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Tracking and Changes in Dietary Patterns of Adolescents: A Longitudinal Study in Southern Brazil

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Abstract

Methods: Longitudinal study carried out in Southern Brazil since 1993. Two food frequency questionnaires were applied at ages 15 and 18 years. The analysis includes 3,911 adolescents. Latent class analysis was used to identify the DPs at 15 and 18 years.

Results: We identified four DPs at 15 and 18 years. Three were similar in both ages: "Varied" (30.2% at age 15 years vs. 21.6% at age 18years), "Traditional" (24.9% at age 15 years vs. 23.7% at age 18years) and "Dieting" (19.4% at age 15 years vs. 28.7% at age 18years), and the fourth DP identified labeled "Processed Meats" (25.5%) at 15 years and "Fish, Fast Food and Alcohol" (26.0%) at 18 years. The three DPs identified at both ages showed poor general agreement (Kappa=0.1). DP tracking was observed in about one third of the adolescents.

Conclusions: Our findings suggest a high adherence to a "Varied" DP at age 15 years and substantial changes in food habits and choices over time, resulting in an increase in the adherence to a "Dieting" DP at age 18 years.

Keywords: Dietary patterns; Tracking; Latent class analysis; Adolescent

Introduction

Adolescence is a period between the ages of 10 and 19 years, characterized by many physiological changes and formation of lifelong eating habits [1,2]. Eating habits acquired during infancy, childhood and adolescence, whether healthy or not, are likely to be maintained throughout life [2,3]. It is largely known that food consumption consists of a risk or protection factor for the development of chronic diseases (CDs) [1]. Therefore, these diseases may have their roots in adolescence, through poor eating habits and other adverse lifestyle factors [3,4].

Dietary components, such as food products rich in cholesterol, saturated fatty acids [5,6], trans fatty acids [7] and sodium [8], can have deleterious effects if consumed in inadequate amounts and intervals, increasing the risk of developing CDs. On the contrary, several dietary components have been associated with decreased risk of CDs, such as polyunsaturated and monounsaturated fatty acids found in fish, vegetable oils and nuts [9].

The dietary habits of a population can be assessed through several approaches [10]. Food consumption is commonly evaluated by estimating total energy intake, micro and macronutrients of separate food-items; in addition, more comprehensive analyses may consider food groups rather than food-items separately, through eating indexes and dietary patterns (DPs) [10,11]. The World Health Organization (WHO) [1] suggested that food intake assessments should be based on food profiles, considering the variety of foods in the daily diet and the possible interaction between nutrients, which can affect its bioavailability. Since the 1980s, the DPs have been widely used in nutritional epidemiology to examine the complex nature of eating [10]. This approach helps in understanding the relationship between food intake and the development of diseases, allowing investigations into interactions and potential synergistic or antagonistic effects between nutrients. DPs can be constructed using principal component analysis (PCA) and cluster analysis, based on data collected using food frequency questionnaires (FFQ), diet record (DR) or 24-h recalls (24 h) [10].

Although several studies have investigated DPs among adolescents [12,13], few evaluate tracking DPs. Tracking DPs has been assessed in nutritional epidemiology studies as the adherence to specific DPs in a certain period. Strong DP tracking indicates the maintenance of similar levels of nutrient intake or food consumption over time, while poor DP tracking suggests a susceptibility to alter dietary habits over time [3].

Despite adolescence being described as a critical period for the establishment of eating behaviors that may be carried into adulthood, little is known about the tracking in DPs over time. Even though evidence suggests that dietary patterns may track from adolescence to adulthood, adults' eating habits are usually perceived as better and healthier compared to adolescents, suggesting that important changes in eating behaviors may occur during adolescence, favoring the adoption of healthier diets [3,14]. Therefore, we aimed to (i) determine DPs in adolescents from the 1993 Pelotas (Brazil) birth cohort at ages 15 and 18 years; (ii) identify characteristics associated with the DPs in both periods; and (iii) examine the DP tracking and changes over the period from 15 to 18 years of age.

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Methods

Study design

This is a prospective longitudinal study carried out with data from the 1993 Pelotas Birth Cohort, Brazil.

1993 Pelotas Birth Cohort 1993, Brazil

It consists of a population-based study that recruited 5,320 hospital births from mothers living in the urban area of Pelotas from 1st January to 31st December of 1993. Of these, 55 were stillborn and the mothers of 16 newborns did not agree to participate in the study. Therefore, the original cohort comprises 5,249 live births (98.7% of all births). More details about this study can be found elsewhere [15,16].

