross-sectional / 24HR	Traditional Brazilian (7.9); Unhealthy (7.2); Coffee and bread (7.1).
Jansen et al., 2020[27], Mexico	N = 550 (age 9.0 – 17.0), both sexes.	Cohort / FFQ	Plant-based and lean proteins (10.3); Meat and starchy (6.5); Eggs, milk, and refined grains (4.8).
Arroyo et al., 2020[28], Chile	N = 882 (median age 12 years), both sexes.	Cohort / 24HR	Breakfast/light dinner (7.4); Natural foods (6.4); Western (5.6); Snacking (5.4).
Frayon et al., 2020[37], New Caledonia	N = 954 (age 10.5 to 16.1), both sexes.	Cross-sectional / FFQ	Meat (11.0); Fast food (10.6); Fruit and vegetables (9.3); Sweets (8.8); Dairy products and breakfast (7.6).
Brito et al., 2020[23], Brazil	N = 153 (age 10.0 to 18.0), both sexes.	Cross-sectional / 24HR	Traditional; Energy-dense food; Western; In transition[¥].
Kafyra et al., 2021[35], study 1 – Greece, study 2 – France	Study 1 - N = 766 (age 13.0 to 15.0), both sexes. Study 2 - N = 287 (median age 13.08 years), both sexes.	Study 1 - Cross-sectional / 24HR Sudy 2 - Cohort / FR	Study 1 - Western breakfast (15.6); Legumes and good fat (10.3); Homemade meal (8.3); Chicken and sugars (7.6); Eggs and fiber (7.4). Study 2 - Western breakfast (10.5); Prudent snacks (10.4); High protein and animal fat (9.2); Fish and seafood (8.1); Sugary snacks (8.1).

Author, year, location	Population	Study design / Dietary survey	Dietary patterns identified (% of variance explained)
Arruda Neta et al., 2021[17], Brazil	N = 1,438 (age 10.0 to 14.0), both sexes.	Longitudinal / 24HR	Traditional; Snacks; Western¥.
Kanellopoulou et al., 2021[30], Greece	N = 1,700 (age 10.0 to 12.0), both sexes.	Cross-sectional / FFQ	Boys: High in starch and protein; Unhealthy or high in fat; Healthy¥. Girls: High in starch and protein; Healthy; Unhealthy or high in fat¥.
Barros et al., 2021[14], Brazil	N = 826 (age 10.0 to 19.0), both sexes.	Cross-sectional / 24HR	Coffee and bread (9.2); Traditional Brazilian (8.2); Mixed (7.8).
Arruda Neta et al., 2021[20], Brazil	N = 1,438 (age 10.0 to 14.0), both sexes.	Cross-sectional / 24HR	Traditional; Snacks; Western¥.
da Silva et al., 2021[10], Brazil	N = 52,038 (age 12.0 to 17.0), both sexes.	Cross-sectional / 24HR	Traditional Brazilian (7.6); Processed meat sandwiches and coffee (7.0); Ultra-processed foods and sweets (7.0).
Pereira et al., 2021[21], Brazil	N = 1,188 (age 11.0 to 18.0), both sexes.	Cross-sectional / FFQ	Unhealthy (39.9); Healthy (8.7); Traditional (5.3).
Bogea et al., 2021[19], Brazil	N = 391 (age 17.0 to 18.0), both sexes.	Cross-sectional / FFQ	Western (12.4); Brazilian basic; Healthy¥.
Sinai et al., 2021[31], Israel	N = 3,902 (age 11.0 to 18.0), both sexes.	Cross-sectional / FFQ	Plant-based food (10.5); Junk food (8.0); Hot sweetened beverages and spreads (7.1); Cereals and milk (6.4); Carnivore (6.3).
Mosha et al., 2022[34], Tanzania	N = 1,170 (age 9.0 to 11.0), both sexes.	Cross-sectional / FFQ	Mixed (25.0); Heath (15.0)
Mirzaei et al., 2022[24], Iran	N = 203 (age 12.0 to < 18), both sexes.	Cross-sectional / FFQ	Mediterranean (11.7); Western (11.3)

Source: Authors (2023). N- sample size. FFQ - Food Frequency Questionnaire. 24HR – 24-hour dietary recall. FR – Food record. ¥: individual variance values not provided by author.

The number of DP identified ranged from two to five[28,35]. They did not present standardized nomenclature, but those most frequent were named “Traditional”, “Healthy”, and "Western"[15,17,19].

Of the 25 studies, 24 [10,15-33,35-37] identified at least one pattern considered “Unhealthy”, characterized by the consumption of sweets, desserts, sugary and soft drinks, ultra-processed foods, fast foods, cheese, red and processed meats, breakfast cereals, chocolate, ready-to-eat foods, bakery products, fried and baked snacks, and pasta. Seventeen studies[10,14-23,25,26,29,32,35,36] identified "Traditional” DP as referring to local cultural eating habits, and fourteen[18,19,21,24-26,27,28,30-37] identified at least one pattern considered “Healthy”, encompassing fruit, vegetables, white meat, and whole grains.

A variety of terms were used to describe DP that are similar in their constituents. For example, "Common Brazilian" and "Traditional" describe the same DP[14,19,23]. Similarly, terms for unhealthy patterns also varied, such as "Western", "Junk food" and "Fast food"[10,18,23,29,32]. “Healthy” DP were also referred to as "Prudent", "Natural foods", "Plant-based foods", "Eggs and fiber", "Legumes and good fat", and "Fruits and vegetables" [28,31,35]. The DP "In transition"[23] can be called "Mixed"[14]. The DP "Bread and Coffee"[15] resembled the DP "Breakfast", "Snack", or "Bread and Butter"[14,15,17,22,31,35,36,37], depending on the context and region.

