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ORIGINAL CONTRIBUTION

Ten-year changes in diet quality among adolescents and young adults (Food Consumption Survey 2004 and 2014, Belgium)

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Abstract

Purpose To estimate the 10-year change in the overall nutritional quality of adolescent and young adult's diet, as measured by the modified Nutrient Profiling System of the British Food Standards Agency individual Dietary Index (FSAm-NPS-DI) which funds the Nutri-Score development, and in different components of this score, overall and according to the individual characteristics.

Methods Two 24-h dietary recalls were carried out in 15- to 39-year-old respondents included in the Belgian Food Consumption Surveys in 2004 ($n = 1186$) and 2014 ($n = 952$). The weighted mean individual FSAm-NPS-DI was computed from all foods and beverages consumed, converted into a scale from 0 to 100 (from the poorest to the most favorable diet), and compared between survey years. Subject characteristics associated with the score, along with the mean daily intake of food groups, energy, and nutrients were explored in multiple linear regressions stratified by survey year and age group.

Results The weighted mean daily FSAm-NPS-DI significantly increased between 2004 and 2014 [2004: 55.3 (SEM: 0.2) vs. 2014: 57.4 (0.5), $P < 0.001$ in 15- to 18-year olds; 55.0 (0.6) vs. 58.1 (0.4), $P < 0.001$ in 19- to 25-year olds; 57.1 (0.4) vs. 58.5 (0.3), $P < 0.01$ in 26- to 39-year olds]. SFA intake decreased in all age groups, and sugar-sweetened beverage, sugar, sodium, and fiber intakes decreased among 15−18-year olds. The nutritional quality changed unevenly according to socio-cultural characteristics, levels of education and regions being the main sources of disparities.

Conclusion The quality of diet improved overall between 2004 and 2014 among young people in Belgium, an uneven change that need to be confirmed in future surveys, following the implementation of the Nutri-Score.

Keywords Dietary quality · Nutrient profiling system · Nutrition survey · Adolescent · young adult · Socioeconomic factors

Introduction

The worldwide prevalence of overweight and obese children and adolescents has considerably increased over the five past decades, though it has plateaued in many high-income countries since 2000 [1]. In various settings, the diet pattern of adolescents has been identified as poor, with low consumption of fruit and vegetables, and a high propensity to snack on nutrient-poor and energy-dense items, skip meals, and eat lots of fast food [2]. Such poor dietary patterns are also correlated with energy-dense, high-fat, and low-fiber diet [3, 4]. In Belgium, adolescents (14−17 years) show the worst adherence to dietary guidelines, being the lowest consumers of fruit and, along with young adults (18−39 years), having the highest energy intake from the nutrient-poor food group (comprising for instance, sugar-sweetened beverages (SSB), alcoholic drinks, biscuits and pastries, confectionary and chocolates, salty and fried snacks, etc.) [5]. Yet, from the beginning of adolescence to the transition to adulthood, i.e., between about 10 and 24 years of age, biological and social transformations make it a key period for health behavior acquisition and strengthening, including diet [6]. Thus, since the health of future adults may be impacted, there is a need to further identify dietary behaviors suited to this life phase, and the determinants associated with diet, in order to adapt dietary recommendations and to target at-risk groups in nutritional policies.

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The Food Standard Agency nutrient profiling system (FSA-NPS) was initially developed in the United Kingdom in order to regulate food advertising for children [7], and, after some modifications, became the basis of the food labeling system Nutri-Score, developed in France [8]. The Nutri-Score, supported by the World Health Organization Regional Office for Europe [9], has been adapted to the French dietary recommendations [8], and was formalized in 2017. Several European countries followed, including Belgium in 2019 [10]. To date, the use of the Nutri-Score is not mandatory but relies on the voluntary participation of the food manufacturers. The FSAm-NPS ("m" is for "modified"), which is typically used to qualify a food or a beverage, can also be applied to the individual diet through a dietary index (i.e., the FSAm-NPS-DI) [11–14]. Like other diet quality scores, the FSAm-NPS-DI makes it possible to describe the overall diet with a synthetic measure, without a hierarchy between the components of the score, and to compare this measure in different samples. In the context of the Nutri-Score labeling on an increasing number of food products sold in Belgium, describing the diet with the underlying FSAm-NPS-DI is of interest.