Several follow-up visits were carried out at different ages, some of them only assessing subsamples of the original cohort. For this study, we used information collected at ages 15 and 18 years, for which all subjects were eligible.

Assessment of frequency of consumption

We applied two adapted versions of Food Frequency Questionnaires (FFQ) previously validated in the Brazilian population [17], in order to study the food consumption at ages 15 and 18 years in members of the 1993 Pelotas birth cohort in the year prior to interview.

At age 15 years, a qualitative FFQ was applied by trained interviewers. It comprises 81 food-items and allows assessment of the frequency of consumption of each food (one to ten times per day/week/month/year). At age 18 years, we used a semi-quantitative self-reported FFQ available in electronic format. It was composed of 88 food-items, assessing the categorized frequency of consumption (never or less than 1 time/month, 1 to 3 times/month, 1 time/week, 2 to 4 times/week, 5 to 6 times/week, 1 time/day, 2 to 4 times/day, 5 times/day or more).

A total of 79 food-items available in both FFQs were included in this analysis. We divided these food-items into 19 foods groups taking into account their nutritional characteristics (Table 1). We estimated the frequencies of consumption of each food group obtained through the FFQ. As we observed skewed distributions for most groups, as well as inflation of zero intake, we opted to divide the frequencies into tertiles.

Constructing dietary patterns (DPs)

The 19 food groups were used to construct the DPs at both ages using latent class analysis (LCA). The LCA is used to recognize distinct groups of individuals from a sample that cannot be observed directly (so-called latent classes), which can be inferred from the observed variables. Based on statistical models it is possible to compute for each subject the probabilities of belonging to a specific class, identifying interpretable item-profiles for each category of the food groups. In this study, the latent classes are referred to as DPs.

The number of DPs was defined according to the Bayesian Information Criterion (BIC) [18], and the model with the lowest BIC was selected in order to optimize the fitness of the model. Starting from a single-class model and increasing one class at each step, the best solution was identified when the increase in the number of classes did not lead to a decrease in BIC. The increase in log likelihood values leveled off when increasing from four to five classes, supporting preference for a four-class solution. All LCA models were fitted using MPlus version 5.2 [19].

Initially, the absolute frequency of individual's adherence to each DP was estimated. Within each DP, the distribution of the subjects was assessed according to the tertiles of daily frequency of consumption of each group, estimating the proportion of individuals in each tertile (lowest/middle/highest).

Food group	Foods
1. Rice, pasta, potatoes	Rice+pasta+potatoes+manioc cassava
2. Beans	Beans+lentil
3. Breads	Brown bread+white bread+bread shape
4. Vegetables	Letucce+tomato+carrot+pumpkin+cole+cabbage+chayote+natural cucumber+string bean+beet+cauliflower+garlic+onion
5. Fruits	Banana+orange or mandarine+papaya+pineapple+alligator pear+mango+peach+guava+pear+apple+watermelon or melon+strawberry+grape+natural fruit juice
6. Snacks	Chips+cracker+cake+popcorn+pies+sweet biscuits
7. Sweets/Candies	Ice cream+candies+desserts+chocolate
8. Soft drinks and sugary beverages	Soft drink+light soda+artificial juice
9. Fast Food	Cheeseburguer+hot dog+pizza+fried polenta+fried cassava+french fries+mayonnaise+canned foods+canned fish
10. Sausages and processed meats	Ham, mortadella or salami+dried meat+sausage
11. Fish	Fish+shrimp
12. Chicken	Chicken
13. Viscera	Viscera
14. Red meat	Beef+carcass meat+pork
15. Eggs	Eggs
16. Milk and dairy products	Milk+yogurt+cheese
17. Added sugar and chocolate powder	Sugar+chocolate powder
18. Alcohol	Wine+whiskey+beer
19. Coffee and tea	Coffee+tea

Table 1: Food groups.

In order to identify the food groups that were more frequent in each DP, we compared the proportion of adolescents in the lowest and the highest tertile of frequency of consumption of each food group with the proportion of adolescents in the lowest and the highest tertiles of frequency of consumption in the whole sample. When the difference in the highest tertile of consumption was equal to or greater than approximately+10 percentage points, we assumed that the DP was characterized by the high consumption of that specific food group. On the contrary, differences equal to or greater than approximately+10 percentage points in the lowest tertile of consumption were interpreted as low consumption of the specific food group in the DP.

Definition of DPs tracking and changes

We defined DP tracking as the individual's adherence to the same DP at both ages (15 and 18 years). In addition, change in individual's DP in the same period was also evaluated.