Besides the diversity in nomenclatures, DP with similar terms often have different dietary constituents depending on the region and period in which the data were collected, as observed in the "Traditional" DP. “Unhealthy” DP was the first to be identified in eight studies, showing the highest percentage of the total variance.

DISCUSSION

This review revealed a diversity of DP identified in adolescents with a wide variation of nomenclatures. The foods and their preparation

also differ depending on the territory and period evaluated. DP with similar names may contain different food constituents. These characteristics are particularly present in the DP considered "Traditional", which vary according to the typical foods of each region.

Adolescents presented DP that represents "Unhealthy", "Healthy", or "Traditional" diets. Most studies evaluating adolescents in different regions of Brazil and worldwide identified at least one DP characterized as "Unhealthy", corroborating other reviews[6,12,19]. Furthermore, "Unhealthy" DP was the first to be derived by the PCA method in eight studies, presenting the highest percentage of the total variance; therefore, these results indicate that this DP was common among adolescents.

The "Unhealthy" DP derived from these studies has a similar composition, regardless of the regions, cultures, and eating habits of the adolescents. These patterns include a variety of items, such as sweets, desserts, sugary drinks, ultra-processed foods, cheese, red and processed meats, and breakfast cereals[12]. Food groups considered to be protective for CNCD, such as fruit, legumes, vegetables, and nuts, tend to be absent or consumed in reduced quantities in this DP despite their presence observed by the studies[6].

In Brazil, adolescents often consume foods with low nutritional value, high energy density, and high fat, sodium, and sugar content[6,15]. This trend is concerning because diet quality is a modifiable risk factor associated with the prevalence of obesity in adolescence[9,18] and the development of health problems that may persist into adulthood[8]. Reducing the consumption of these foods is one of the recommendations of the Dietary Guidelines for the Brazilian Population, as high consumption increases the risk of obesity and CNCD[38].

Another DP commonly identified among adolescents is the "Healthy" diet, which includes fresh or minimally processed foods, such as fruit, vegetables, whole grains, nuts, seeds, fish, poultry, and eggs[36,34]. Of those, fish and eggs are the most common types of animal protein[21,35]. Skimmed milk and dairy products, especially yogurt[36,31,32], olive oil and olives[35], are also included in this pattern.

A multicenter study conducted on European and Brazilian adolescents showed the presence of "Healthy" DP only among Brazilian male adolescents[36]. The results suggested that sex is also a characteristic that should be considered in studies of DP derivation during adolescence. Multiple factors influence adherence to DP considered "Healthy", including political-economic, social, cultural, and food-related aspects[38,18].

"Traditional" DP has been characterized by a wide diversity in the nutritional quality of the foods that comprise it. In China, "Traditional" DP had a high intake of rice, flour, whole grains, vegetables, fresh fruit, poultry, eggs, nuts, snacks, sugar, and barbecue[26]. In Greece and Ghana, this pattern was associated with the consumption of legumes, fish, seafood, and olive oil[29,30], and Attica (Greece) showed a high consumption of red meat and potatoes, with no fish[35]. This trend was also observed in Brazil. Rice, beans, meat, pasta, oils, and farinaceous products[10,16-19,36]; tubercles and vegetables[18]; processed, ultra-processed and ready-to-eat foods[9]; and dairy products[19,23] and bread[21,36] were foods that constituted "Traditional" DP.

The constitution of "Traditional" DP differed between sexes[36] and regions of Brazil[15]. The Study of Cardiovascular Risks in Adolescents (ERICA) derived DP called "Traditional", "Bread and Coffee", and "Unhealthy" in the South, Midwest, Southeast, and Northeast regions. In the North, a DP called "Traditional North" was also described, characterized by the consumption of foods typical of that region[15]. These findings highlight the importance of developing population-based studies on DP in different regions to identify local particularities, which may guide the development of interventions during adolescence, the opportune time to promote nutritional actions to improve health and prevent current or future diseases[8].

The limitations of this study include selection bias, the heterogeneity of the studies, and the synthesis of results. Selection bias means that relevant studies may have been excluded or studies with similar results may have been included. The lack of heterogeneity in the studies hindered the standardization of the

nomenclatures assigned to the identified DP and the synthesis, comparison, and generalization of results.

CONCLUSION

This review highlights the diversity of DP among adolescents, usually two to five distinct DP, which were identified using the PCA statistical method. The most frequent DP observed were characterized by a "Traditional", "Unhealthy", and "Healthy" diet. The "Unhealthy" pattern was the most common, including in Brazilian adolescent populations. Studies showed that similar patterns may have different dietary constituents due to regional variations, data collection periods, cultural influences, and sex. The "Traditional" DP showed the greatest diversity of constituents in the studies.

The derivation of DP can be a challenge due to the complexity of the data and the difficulty in external validation. However, the study of DP is useful in nutritional epidemiology because it complements the analysis of isolated nutrients or foods, and allows for a better understanding of eating habits and their relationship with disease risk. The identification of DP in different populations of adolescents may contribute to the development of dietary interventions aimed at promoting health and preventing current or future diseases, as well as subsidizing public health policies in nutrition.

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