Despite a continuing inadequate diet, an overall improvement in fruit, vegetable, SSB, sweet snack, and energy from solid fat and from added sugar intakes has been observed among adolescents from several European countries and the United States since the early 2000s [15–18]. However, disparities in level of education, country of birth, and region of residency were noted in relation to the food group consumption of adolescents and young adults living in Belgium in 2014 [19]. The rapid change in social environments in recent decades may have impacted eating habits and diet disparities [6]. The Belgian Food Consumption Surveys (FCS) from 2004 to 2014 provide an opportunity to examine dietary trends within this particular age group, and to identify potential changes in diet disparities.

The primary objective of our study was to estimate the change in the overall nutritional quality of diet, as measured by an individual dietary index based on the FSAm-NPS-DI, between 2004 and 2014, of adolescents (15−18 years), young adults (19−25 years) and adults (26−39 years) living in Belgium. The specific objectives were (i) to estimate the change in nutritional quality according to the socioeconomic and regional characteristics of the three age groups; and (ii) to examine how the change in intake of the different food groups and nutrients, which are components of the score, may support the potential change in dietary quality.

Subjects and methods

Sampling

The research was based on the two nationally representative cross-sectional FCSs conducted in 2004 and 2014 in Belgium. Methods of the surveys, described elsewhere [20, 21], followed the European Food Safety Authority (EFSA) guidelines for the harmonization of the food consumption data collection [22]. The FCS from 2004 included persons aged 15 years and older, and the FCS from 2014 included persons aged three to 64 years (Supplemental Fig. 1). The two samples were randomly selected from the Belgian national population register, following similar multistage stratified sampling procedures [20, 21]. In brief, the sampling process consisted of a geographic stratification according to the 11 provinces, followed by a selection of municipalities proportional to the size of each province, and a selection of one individual per household according to different age and sex strata (8 in 2004; 10 in 2014). The data collection for each survey was divided equally over the four seasons and seven days of the week so as to take into account seasonal and day-to-day variations in food intake.

Ethics

The two FCS protocols were approved by the relevant ethical authorities (2004: Ethics Committee of the Scientific Institute of Public Health in Brussels; 2014: Ethics Committee of Ghent University and Belgian Commission for the Protection of Privacy (protocol number B670201319129, approved on 19/12/2013)). All participants (or their parents or guardians) provided written or verbal informed consent. Verbal consent was witnessed and formally recorded. The two surveys were conducted in accordance with ethical principles for medical research involving human subjects (Declaration of Helsinki).

Dietary data collection

During both surveys, two nonconsecutive computerized 24-h dietary recalls (24 h-R) were conducted for each participant by a trained dietician. EPIC-Soft in 2004 [23] and GloboDiet® in 2014 [24], both developed and maintained by the International Agency for Research on Cancer (IARC), were used. The Multiple-Pass 24 h-R method [25] was applied successively, including: a rapid and consecutive list of foods consumed and recipes used on each eating occasion; a description and quantification of such foods and recipes; a summary of the 24 h-R; and a description and quantification of dietary supplements. Each recipe was broken down into a list of foods.