Sociodemographic variables

The sex of the child was based on observation by the trained interviewers. The asset index (AI), based on the ownership of 16 assets (colored television, television LCD or plasma TV, car, vacuum cleaner, DVD, video game, washing machine, microwave, refrigerator, freezer, telephone line, desktop, notebooks internet available 24 hours, air conditioner or split, number of rooms used to sleep, number of bathrooms, ownership of another property, and domestic housemaids) [20] was based on information collected from the mother or guardian of the adolescent at 15 years, and by the participant adolescent at age 18 years.

Anthropometric measures

Weight and height were collected by trained anthropometrists. The body mass index (BMI) was calculated by dividing the weight (kg) by the height squared (m^2). BMI was calculated separately at ages 15 and 18 years and the obesity status (yes/no) was defined according to the WHO criteria (2007) [21].

Physical activity (PA)

The International Physical Activity Questionnaire (IPAQ) was applied to assess habitual physical activity during the seven days prior to survey. We used the short interview-administered version composed of seven items, which covers three domains of physical activity: transportation, household/gardening and leisure-time activities [22]. The number of days per week and the time spent on physical activities per day from all three domains were recorded. Adolescents were considered active if they reported engaging in physical activity for at least 300 minutes/week.

Statistical analyses

Data management and analysis were carried out using Stata (version 12.1) [23]. Firstly, relative frequencies of categorical variables were compared by their 95% confidence interval (95% CI). Secondly, we applied the Pearson's chi square test to test the associations of the sociodemographic and lifestyle variables with the DPs, adopting a significance level of 5%. Thirdly, we tested for differences in the associations between each independent variable and the DPs stratified by sex, but no evidence of interactions was found. We therefore presented the results for the whole sample. Finally, we estimated DP tracking by analyzing the concordance between the proportion of DP tracking identified in both ages (15 years and 18years) using kappa concordance coefficient (<0.20: poor, 0.21-0.40: weak, 0.41-0.60: moderate, 0.61-0.80: good, 0.81-1.00: excellent) [24].

Ethical aspects

This study is part of the project entitled "Early and contemporary influences on body composition, human capital, mental health and chronic disease precursors in complex cohort born in 1993 in Pelotas, Brazil", which was approved by the Ethics Committee in Research of the School of Medicine, University Federal of Pelotas (process number 05/11). An informed consent was signed by all participants or parent/responsible (under 18 years).

Results

Characteristics of the participants

At ages 15 and 18 years, 4,325 and 4,106 participants were interviewed, respectively; therefore, follow-up rates of 85.7% (15years) and 81.4% (18years) were achieved. More details about the study design and follow-up visits can be found elsewhere [23,24]. This study was restricted to the 3,911 adolescents with complete information on FFQs in both follow-ups (52.1% were girls). At age 15 years, the prevalence of obesity was 8.7%, and 46.5% of the adolescents were considered active. In addition, we observed significant increases in both obesity prevalence (10.4%; $p<0.001$) and practice of physical activity (58.7%; $p<0.001$) from 15 to 18 years of age (data not shown in table).

Label of DPs

For each follow-up visit, four DPs were identified through LCA, which are presented in Table 2. At age 15 years, the first pattern was characterized by the high proportion of adolescents in the highest tertile of frequency of consumption of all food groups; this pattern was labeled "Varied" DP. In the pattern 2, we identified high intake of traditional food groups in Brazil, such as: rice, pasta, potatoes, beans, breads, added sugar and chocolate powder, coffee and tea; this pattern was labeled "Traditional" DP. Pattern 3 presented low frequency of consumption of the majority of food groups and was labeled "Dieting" DP. About 25% of the adolescents adhered to pattern 4, showing high intake of processed foods, such as fast food, sausages and processed meats; this pattern was labeled "Processed Meats" DP. The patterns 1, 2 and 3 were also identified at age 18 years. In addition, a fourth different pattern characterized by high intake of fish, fast foods and alcohol was identified and labeled "Fish, Fast Foods and Alcohol" DP.

Description of DPs

Table 3 shows the frequencies of each DP at age 15 years and associated characteristics. The "Varied" DP was the most prevalent (30.2%; 95%CI 28.7, 31.6); conversely, the least prevalent was the "Dieting" DP, with adherence of 19.4% (95%CI 18.1, 20.6) of the adolescents. We found that boys' adherence to "Traditional" DP was significantly greater when compared to girls. The poorest were more likely to adhere to the "Traditional" DP (38.1%-95%CI 34.6, 41.5), while the wealthiest tended to adhere to the "Dieting" DP (41.3%-95%CI 37.8, 44.7). Among the obese individuals, most of them adhered to the "Processed Meats" DP (33.0%-95%CI 27.9, 38.1), while the "Dieting" was the less adhered DP (18.8%-95%IC 14.6, 23.0). The "Varied" DP was the most prevalent among those adolescents who engaged in physical activity for at least 300 minutes/week (35.0%-95%IC 23.6, 27.6); in adolescents with insufficient physical activity, the "Processed Meats" DP (26.8%-95%IC 24.9, 28.7) was the most prevalent.

