Peer-reviewed version available at Nutrients 2017, 9, 990; doi:10.3390/nu9090990

Article

Tracking Dietary Patterns over 20 Years from Childhood through Adolescence into Young Adulthood: The Saskatchewan Pediatric Bone Mineral Accrual Study

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Abstract: Dietary patterns established during adolescence might play a role in adulthood disease. We examined the stability of dietary patterns (DPs) from childhood through adolescence and into young adulthood (from age 8 to 34 years). Data from 130 participants (53 females) of Saskatchewan Pediatric Bone Mineral Accrual Study (aged 8-15 years, at baseline) were included. Multiple 24-hour recalls were collected annually from 1991 to 1997, 2002 to 2005 and 2010 and 2011. Using principal component analysis, "Vegetarian-style", "Western-like", "High-fat, high-protein", "Mixed" and "Snack" DPs were derived at baseline. Applied DP scores for all annual measurements were calculated using factor loading of baseline DPs and energy-adjusted food group intakes. We analyzed data using generalized estimating equations. The tracking coefficient represents correlation between baseline dietary pattern scores and all other follow-up dietary pattern scores. We found a moderate tracking for the "Vegetarian-style" ($ß=0.44$, $P<0.001$) and "High-fat, high-protein" ($ß=0.39$, $P<0.001$) DPs in females and "Vegetarian-style" DP ($ß=0.30$, $P<0.001$) in males. Remaining DPs showed a poor-to-fair tracking in both sexes. No tracking for "Western-like" DP in females was observed. Assessing overall change in DP scores from childhood to young adulthood showed an increasing trend in adherence to "Vegetarian-style" DP and decreasing trend in adherence to "High-fat, high-protein" DP by age in both sexes ($P<0.001$). While "Western-like" and "Mixed" DP scores increased only in males ($P<0.001$). These findings suggest that healthy dietary habits established during childhood and adolescence moderately continue into adulthood.

Keywords: dietary patterns; tracking; stability; longitudinal change; generalized estimating equations; childhood; adolescence; adulthood

1. Introduction

Nutrition is a lifestyle factor that is associated with the etiology of numerous chronic conditions [1]. The complex mixture of nutrients and dietary components from a variety of foods, with synergistic or confounding effects on each other, might influence health outcomes [2]. In nutritional epidemiology, the dietary pattern approach has gained growing attention as an alternative to the conventional method of assessing single nutrient or food intakes [3]. Dietary patterns provide a comprehensive view and allow for assessing the contributions from various dietary aspects on health outcomes, simultaneously [4].

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Peer-reviewed version available at Nutrients 2017, 9, 990; doi:10.3390/nu9090990

There is the belief that dietary habits established during childhood and adolescence might persist into adulthood. Accordingly, early modification in eating habits and behaviors might promote health, and decrease the risk of developing certain health conditions during later life [5]. However, there are limited studies evaluating stability of dietary patterns over time from childhood to adolescence [6] or from childhood to adulthood [7]. Most studies in children and adolescents followed participants over short periods, ranging from 3 to 6 years [8-11]. Findings from these studies were inconclusive due to variations in age at baseline, length of follow-up periods and different dietary pattern approaches or analysis used.

None of these studies [8-11] examined the consistency of dietary patterns at the individual level over the entire time. In 2003, Twisk suggested an approach to measure how individuals maintained their position in a study population distribution in subsequent measurements [12]. Using this methodology tracking coefficients can be calculated for dietary pattern scores in longitudinal study designs with repeated measurements within individuals. The mixed longitudinal data from Saskatchewan Pediatric Bone Mineral Accrual Study (PBMAS, 1991-2011) [13,14] provides a unique opportunity for tracking dietary patterns from childhood to adulthood and overall changes in dietary pattern scores by age.

Previously we identified five dietary patterns in the PBMAS participants during adolescence, using the dietary intake data collected in 1992/1993. In this study, our objective is to evaluate 1) stability of these dietary patterns from childhood to adolescence and from adolescence to young adulthood by calculating tracking coefficients; and 2) change in dietary pattern scores by each year increase in age from 8 to 34 years of age.