All foods were sorted according to the food classification system developed by the EFSA (FoodEx2 is the latest version used in 2014 [26]), and linked to the current Belgian (Nubel) and Dutch (NEVO) food composition data, in order to estimate total energy and nutrient intake. The Black method and Goldberg cutoff [27] were used to identify 18- to 39-year-old under-reporters: the mean energy intake of each subject was compared with the basal metabolic rate (BMR), estimated by the Schofield equation [28]. A mean physical activity level of 1.55 was used. Energy intake day-to-day variations, between-subject BMR variation (8.5%), and between-subject physical activity level variation (15%) were considered. Among 15–17-year olds, since the Schofield equations to estimate BMR do not take into account energy needs related to growth [29], under-reporters were those declaring mean energy intake below two standard deviations of the mean energy intake of the sample. Proportions of under-reporters identified as such were 4.3%, 16.6%, and 24.3% in 2004, and 3.4%, 19.2%, and 19.2% in 2014, among 15−18-, 19−25-, and 26−39-year olds, respectively. As recommended by the EFSA [22], we have kept under-reporters in our analyses especially since under-reporting has previously been shown to be associated with individual factors, such as sex, age, psychologic characteristics, etc. and more particularly with BMI [30–32]. Indeed, discarding them would drive to introduce additional selection bias by excluding some specific categories of the population more likely to be considered as under-reporters.

FSAm-NPS-DI and other diet outcomes

The FSAm-NPS-DI was calculated as follows (Table 1): for each food and beverage consumed during the two surveys, points were attributed according to the 100 g nutrient content of foods that should be limited [energy (kJ), SFA (g), sodium (mg) and sugar (g)], and points were subtracted according to the 100 g nutrient content of foods that should be favored [fruit, vegetables, legumes, nuts, and olive, canola and walnut oil (FVLNO, %), fiber (g) and protein (g)], using specific thresholds for beverages and added fats [14]. The FVLNO content of food was determined according to the ingredient list of food products available on the participatory Openfoodfacts online platform [33] and from the websites of the retailers and manufacturers. In a second step, the points for each food were totaled using an algorithm dependent on the total content of dietary components to limit and the content of FVLNO (Table 1). For each participant, the arithmetic daily energy-weighted mean of the score was then calculated [11, 14], ranging from −15 (most favorable diet) to 40 (poorest diet). To facilitate interpretation, the final FSAm-NPS-DI was converted into a scale theoretically ranging from 0 (poorest diet) to 100 (most favorable diet) [34, 35]:

$$\text{Final FSAm - NPS - DI} = \frac{\text{FSAm - NPS - DI} - 40}{-55} \times 100$$

Besides the mean daily FSAm-NPS-DI, the mean daily intake of specific food groups (fruits and vegetables, whole grain breads and cereals, refined starchy food, and SSB), energy, and nutrients (SFA, sodium, sugar, and fiber) were calculated for each participant.

Exposure variables

The demographic and socioeconomic variables shared by the two surveys and analyzed here were sex, household type, highest education level in the household, and region of residency. The household type in which the participant lived was categorized into two or four categories, depending on the age group of the participant (see “Results” section). All

Table 1 Calculation process of the FSAm-NPS

Components to limit /100 g	Points	Components to favor /100 g	Points
Step 1			
Energy (kJ)	0−10	FVLNO[a](%)	0–5
Sugar (g)	0−10	Fiber (g)	0–5
Saturated fatty acids (g)	0−10	Protein (g)	0–5
Sodium (mg)	0−10		
Total A	0−40	Total B	0–15
Step 2			
If A ≥ 11 and FVLNO = 5,		Score = A – B	
If A ≥ 11 and FVLNO < 5,		Score = A – (FVLNO + fiber points)	
If A < 11,		Score = A – B	
Final score (− 15 to 40)			

See references for the detailed point allocation thresholds of the different components [7, 66]

FVLNO fruit, vegetables, legumes, nuts, and olive, canola, and walnut oil participants under 18 years of age were counted as "children" of the household in both surveys, as well as participants still in school but of adult age in the 2014 survey.