At age 18 years, the "Dieting" DP showed greater adherence by youth (28.7%-95%CI 27.2, 30.1), whilst the lowest adherence was found for the "Varied" DP (21.6%-95%CI 20.3, 22.9) (Table 4). The

Age	Consumption frequency	Pattern 1	Pattern 2	Pattern 3	Pattern 4
15 years	Low	-	Fruits Fast food Sausages and processed meats Red meat Milk and dairy products Snacks Sweets/candies Soft drinks and sugary beverages	Rice, pasta, potatoes Breads Vegetables Fruits Snacks Sweets/Candies Soft drinks and sugary beverages Sausages and processed meats Chicken Red meat Added	Rice, pasta, potatoes Beans Breads Vegetables Chicken Eggs Milk and dairy products Coffee and tea
	High	All food groups *(except alcohol and coffee and tea)*	Rice, pasta, potatoes Beans Breads Vegetables Coffee and tea	-	Sausages and processed meats
	Dietary pattern (DP)	Varied (V)	Traditional (T)	Dieting (D)	Processed meats (PM)
18 years	Low	-	Sweets/Candies Fast food Milk and dairy products	All food groups (except alcohol)	Rice, pasta, potatoes Beans
	High	All food groups	Rice, pasta, potatoes Beans Breads Vegetables	-	Fish Fast Food Alcohol
	Dietary pattern (DP)	Varied (V)	Traditional (T)	Dieting (D)	Fish, Fast Food and Alcohol (FFA)

Table 2: Characteristics (food groups) of dietary patterns at ages 15 and 18 years.

Variables	Dietary pattern at age 15 y				P value
	Varied (n=1,180)	**Traditional** (n=975)	**Dieting** (n=758)	**Processed meats** (n=998)	
	% (95%CI)	% (95%CI)	% (95%CI)	% (95%CI)	
Overall	30.2 (28.7 , 31.6)	24.9 (23.5 , 26.3)	19.4 (18.1 , 20.6)	25.5 (24.2 , 26.9)	
Sex					
Boys	30.3 (28.2 , 32.4)	26.7 (24.7 , 28,7)	18.7 (16.9 , 20.5)	24.2 (22.3 , 26.2)	0.049*
Girls	30.0 (28.1 , 32.0)	23.3 (21.4 , 25,1)	19.9 (18.2 , 21.7)	26.7 (24.8 , 21.7)	
Asset index (quintiles)					
1st (20% poorest)	30.1 (26.9 , 33.3)	38.1 (34.6 , 41.5)	5.9 (4.3 , 7.6)	25.8 (22.7 , 28.9)	
2nd	31.9 (28.6 , 35.2)	33.2 (29.8 , 36.5)	9.5 (7.4 , 11.6)	25.4(22.3 , 28.5)	0.000#
3rd	33.8 (30.5 , 37.1)	27.5 (24.3 , 30.6)	14.7 (12.3 , 17.2)	24.0 (21.1 , 27.0)	
4th	31.7 (28.5 , 34.9)	17.4 (14.8 , 20.1)	25.2 (22.2 , 28.2)	25.7 (22.7 , 28.7)	
5th (20% wealthiest)	23.1 (20.1 , 26.1)	8.9 (6.9 , 10.9)	41.3 (37.8 , 44.7)	26.7 (23.6 , 29.8)	
Obesity (WHO, 2007)					0.012*
No	30.5 (28.9 , 31.9)	25.4 (23.9 , 26.8)	19.3 (17.9 , 20.6)	24.9 (23.5 , 26.4)	
Yes	26.9 (22.2 , 31.8)	21.2 (16.8 , 25.6)	18.8 (14.6 , 23.0)	33.0 (27.9 , 38.1)	
Physical activity (300m/w)					
No	25.9 (24.1 , 27.9)	24.4 (22.5 , 26.2)	22.8 (21.0 , 24.6)	26.8 (24.9 , 28.7)	0.000*
Yes	35.0 (32.8 , 37.2)	25.6 (23.6 , 27.6)	15.4 (13.7 , 17.0)	24.1 (22.1 , 26.0)	
Note: *Pearson's Chi square test, #Linear tendency test					

Table 3: Dietary patterns at age 15 years old and associated characteristics (n=3,911).

rich adolescents adhered mostly to the "Fish, fast food and alcohol" DP and "Dieting" DP (35.6%-33.4%, respectively); conversely, the poorest adolescents adhered mostly to the "Traditional" (31.1%) and "Varied" (28.7%).