2. Materials and Methods

2.1. Participants

Longitudinal data from the PBMAS participants were analyzed in this study. The details about the mixed longitudinal design of the study have been described elsewhere [13,14]. In brief, 251 children (133 girls and 118 boys; aged 8 to 15 years) were recruited from two elementary schools in the city of Saskatoon between 1991 and 1993. Participants then were followed with annual measurements until 2011 except two gaps between 1997 and 2002 and between 2005 and 2010. During each study year, anthropometrics, dietary intake, physical activity (PA) and body composition were assessed.

For the present study, 130 participants (53 females and 77 males), with available data for food group intakes, comprised our data set. There were at least five and maximum thirteen observations for each participant, corresponding to the total number of annual measurements conducted during the study years: 1991, 1992, 1993, 1994, 1995, 1996, 1997, 2002, 2003, 2004, 2005, 2010, 2011. Decimal chronological age of participants was calculated using their date of birth and test date. We created chronological age groups using one-year intervals, for instance we included observations between 8.50 and 9.49 years in the 9 years old age group. Because of various number of subsequent measurements for each participant and overlapping in ages, there were a different number of observations at each age group. Overall, there was a consecutive 27-year developmental pattern (8 to 34 years) over the 20-year period of the study from 1991 to 2011. Ethics approval was obtained from the University of Saskatchewan and Royal Hospital advisory boards on ethics in human experimentation [13].

2.2. Dietary Intake

The dietary intakes of participants were assessed using 24-hour recalls. For all participants 24-hour recalls were self-administered, except for the younger children from grades 2 and 3 for which the interviewer wrote down the verbally provided information. A training session on food portion sizes was conducted for children at the beginning of the study. In addition, to determine accurate estimates of portion sizes, participants had access to pictures of food sizes. Dietary intake information

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was collected 3-4 times per year during the first four years of study from 1991 to 1994 and 2-3 times per year during 1995 and 1996. Dietary intake data from multiple 24-hour recalls per year were used to estimate average intake during the year. Only one 24-hour recall per year was completed for each participant, thereafter. To have a consistent unit of measure, quantities of consumed foods reported in the 24-hour recalls were converted to gram weight. Then, we assigned all food and beverage items into 25 non-overlapping food groups based on their similarity in nutrient content or culinary usage. These food group intake data then were aligned with other measurements for each year, as annual measurements. We used the dietary intake data of 25 food groups in dietary pattern analysis. Table 1 represents the 25 food groups and food items assigned to each group.

To estimate total energy intake per day, dietary intake data collected from 1991 to 1997 was analyzed using Canadian compatible nutrition assessment software: NUTS Nutritional Assessment System, version 3.7 (Quilchena Consulting Ltd, Victoria, BC, 1988). Estimates of total energy for the other follow-up years was obtained using Food Processor version 8.0 and its revisions (ESHA Research Inc, Salem, Ore, 2003).