Statistical analyses

All analyses were stratified by survey year and according to three age groups: 15–18 years, 19–25 years, and 26–39 years. Pregnant and breastfeeding women were excluded; energy under-reporters were included [22]. A weighting factor calculated according to age, sex, day of first dietary recall (weekday or weekend), season, and province of residency, along with sample design, was taken into account in the statistical analyses (using the "svyset" function, Stata®). Each dietary outcome, i.e., the mean daily FSAm-NPS-DI and the mean daily intake of food groups, energy, and nutrients, was compared between survey years with *t* test (after checking for normality of the distribution and homoscedasticity). In order to identify subjects' characteristics independently associated with dietary outcomes, multiple linear regression was used, with *F* test corrected for the sampling plan. Total energy intake was systematically included in the models. Before being included in the models, the categorical covariates were transformed into indicators. Adjusted (for all variables included in the models) mean dietary outcomes were post-estimated from the regression models using predictive margins, with covariates being treated as nonfixed [36]. Factors (VIF) were used to check the absence of collinearity between variables included in multivariate models; normal distribution, homoscedasticity, and linearity, along with the absence of influence of potential outliers, were graphically verified by residual analyses in unweighted models. *P* values < 0.05 were considered statistically significant, except in the case of multiple comparisons (Table 3) where the Bonferroni correction was applied (threshold set at 0.017 in that situation). All analyses were performed using Stata® version 14.2 (StataCorp, College Station, TX, USA).

Results

In total, 1186 15−39-year-old subjects completed two non-consecutive 24 h-R in 2004, and 952 in 2014. Between the two surveys, the proportion of single-parent families significantly increased among the 15−18-year olds, as well as the proportion of households having a postgraduate education level in the 19−25- and 26−39-year-old groups (Table 2).

FSAm-NPS-DI change and disparities

In all age groups, the weighted mean daily FSAm-NPS-DI significantly increased between 2004 and 2014 (Table 3). After adjustment for total energy intake and other covariates, the scores of the 15−18- and the 26−39-year-old subjects were the lowest when the highest education level of the household was secondary school or lower as compared to households with a postgraduate or bachelor's degree or equivalent in 2004 but not in 2014 (Table 4). The FSAm-NPS-DI was significantly lower among females than males, in 19−25- and 26−39-year olds in 2004 and in 15−18-year olds in 2014. In 2004 only, the 26−39-year olds who lived alone had lower scores and those who lived in a single-parent household had higher scores than those who lived in a two-parent household. Finally, 26−39-year-old Wallonia residents had a significantly lower score than Flanders residents in both surveys.

Change and disparities in the components of the score

Among 15−18-year-old adolescents, mean daily SSB, SFA, sodium, and sugar intakes decreased significantly between 2004 and 2014, but fiber intakes also decreased (Table 3). Regarding disparities, in 2004, 15−18-year olds living in less-educated households had lower favorable intakes than those living in more educated ones for SSB, fruit, vegetables, and fiber (Supplemental Tables 1, 2, 3). In 2014, such educational differences were maintained regarding SSB consumption, while they became nonsignificant for fruit, vegetable, and fiber intake. Sex disparities for fruits and vegetables in 2004 became nonsignificant in 2014, while such disparities in SFA intake remained stable over time (Supplemental Table 4). Significant differences in SSB consumption according to the region of residence appeared in 2014, to the disadvantage of Flanders.

Among 19−25-year olds, mean daily SFA intake significantly decreased between the two survey years (Table 3). While, no regional disparity was visible in 2004, subjects living in Flanders consumed higher amounts of SSB than Brussels inhabitants in 2014 (Supplemental Table 1).

Among 26−39-year olds, mean daily SFA intake improved between the two surveys (Table 3). Both study years showed educational disparities in daily consumption of fruits and vegetables, SSB, and fiber, while the 2004 disparities in sodium intake became nonsignificant in 2014 (Supplemental Tables 1, 2, 3, 4, 5). We observed regional disparities, to the detriment of Wallonia, which were stable over time for SFA and fiber intakes. SFA intake was also significantly higher among females than among males in both study years.