The highest proportion of obese adolescents was found among those who adhered to a "Dieting" DP (37.8%-95%CI 32.9%, 42.7%); in contrast, the lowest proportion was found among those who adhered to a "Varied" DP (17.6%-95%CI 13.8%, 18.1%). In addition, more adolescents who were considered physically active adhered to the "Fish, fast food, alcohol" DP (27.1%-95%CI 25.3, 28.9) compared to the other three DPs. In addition, most adolescents who referred insufficient physical activity adhered to the "Dieting" DP (33.5%-95%IC 31.2, 35.8).

Tracking and changes

Table 5 shows the DP tracking and changes from 15 to 18 years. About 30% of the adolescents adhered to the same DP at both ages, characterizing the DP tracking. The Kappa general concordance coefficient including the DPs identified at both ages was 0.1 ($p<0.001$), with a percentage of agreement of 30.5%. The highest Kappa was found for the "Varied" DP (kappa=0.2), followed by the "Traditional" DP (kappa=0.1) and the "Dieting" DP (kappa=0.1) (data not shown in table), while the greatest tracking proportion was observed for the "Dieting" DP (36.5%). The "Processed Meats" DP identified at age 15 years was replaced by the "Fish, Fast Foods and Alcohol" DP at 18 years. Most participants who adhered to the "Processed Meats" DP at baseline changed to the "Dieting" DP at 18 years (37.9%). The highest proportion of "Dieting" DP tracking (39.1%) was observed among girls, while the tracking of the "Varied" (40.5%) and the "Traditional" (33.5%) DP tracking was more common among the poorest 20%.

About one-third (34.8%) of the adolescents who adhered to a "Dieting" DP at age 15 years changed to a "Fish, Fast Food and Alcohol" DP at age 18 years. Among the poorest adolescents, the most frequent change was from a "Dieting" to a "Fish, Fast Food and Alcohol" DP; conversely, most rich adolescents changed from a "Processed Meats" to a "Dieting" DP (48.5%).

Half of the obese adolescents who adhered to a "Processed Meats" DP at age 15 years changed to a "Dieting" DP at age 18 years. The same change was also common among the physically active adolescents (31.6%).

Discussion

This study was carried out in a middle-income setting, with data from the 1993 Pelotas birth cohort. Three out of the four patterns identified in each follow-up visit were similar (Varied, Traditional, and Dieting). The fourth pattern was characterized by the frequency of consumption of "Processed Meats" at age 15 years and by "Fish, Fast Foods, and Alcohol" at age 18 years. Adolescents adhered mostly to the "Varied" and the "Dieting" DPs at ages 15 and 18 years, respectively. The "Varied" DP is characterized by high frequency of consumption of the so-called "healthy food" groups (fruits, vegetables, beans, etc.) and "unhealthy food" groups (processed meats, fast foods, sugary drinks, etc.), while the "Dieting" DP represents the rare consumption of the same food groups. About one-third of the adolescents showed stability in the DP over time, characterizing the DP tracking. Changes in DP varied widely according to sex, wealth, obesity status and physical activity in the same period.

During adolescence, individuals tend not to be concerned about the consequences of their eating habits, which cumulatively can be harmful