Table 1. Food groups and food items included in principal component analysis

Food groups	Food items
Dark green vegetables	Asparagus, green beans, broccoli, lettuce, green pepper, sea weed, spinach, mixed greens, snow peas
Eggs	Eggs
Non-refined grains	Whole grains and partially whole grains (60%) mostly cereals, mixed granola/grain bar, cracker, oat flakes, wheat germ, whole wheat breads, puffed wheat, brown and wild rice, popcorn, barley
Fruit juice 100%	Apple cider, limeade, apple, lemon, orange juice canned or bottled, unsweetened cranberry
Legumes, nuts and seeds	Beans (black, kidney, lima, navy, small white, soy), chickpeas, hummus, tofu, brazil nuts, coconut, almond, hazelnuts, walnuts, cashew, peanuts, mixed nuts, pecans, peanut butter, sunflower seeds
Added fats	Butter, margarine, vegetable oil, cooking oil, mayonnaise (salad dressing, miracle whip), coconut milk, dream whip, olive oil, pesto, meatless bacon bits
Fruits	All fresh and dried fruits, canned fruits (not sweetened), avocado, olives
Low-fat milk	1%, skim, rice beverage, soy beverage
Fruit drinks	Fruit juice (sweetened), fruit drinks, iced tea
Refined grains	Refined cereals, white bread, white rice, refined pasta, noodles, pop corns, ice cream cone, pie crust, pizza pop, pizza pocket
Cream	Sour cream, cream (10%, whipped or low fat)
Poultry	Chicken and turkey
Processed meats	Burger patties (beef, ham, chicken, etc.), sausages, bacon, canned meat (beef, ham, pork, chicken, turkey), dry ribs, fried chicken, nugget
High-fat milk	2%, whole or almond milk
Tomato	Tomato and its products
Red meat	Beef, ham, pork, bison (ground, loin, rib, steak, stew, fried, pot roast, balls, loaf, chop)
Cheese	All kind of cheese
Yogurt	Yogurt (plain, vanilla or fruit)
Desserts and sweets	Sweet baked products, milk desserts, jelly, chocolate, sugar, jam, syrups, honey and candies
Fish and seafood	Fish, shrimp, lobster, mussels, pickerel, prawns, scallops

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Dressings, sauces, gravy	Gravy, dressings, Caesar, French, ranch, Italian, 1000 island, Alfredo, blue cheese, chip dip, Greek, honey garlic, white sauce, sandwich spread, tartar, teen, sundried tomato
Vegetables, others	Carrots, snap beans, cabbage, cauliflower, celery, cucumber, garlic, mushroom, pepper, squash, bean sprouts, beets, onion, eggplant, radish, zucchini, potato, green peas, corn, sweet potato and soups
Chips & fries	Potato chips, fries, corn chips, nacho, hash brown
Soft drinks	Soft drinks (sugar-sweetened or diet)
Others	Salt, spices, seasonings, additives, pickles (dill, beet), low fat sauces (mustard, hot, soy, teriyaki), vinegar

2.3.Statistical analysis

Principal component analysis (PCA) was used to derive dietary patterns. We identified five dietary patterns using 25 food groups' intake data collected at baseline in the PBMAS participants. The number of dietary patterns were identified by assessing the break point in the scree plot, eigenvalues >1.5, and proportion of variance explained by a factor. Then we run the analysis using the five-factor solution. The orthogonal (Varimax) rotation was applied to achieve the highest interpretability. We labeled the derived dietary patterns as the "Vegetarian-style" dietary pattern, rich in dark green vegetables, eggs, non-refined grains, 100% fruit juice, legumes, nuts and seeds, added fats, fruits and low-fat milk; the "Western-like" dietary pattern, characterized by higher intakes of fruit drinks, refined grains, cream, poultry and processed meats; the "High-fat, high-protein" dietary pattern, associated with higher intakes of high-fat milk, tomato, red meat and legumes, nuts and seeds and lower intake of low-fat milk; the "Mixed" dietary pattern, characterized by high intake of yogurt, cheese, desserts and sweets, fish and seafood and %100 fruit juice; and the "Snack" dietary pattern, associated with higher intakes of dressings and sauces, vegetables (excluding dark green vegetables), chips and fries and poultry and lower intakes of cheese.

We calculated the applied dietary pattern scores for all study years from 1991 to 2011, based on the factor loadings for 25 food groups in five dietary patterns (Table 2). To control for the increase in overall intake over the time, first, we adjusted intakes of 25 food groups for total energy intake (g/1000 kcal). Then, energy-adjusted food group intakes (g/1000 kcal) were multiplied by their factor loadings for each dietary pattern and were summed, or subtracted for negative loadings, to generate a dietary pattern score for each participant during each study year. This method of computing the dietary pattern scores allows food groups with higher factor loadings to have a higher contribution to the total dietary pattern score [15].

Table 2. Food groups included in principal component analysis and their factor loading for the identified five initial dietary patterns

	Factor loadings for dietary patterns				
	Vegetarian style	Fast food	High-fat, high-protein	Mixed	snack
Dark green vegetables	**0.64**	0.02	-0.00	0.07	-0.22
Eggs	**0.63**	-0.18	0.23	-0.05	-0.15
Non-refined grains	**0.54**	-0.13	-0.11	0.10	0.20
Added fats	**0.41**	**0.39**	-0.03	-0.04	-0.00
Fruits	**0.40**	0.24	-0.16	0.13	0.23
Others	-0.28	0.03	0.08	0.08	0.04
Fruit drinks	0.00	**0.73**	-0.04	-0.03	0.04
Refined grains	0.06	**0.66**	0.21	-0.10	-0.03

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Cream	-0.06	**0.55**	-0.01	0.13	-0.02
Poultry	-0.27	**0.41**	-0.04	-0.10	**0.40**
Processed meats	-0.05	**0.35**	-0.12	0.01	-0.09
High-fat milk	-0.12	-0.17	**0.74**	-0.04	0.18
Tomato	0.22	0.30	**0.59**	-0.14	-0.34
Red meat	-0.07	-0.05	**0.52**	0.14	-0.07
Low-fat milk	**0.35**	0.03	**-0.48**	-0.01	-0.16
Legumes, nuts and seeds	**0.45**	0.11	**0.47**	-0.09	0.06
Cheese	0.03	0.12	0.06	**0.72**	**-0.36**
Yogurt	-0.11	0.04	-0.12	**0.61**	0.19
Desserts and sweets	-0.18	-0.05	0.23	**0.59**	0.08
Fish and seafood	0.24	-0.10	-0.08	**0.52**	-0.13
Fruit juice 100%	**0.46**	0.02	-0.04	**0.49**	0.18
Dressings, sauces, gravy	0.09	-0.30	0.24	0.08	**0.64**
Vegetables, others	-0.03	0.22	0.06	-0.03	**0.58**
Chips & fries	-0.03	-0.09	-0.02	0.00	**0.40**
Soft drinks	0.00	-0.02	-0.16	-0.20	0.20

To evaluate tracking (stability) of the five dietary patterns over time (addressing the first objective), applied dietary pattern scores from 1991 to 2011 were used. For each participant, the first available measurement was considered as baseline dietary pattern score. Dietary pattern scores for all repeated measurements were standardized for mean and standard deviation of baseline dietary pattern scores, using this formula:

$$Z - score\ (\text{DP score}) = \frac{X(\text{DP score}) - \bar{X}(\text{baseline DP score})}{SD(\text{baseline DP score})}$$

Tracking coefficients for each dietary pattern was calculated using generalized estimating equations (GEE). We regressed baseline standardized dietary pattern scores (independent variable) against all other standardized dietary pattern scores (dependent variable) during entire follow-up time, simultaneously, while adjusting for chronological age groups (age 8 to 34 years) as time-dependent variable, and sex and age at baseline as time-independent variable. As sex and its interaction with age was significant, we evaluated tracking for males and females separately. As we used the standardized values, the tracking coefficient only takes values between 0 and 1, indicating no tracking and strong tracking, respectively. However, there are no standard cutoffs indicating classification of tracking strength within this spectrum. Some investigators categorized coefficients between 0.30 and 0.60 as moderate tracking [8]. The beta coefficient for chronological age represents the change in dietary pattern score for each year increase in age (addressing the second objective).

To assess the stability of dietary patterns we also evaluated the transition between dietary pattern score quartiles from childhood to adolescence and adulthood (addressing the first objective). To do this, we averaged all the measurements collected during age 8-13 years, 14-18 years and >18 years as childhood, adolescence and young adulthood measurements for each participant, respectively. The number of participants who had one average measurement during childhood, adolescence or young adulthood was 100, 119 and 124, respectively. Participants were assigned into quartiles of dietary pattern scores during childhood, adolescence and young adulthood. Participants in quartile four had the highest adherence and those in quartile one had the lowest adherence to the dietary pattern. Proportion of participants (%) who remained in the same quartile from childhood to

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adolescence or young adulthood and from adolescence to adulthood was determined and the level of agreement was estimated using the Cohen's kappa coefficient. The kappa agreement represents the proportion of participants who remained in the same quartile after accounting for the possibility of chance. Standard cut-offs for kappa coefficient are as follows: <0.2 poor; 0.2–0.4 fair; 0.41–0.6 moderate; 0.61– 0.8 good and >0.81 very good [16].