Variables	Dietary pattern at age 18 years				P value
	Varied (n=846)	**Traditional** (n=926)	**Dieting** (n=1,122)	**Fish, fast food and alcohol** (n=1,017)	
	% (95%CI)	% (95%CI)	% (95%CI)	% (95%CI)	
Overall	21.6 (20.3 , 22.9)	23.7 (22.3 , 25.0)	28.7 (27.2 , 30.1)	26.0 (24.6 , 27.4)	
Sex					
Boys	22.7 (20.8 , 24.6)	24.8 (22.9 , 26.8)	26.4 (24.4 , 28.4)	25.9 (24.0 , 27.9)	0.014*
Girls	20.6 (18.8 , 22.4)	22.6 (20.8 , 24.4)	30.8 (28.8 , 32.8)	26.0 (24.1 , 27.9)	
Asset index (quintiles)					
1st (20% poorest)	28.7 (25.5 , 31.8)	31.1 (27.8 , 34.3)	22.2 (19.4 , 25.2)	17.9 (15.3 , 20.7)	
2nd	25.3 (22.2 , 28.4)	26.1 (22.9 , 29.2)	24.9 (21.9 , 28.0)	23.6 (20.6 , 26.6)	0.000#
3rd	20.7 (17.8 , 23.5)	24.6 (21.6 , 27.6)	31.9 (28.7 , 34.2)	22.8 (19.9 , 25.7)	
4th	17.8 (15.1 , 20.4)	20.9 (18.1 , 23.8)	31.0 (27.8 , 34.2)	30.2 (27.0 , 33.5)	
5th (20% wealthiest)	15.5 (12.8 , 18.1)	15.4 (12.9 , 17.9)	33.4 (30.1 , 36.8)	35.6 (32.2 , 39.0)	
Obesity (WHO, 2007)					
No	19.3 (18.0 , 20.7)	24.5 (23.0 , 25.9)	28.6 (27.1 , 30.2)	27.6 (26.0 , 29.1)	0.002*
Yes	17.6 (13.8 , 21.4)	22.8 (18.6 , 26.9)	37.8 (32.9 , 42.7)	21.8 (17.6 25.9)	
Physical activity (300m/w)					
No	17.6 (15.8 , 19.4)	24.3 (22.1 , 26.4)	33.5 (31.2 , 35.8)	24.6 (22.5 , 26.7)	0.000*
Yes	24.4 (22.6 , 26.1)	23.2 (21.4 , 24.9)	25.3 (23.5 , 27.1)	27.1 (25.3 , 28.9)	
Note: *Pearson's Chi square test, #Linear tendency test					

Table 4: Dietary patterns at age 18 years old and associated characteristics (n=3,911).

Variables	V 15 y				P value	T 15 y				P value	D 15 y				P value	PM 15 y				P value
	Tracking 18y	T 18y	D 18y	FFA 18y		Tracking 18y	V 18y	D 18y	FFA 18y		Tracking 18y	V 18y	T 18y	FFA 18y		V 18y	T 18y	D 18y	FFA 18y	
Overall	32.0	23.4	17.0	27.5		31.6	22.6	27.2	18.7		36.5	11.8	14.9	36.8		15.9	23.0	37.9	23.2	
Sex†																				
Boys	32.9	24.5	15.9	26.8	0.579*	29.7	23.8	25.8	20.8	0.175*	33.6	13.1	18.5	34.8	0.029*	16.3	24.9	34.8	24.0	0.270*
Girls	31.2	22.4	18.1	28.3		33.5	21.3	28.7	16.5		39.1	10.6	11.8	38.6		15.6	21.3	40.6	22.4	
Asset index (quintiles) †																				
1st (20% poorest)	40.5	24.6	12.9	21.9		33.5	28.7	21.2	16.7		23.9	21.7	13.0	41.3		24.1	26.6	29.7	19.6	
2nd	37.1	28.6	13.5	20.8		30.6	24.7	28.6	16.1		26.0	24.7	17.8	31.5		20.0	29.2	30.8	20.0	
3rd	29.3	22.2	21.8	26.7	0.000#	29.6	18.9	26.4	25.0	0.000#	39.7	11.2	18.1	31.0	0.001#	17.5	24.9	37.0	20.6	0.000#
4th	29.6	21.3	17.4	31.6		31.7	14.4	37.4	16.6		38.8	11.9	16.9	32.3		11.2	20.9	42.9	24.9	
5th (20% wealthiest)	21.4	20.2	19.7	38.8		31.9	17.4	30.4	20.3		38.1	7.2	12.3	42.5		7.3	13.6	48.5	30.6	
Obesity (WHO, 2007) †																				
No	32.2	23.3	16.7	27.9	0.825*	31.5	23.7	25.9	18.9	0.125*	35.8	11.9	14.9	37.4	0.350*	16.4	22.9	36.1	24.6	0.006*
Yes	33.7	23.6	19.1	23.6		25.7	17.1	38.6	18.6		45.2	11.3	8.1	35.5		15.6	23.9	49.5	11.0	
Physical activity (300m/w) †																				
No	30.7	22.6	18.0	28.7	0.601*	32.4	22.8	28.8	16.1	0.164*	38.5	10.9	11.9	38.7	0.012*	12.3	21.9	42.9	22.8	0.000*
Yes	33.2	24.1	16.2	26.6		30.8	22.4	25.4	21.5		33.3	12.9	20.1	33.7		20.6	24.3	31.6	23.6	

Note: *Pearson's Chi square test, #Linear tendency test, †Variables at 15 years
Abbreviates: V: Dietary Pattern Varied; T: Dietary Pattern Traditional; D: Dietary Pattern Dieting; PM: Dietary Pattern Processed Meats; FFA: Dietary Pattern Fish, Fast Food and Alcohol