All statistical analysis was performed using SPSS software, version 24.0 (SPSS, Chicago, IL, USA). A P-value <0.05 was considered significant.

3. Results

Tracking coefficients for standardized scores of five dietary patterns and change in the score by age from age 8 to 34 in 53 females and 77 males are presented in Table 3. The tracking coefficient represents correlation between baseline dietary pattern scores and all other follow-up dietary pattern scores. In other words, it shows how participants maintained their position in the total sample distribution from baseline to the last follow-up measurement. The greater tracking coefficients show the higher stability of dietary patterns at individual level. Dietary patterns ordered from more stable to less stable dietary patterns, were "Vegetarian-style", "High-fat, high-protein", "Snack" and "Mixed" dietary patterns, in females; and were "Vegetarian-style", "High-fat, high-protein" and "Snack", "Mixed" and "Western-like" dietary pattern, in males. Tracking coefficient for "Western-like" dietary pattern in females was not significant. Overall, we found a significant moderate tracking (0.30-0.44) for the "Vegetarian-style" and "High-fat, high-protein" dietary patterns in females and "Vegetarian-style" dietary pattern in males. Remaining dietary patterns, except "Western-like" dietary pattern in females, showed a significant poor-to-fair tracking (0.19-0.28) in both sexes.

Change in dietary pattern score by age from age 8 to 34 are presented in Table 3 for 53 females and 77 males. Since all follow-up dietary pattern scores have been standardized for the baseline dietary pattern scores, beta coefficient for age variable represented the amount of change in z-score. For example, for each year increase in age, "Vegetarian-style" dietary pattern score increased by 0.017 z-score, in females. Overall, "Vegetarian-style" dietary pattern score increased and "High-fat, high-protein" dietary pattern score decreased in both females and males. In males, scores for "Western-like" and "Mixed" dietary patterns also increased by age. The "Western-like" and "Mixed" dietary patterns in females and "Snack" dietary pattern in females and males did not reveal any significant change by age (Table 3).

Table 3. Tracking coefficients of standardized dietary pattern score and change of standardized dietary pattern score by age in PBMAS participants[a]

	Tracking dietary patterns			Change in dietary patterns		
	ß (baseline score)	95% CI	P value	ß (age)	95% CI	P value
Females (*n*=53)						
Vegetarian-style	0.44	0.32, 0.56	<0.001	0.017	0.003, 0.031	0.020
Western-like	0.11	-0.08, 0.31	0.264	-0.009	-0.026, 0.008	0.321
High-fat, high-protein	0.39	0.27, 0.51	<0.001	-0.019	-0.031, -0.007	0.002
Mixed	0.22	0.07, 0.37	0.004	-0.014	-0.031, 0.004	0.127
Snack	0.26	0.17, 0.36	<0.001	0.009	-0.002, 0.020	0.124
Males (*n*=77)						
Vegetarian-style	0.30	0.13, 0.46	<0.001	0.032	0.015, 0.048	<0.001
Western-like	0.19	0.07, 0.31	0.001	0.028	0.011, 0.045	0.001
High-fat, high-protein	0.28	0.15, 0.40	<0.001	-0.014	-0.027, -0.001	0.042
Mixed	0.25	0.13, 0.38	<0.001	0.019	0.003, 0.035	0.018

Snack	0.28	0.20, 0.36	<0.001	-0.013	-0.028, 0.002	0.096

[a]Generalized estimating equations (GEE) was used to estimate tracking coefficient. Tracking coefficient was adjusted for chronologic age and age at baseline. In each category, z-scores calculated for just the corresponding category. Beta coefficient for age represents z score change in dietary pattern score from baseline to adulthood. CI, confidence intervals.

Mean age of participants during childhood (aged 8-13 years), adolescence (aged 14 to 18 years) and young adulthood (aged >18 years) were 12.2±0.7 years, 15.6±1.1 years, and 25.1±2.6 years, respectively. Table 4 shows the proportion (%) of participants who remained in the same quartile of dietary pattern score from childhood to adolescence or young adulthood and from adolescence to young adulthood. In females, the proportion ranged between 34% to 44% for "Vegetarian-style", 22% to 34% for "Western-like", 43% to 48% for "High-fat, high-protein", 25% to 44% for "Mixed" and 33% to 41% for "Snack" dietary patterns. There was a significant level of agreement in quartile assignment for "High-fat, high-protein" (κ 0.24) or "Snack" dietary patterns (κ 0.21) from childhood to adolescence; for "Vegetarian-style" (κ 0.22), "High-fat, high-protein" (κ 0.30), "Mixed" (κ 0.25) and "Snack" (κ 0.16) dietary pattern from adolescence to young adulthood, and for "Vegetarian-style" (κ 0.26) or "High-fat, high-protein" (κ 0.26) from childhood to young adulthood, in females.

In males, proportion of participants who remained in the same quartile varied from 31% to 51% for "Vegetarian-style", 21% to 34% for "Western-like", 18% to 49% for "High-fat, high-protein", 25 to 35% for "Mixed" and 25% to 35% for "Snack" dietary patterns. There was a significant level of agreement in quartile assignment for "Vegetarian-style" (κ 0.34) or "High-fat, high-protein" (κ 0.32) from childhood to adolescence; for "Mixed" (κ 0.13) and "Snack" (κ 0.13) dietary pattern from adolescence to young adulthood, in males. No significant level of agreement was detected from childhood to adulthood in males (Table 4).

Table 4. Proportion (%) of participants remaining in the same quartile for dietary pattern score from childhood to young adulthood in total sample

	Childhood vs. adolescence			Adolescence vs. adulthood			Childhood vs. adulthood		
	%	Kappa agreement	P value	%	Kappa agreement	P value	%	Kappa agreement	P value
Females	*n=44*			*n =48*			*n=45*		
Vegetarian style	34.1	0.121	0.164	41.7	0.222	0.008	44.4	0.259	0.003
Fast food	34.1	0.121	0.164	33.3	0.111	0.182	22.2	-0.038	0.663
High fat, high-protein	43.2	0.242	0.005	47.9	0.306	<0.001	44.4	0.259	0.003
Mixed	25.0	0.000	1.000	43.8	0.250	0.003	28.9	0.051	0.551
Snack	40.9	0.212	0.015	37.5	0.167	0.046	33.3	0.111	0.199
Males	*n=47*			*n=65*			*n=50*		
Vegetarian style	51.1	0.347	<0.001	30.8	0.077	0.284	32.0	0.093	0.256
Fast food	34.0	0.120	0.154	21.5	-0.046	0.517	28.0	0.039	0.629
High fat, high-protein	48.9	0.319	<0.001	24.6	-0.005	0.940	18.0	-0.094	0.250
Mixed	25.5	0.007	0.937	35.4	0.138	0.054	32.0	0.093	0.256
Snack	25.5	0.007	0.937	35.4	0.138	0.054	32.0	0.093	0.256

Childhood: 9-13 years; adolescence: 14-18 years; adulthood: >18 years

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4. Discussion

We derived five dietary patterns using PCA method. In this method, each participant was allocated a score for each derived dietary pattern for each dietary intake measurement. Despite cluster analysis, in PCA method we cannot categorize participants into exclusive non-overlapping groups. Hence each participant could have a high score for more than one dietary pattern. This makes it difficult to interpret change in scores of one dietary patterns in association with other dietary patterns. However, we could examine stability of each dietary pattern over time, separately. We found moderate tracking by age for the "Vegetarian-style" and "High-fat, high-protein" dietary patterns in females and "Vegetarian-style" dietary pattern in males. Except for no tracking for the "Western-like" dietary pattern in females, remaining dietary patterns showed a poor-to-fair tracking in females and males. Assessing transition between dietary pattern score quartiles from childhood to adolescence or young adulthood or adolescence to young adulthood revealed no consistent trend in males and females for different dietary patterns. Overall, percent of participants remained in the same quartile of scores for different dietary patterns ranged from %22 to %48 in females and 21% to 49% in males. We found an upward trend for the "Vegetarian-style" dietary pattern and downward trend for "High-fat, high-protein" dietary pattern in females and males and an upward trend for "Western-like" and "Mixed" dietary patterns, only in males, by age.