Table 5: Proportion of tracking and change of dietary patterns at 15 and 18 years and associated characteristics (n=3,911).

to their health [25]. In general, the food choices of adolescents are influenced by social interaction, family habits, personal preferences and daily activities [25-27]. In our study, higher adherence to a "Varied" DP was found among adolescents at age 15 years. As mentioned previously, this pattern is characterized by the high frequency of food consumption of either healthy or unhealthy food, probably leading to a high calorie intake. Conversely, a higher proportion of physically active adolescents were found in this group, which may explain the lack of association between the "Varied" DP and obesity at both ages. We found only one study addressing associations between DPs and physical activity during adolescence. Grieger et al. [28] carried out a cross-sectional study in 1,114 girls aged 9-16 years in Australia, deriving four dietary clusters, labelled as follows: combination, mixed dishes, meat and vegetable, and take-away. The study showed that those identified in a "meat and vegetable" cluster – characterized by high intake of red meat and vegetables, as well as fruit, whole grain breads, low fat yoghurt, and lower intakes of take-away foods and soft drinks – were more likely to engage in physical activity, in comparison with those in the remaining clusters.

We identified a few studies that have also assessed DP during adolescence and associated factors [13,29,30]. An English longitudinal study assessed a priori DP among children and adolescents followed up from age 7 to 15 years, reporting that an energy-dense, high-fat, low-fiber DP was prospectively associated with greater levels of adiposity [30]. In the United States of America, Ritchie et al. [29] studied DPs among adolescent girls using cluster analysis. Four DPs were identified among African-American girls: customary (53%), snack-type (23%), meal-type foods (22%) and sweets and cheese (<2%). The "meal-type foods" DP, which is similar to the "Varied" DP identified in our study, showed a high consumption of both "healthy" (grains, vegetables, etc.) and "unhealthy" food groups (chips, sandwiches, etc.), but no evidence of association between this DP at age 9-10 years and BMI ten years later was found. Among white girls, the study [29] reported four different DPs (convenience (45%), sweets and snack-type (33%), healthy (12%) and fast food (10%), also finding a significant association between adherence to a "healthy" DP and lower waist circumference 10 years later.

At age 18 years, most adolescents adhered to a "Dieting" DP, which is characterized by the lower frequency of consumption of all food groups included in the analysis. This change in behavior compared to the baseline could be related to the end of adolescence and the start of early adulthood, during which the individual usually becomes more concerned about body image, especially among women. Although lowering the frequency of consumption would generally lead to lower calorie intake and, consequently, weight loss, in qualitative terms it also reflects a lower consumption of healthy food groups, such as fruits, vegetables, beans and others. A low consumption of fruit and vegetables, as well as grains, has been associated with increased risk of the incidence of chronic diseases. "Dieting" DP had greater adherence among girls and wealthier subjects. Consistently, a study carried out by Oellingrath et al. [31] with Norwegian pre-teens and adolescents identified four DPs using PCA (snacks, convenient, varied Norwegian, and dieting), reporting greater adherence to "Dieting" DP among girls. Additionally, in a study including Portuguese adolescents aged 13 years, 40% of them adhered to a dietary pattern named "low intake", which was associated with higher proportion of overweight/obese [13].

Differences in eating habits between boys and girls during adolescence have been widely documented in the literature. The body self-image and the lack of sense of urgency about personal health strongly affect health habits, especially among adolescents, commonly leading to adoption of unhealthy eating habits [32]. The Brazilian National Adolescent School-based Health Survey (PeNSE) [33] assessed ten food indicators (eight foods or food groups and two eating behaviors), showing that girls reported more frequent consumption of sweets, sweet biscuits, and sausages than boys; conversely, beans and milk were less frequently consumed among girls, which may indicate that girls tend to restrict the main meals or isolated food-items that are part of them, replacing them by calorie-dense foods with poor nutritional value.

Regarding the DP tracking from age 15 to 18 years, we found poor general agreement coefficient (kappa=0.1), similarly to other studies that found poor to fair tracking at this stage of life [34,35]. Only one-third of adolescents showed stability in DP over time; showing that significant changes in dietary habits happened in this period. About 40% of participants reported stability of the "Dieting" DP over the years, showing low frequency of consumption of all food groups and high proportions of physically active adolescents. Those adolescents may be more concerned about their weight and physical appearance, which could explain dieting and regular engagement in physical activities.