To our knowledge only two studies in adults [17,18] and one study in children [9] have used GEE for tracking dietary pattern scores over time. In the China health and nutrition survey, applied scores for "traditional southern" and "modern high-wheat" dietary patterns, derived using PCA, were tracked in 9253 participants aged ≥18 years from 1991 to 2009. Dietary intake data were collected using 3-day 24-hour recalls at 7 time points over 18 years. Both dietary patterns were remarkably stable over time, with stronger tracking for traditional southern compared to modern high-wheat dietary patterns (0.71 vs. 0.55) [17]. In the Swedish obese subjects (SOS) study, the "energy-dense, high saturated fat and low fiber density" dietary pattern derived using reduced-rank regression (RRR) method, were tracked in 2037 severely obese subjects aged 47±6 years at baseline. A semi-quantitative diet questionnaire was used to assess dietary intake at 10 time points over ten years. They found a moderate tracking, 0.40 in women and 0.38 in men [18]. Even though we used similar approach in tracking dietary pattern scores over time, our findings are not directly comparable to these results since these studies only evaluated change in dietary pattern during adulthood. In the Avon Longitudinal Study of Parents and Children (ALSPAC) in UK, a "high energy, high fat, low fiber" dietary pattern identified by RRR method in 7027 children aged 7 years at baseline were tracked 3 years and 6 years later. They reported a moderate tracking, 0.38 in girls and 0.48 in boys, from 7 to 13 years of age [9]. Despite of shorter follow-up time in this study, the tracking coefficients were comparable to those estimated in our study for "high-protein, high fat" dietary pattern.

Another popular method of evaluating change in dietary patterns over time is assessing the proportion of participants who remained in the same class of dietary pattern score or same cluster over time. In the Doetinchem cohort study in the Netherlands, stability of two dietary patterns, "low-fiber bread" and "high-fiber bread", derived using cluster analysis was investigated in children from age 6 (n=6113) to age 11 (n=4916) and 16 (n=4520) years. Results of the study showed that there was a good reproducibility for food groups at each cluster and almost 42% of participants remained in the same cluster of dietary patterns after 10 years [6]. In another study, change in dietary patterns of 3823 adolescents in Brazil was investigated from age 15 to 18 years. Using latent class analysis, participants were categorized into four dietary pattern classes including "varied", "traditional" and "dieting" at both time points, and "processed meats" at age 15 years or "fish, fast food and alcohol" at age 18 years. The most frequent change was transition of participants from "processed meat" to "dieting" class (38%). However, 36% of participants in "dieting" class at age 15 remained in the same class at age 18 years [11]. These studies were different from our study due to shorter period of follow-up time, different dietary pattern approaches and smaller number of repeated measurements.

Only one study has evaluated change in dietary patterns from childhood to adulthood [7]. Mikkila et al [7] has investigated longitudinal change of dietary patterns in participants of Cardiovascular Risk in Young Finns Study (aged 3-18 years at baseline, n=1768) after 6 and 21 years

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using a 48-hour recall at each time point. The two "traditional Finnish" and "health-conscious" dietary patterns, derived using PCA, showed a moderate correlation (0.32 and 0.38, respectively) between baseline and 21-year follow-up, with higher tracking in adolescents (aged 15-18 years) compared to children (aged 3-14 years). Assessing the transition between quintiles of dietary pattern scores showed that 41% and 38%of participants remained in the top quintile of "traditional Finnish" and "health-conscious", respectively, after 21 years [7]. In our study, the overall proportion of participants remained in the same quartile of "Vegetarian-style" dietary pattern, from childhood (mean age of 12.2±0.7 years) to adulthood (mean age of 25.1±2.6 years), was 44% in females and 32% in males. However, our findings are not directly comparable to this study because of different analytical approaches and age at baseline. Larger number of repeated measurements and mixed longitudinal design in our study allowed for tracking dietary patterns from age 8 to 34 with a maximum number of thirteen measurements for each participant over the entire period from childhood to adulthood.

Our findings of higher tracking for the "Vegetarian-style" dietary pattern, representing a healthy diet, and lower tracking for "Western-like" dietary pattern, representing an unhealthy diet, are in line with other studies implying that healthy dietary habits are more stable over time [7, 10, 19-22]. However, some investigators reported a higher stability for Western/unhealthy dietary pattern compared to healthy dietary pattern [8, 23]. All components of "Vegetarian-style" dietary pattern seems to be healthy, except added fats (butter, margarine, vegetable oils and mayonnaise). Stronger tracking or more stability means that higher or lower adherence to "Vegetarian-style" dietary pattern which is established during childhood or adolescence could persist into adulthood. However, it seems that adherence to "Western-like" dietary pattern could be inconstant over time. Therefore, it seems that childhood or adolescence is the best time for any modification diet in terms of enhancing health conscious dietary habits.

In our study, we computed applied dietary pattern scores for all observations based on the factor loadings of the initial dietary patterns, as an alternative approach of deriving dietary patterns at each time point. Several previous studies used applied dietary pattern scores similar to our study [9, 17-20, 24]. This method has the advantage of assessing change in a specific baseline dietary pattern over time. However, it could not identify any new dietary pattern that might have arisen during later years. Assessing stability of dietary patterns over time by deriving dietary patterns at each of multiple time points, especially when derived dietary patterns have altered food composition and factor loadings, is challenging.

The present study has some strengths. This is the first study tracking change in PCA-derived dietary patterns from childhood to adulthood over the entire time using GEE modeling. Stability of dietary patterns were assessed as participants grew from their age at elementary school to early adulthood, incorporating the critical periods during growth. Owing to the mixed longitudinal design of study, it was possible to assess change in dietary patterns from age 8 to 34 years over a 20-year period of the study. The number of available repeated measurements for each participant was more than any similar studies. We used multiple 24-hour recalls representing usual intake. Compared to FFQ, the commonly used method in other studies, this method does not depend on long-term memory and has the advantage of being more flexible and open-ended to collect the more detailed food consumption data [25]. The limitations of our study were the smaller convenient sample size (not population-based) compared to other studies and using a single 24-hour recall to assess dietary intake during each study year after 1997.

5. Conclusions

Overall, the "Western-like" dietary pattern had the poorest tracking and "Vegetarian-style" dietary pattern had the strongest tracking over entire time. Tracking was stronger in females than males and there was a fair-to-moderate tracking for "Vegetarian-style" and "High-fat, high-protein" dietary patterns. Adherence to the "Vegetarian-style" dietary pattern increased and "High-fat, high-protein" dietary pattern decreased by age, in females and males. There was also an increase in

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adherence to "Western-like" and "Mixed" dietary patterns, only in males. This increase was independent of increase in total energy intake by age. Our findings suggest that healthy dietary habits established during childhood and adolescence could continue into adulthood. Therefore, it is necessary to implement policies for dietary intake modifications in children and adolescents to increase intake of fruit and vegetables, non-refined grains and low-fat milk and milk alternatives, as the key components of a healthy dietary pattern, which could continue until adulthood.

Supplementary Materials: No Supplementary Materials is provided.

Acknowledgments: The project was funded by the Canadian Institutes of Health Research (grant number MOP 98002; MOP57671). Dairy Farmers of Canada provided funding for PhD student support (E.Z.M., grant number DFC- 417283).

Author Contributions: E.Z.M. and H.V. conceived and designed the present study; A.D.J.B., S.J.W, S.K. and H.V. conducted the study and collected data; E.Z.M. analyzed the data and wrote the paper. All authors revised and approved the final manuscript.

Conflicts of Interest: The authors declare no conflict of interest. The founding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

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