We found no evidence of association between the "Dieting" DP tracking from 15 to 18 years of age with obesity prevalence, however, the highest proportion of obesity at age 18 years was found among adolescents who adhered to a "Dieting" DP at the same age, in comparison with the other groups. A study in Norwegian schoolchildren previously mentioned also found that children aged 9-10 years who migrated to the "Dieting" DP 3-4 years later presented higher prevalence of overweight [31].

At age 18 years old, the "Processed Meats" DP previously identified at baseline was replaced by the "Fish, Fast Foods and Alcohol DP". Changing from a "Processed Meats" DP at age 15 years to a "Fish, Fast Food and Alcohol" DP at 18 years was associated with lower proportions of obesity (5.4%), in comparison with the other DPs. In Southern Brazil, Assunção et al. [36] reported little consumption of fish among adolescents due to cultural reasons. The increase in the frequency of fish consumption at age 18 years may be related to the incorporation of Japanese cuisine into the menu of Brazilians in recent years. Fast foods presented high frequency of consumption among subjects who adhered to this pattern at age 18 years, which may be due to changes in lifestyle motivated by entering the labor market, starting at the university, among other reasons. Cutler et al. [12] investigated DPs among adolescents at ages 15 and 20 years in the United States of America; consistent with our findings, the authors documented the presence of a "Fast Food" DP in early adulthood, that were not identified previously at age 15 years. Regarding the increased consumption of alcohol, we highlight that the acquisition of alcoholic beverages is only permitted after the age of 18 years in Brazil. Culturally, this age marks the beginning of a more active social life, which may bring the adolescents into contact with alcoholic beverages. We also acknowledge that some subjects may have already consumed these beverages at age 15 years, but they would probably misreport this habit considering the implications of the illegal use, even after being informed that all information would be kept confidential. Movassagh et al. [3] examined the stability of DPs from childhood through adolescence and into young adulthood (from age 8 to 34 years) from 130 participants (53 females) of Saskatchewan Pediatric Bone Mineral Accrual Study found a moderate tracking for the "High-fat, high-protein" (β=0.39, $p<0.001$) DPs in females. But found a moderate tracking for the "Vegetarian-style" DP (β=0.44, $p<0.001$; β=0.30, $p<0.001$) in females and males, respectively.

We acknowledge some limitations of our study. Firstly, the use of versions of FFQs with some differences to investigate the frequency of consumption of food at ages 15 and 18 years limited the number and variety of items included in the LCA. Secondly, the FFQs were administered using different approaches in each follow-up visit: an interview-administered version of the questionnaire was applied at baseline, while an electronic self-administered version was used at age 18 years; although a trained interviewer was available to help filling out the questionnaire and to resolve questions, some subjects may have misreported their frequency of consumption of food, referring to the current daily consumption rather than the dietary habit in the year prior to interview. In addition, we acknowledge that our estimates may be under or overestimated due to recall error. In order to minimize this error and avoid misclassification, we opted to analyze the frequency of consumption in tertiles. We highlight that, in spite of its limitations, the FFQ is one of the most applied methods for assessing dietary consumption and has been considered appropriate for this purpose [10,11]. Our findings must be interpreted carefully as the adherence to the "Dieting" DP, for instance, does not indicate lower calorie or nutrients intake, but a lower frequency of consumption of all food groups.

To our knowledge, this is the first study assessing DP tracking in a birth cohort from a middle-income setting. The 1993 Pelotas (birth) cohort allowed assessment of the stability and modifications in dietary habits during adolescence, based on two follow-up visits, also investigating associations with obesity and physical activity. In order to construct the DPs, we applied the LCA, a type of cluster analysis, which assesses whether there are distinct groups of food consumption habits in the population. The cluster analysis provides a linear score of the frequency of consumption and allocates the individuals inside of different DPs according to this consumption, and, therefore, is appropriate to investigate individual's adherence to specific DPs over time [11,18]. Differently, the principals components analysis generates DPs to explain the maximum variance in a correlation matrix, having the possibility that an individual has a higher adhesion score in more than one DP at the same time [11,18].

Conclusion

Our findings suggest a high adherence to a "Varied" DP at age 15 years and changes in concrete food choices over time, resulting in an increase in the adherence to a "Dieting" DP at age 18 years, especially among girls and wealthier subjects. Substantial changes in DPs were identified over a relatively short period, which is an important finding for future studies aiming to track food patterns over time. An understanding of the DP tracking and changes is crucial for elaborating policy and interventions to improve adolescent and young adult nutrition and related health outcomes. The effectiveness of these strategies depends on addressing a broad range of factors, in particular environmental factors, such as increasing availability and promotion of healthy and convenient food, as well as satisfaction with body image, awareness of healthy weight management methods and importance of physical activity.

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