Discussion

In adolescents and young adults living in Belgium, the FSAm-NPS-DI improved between 2004 and 2014, denoting an increase in diet quality. The change in consumption of the foods and nutrients that make up the score helps

Table 2 Demographic and socioeconomic characteristics of the 2004 and 2014 Belgian Food Consumption Survey populations, according to the age group

Survey year	2004						2014						2004−2014		
	15−18 years, $n=760$		19−25 years, $n=163$		26−39 years, $n=263$		15−18 years, $n=415$		19−25 years, $n=182$		26−39 years, $n=355$		15−18 years	19−25 years	26−39 years
Characteristics	*n*	%[a]	*n*	%[a]	*n*	%[a]	*n*	%[a]	*n*	%[a]	*n*	%[a]	P^b		
Sex													0.34	0.13	0.84
Male	381	52.2	71	41.2	134	51.3	203	47.8	90	52.3	188	52.3			
Female	379	47.8	92	58.8	129	48.7	212	52.2	92	47.7	167	47.7			
Household type													**0.02**	0.39	0.06
Single	–	–	–	-	24	10.4	–	–	–	–	39	12.9			
Single-parent family	142	21.4	29	17.1	17	8.4	124	31.0	30	25.3	29	8.6			
Couple without children	–	–	14	16.2	31	11.5	–	–	16	10.3	68	20.4			
Two-parent family	564	78.6	107	66.7	171	69.7	286	69.0	98	64.4	191	58.1			
Unknown	54		13		20		5		38		28				
Highest education level in the household													0.24	**< 0.01**	**< 0.01**
Secondary education or lower	346	48.2	78	53.1	116	40.5	154	41.2	53	28.3	95	26.1			
Bachelor's degree or equivalent	168	22.8	38	24.7	78	30.6	115	28.6	74	38.1	111	32.4			
Postgraduate education	164	29.0	29	22.2	65	28.9	139	30.2	52	33.6	148	41.5			
Unknown	82		18		4		7		3		1				
Region of residency													0.58	0.31	0.85
Flanders	339	58.2	62	56.5	114	55.5	231	53.3	111	63.9	209	57.8			
Brussels	139	9.4	30	9.5	45	11.5	38	11.0	11	11.5	30	11.8			
Wallonia	282	32.4	71	34.0	104	33.0	146	35.7	60	24.6	116	30.4			

Statistically significant results at level $P < 0.05$ are presented in bold

[a]Weighted proportion

[b]Rao−Scott Chi-square test of the differences between the two surveys

– Category not relevant

Table 3 Weighted mean daily FSAm-NPS-DI, four food group consumption, energy and nutrient intakes involved in the calculation of the score, according to age group, in 2004 and 2014 Belgian food consumption surveys

Survey year	2004			2014			P^a		
	15−18 years, $n=760$	19−25 years, $n=163$	26−39 years, $n=263$	15−18 years, $n=415$	19−25 years, $n=182$	26−39 years, $n=355$	15−18 years	19−25 years	26−39 years
FSAm-NPS-DI	**55.3 (0.2)**	**55.0 (0.6)**	**57.1 (0.4)**	**57.4 (0.5)**	**58.1 (0.4)**	**58.5 (0.3)**	**< 0.001**	**< 0.001**	**0.003**
Fruits and vegetables (g/d)	216.6 (6.3)	222.5 (15.5)	242.1 (11.5)	193.0 (10.1)	235.4 (14.1)	269.6 (11.5)	0.047	0.539	0.092
Whole grain breads and cereals (g/d)	40.3 (2.7)	48.2 (7.2)	48.8 (5.1)	37.3 (3.3)	48.2 (6.2)	63.5 (4.9)	0.489	0.999	0.037
Refined starchy food (g/d)	245.8 (6.2)	218.3 (11.9)	229.5 (8.9)	229.2 (9.5)	217.1 (12.9)	203.4 (7.4)	0.146	0.943	0.024
Sugar-sweetened beverages (g/d)	**404.1 (19.6)**	406.5 (60.1)	245.2 (29.3)	**311.1 (26.7)**	328.1 (40.2)	239.1 (21.1)	**0.005**	0.278	0.864
Energy (kcal/d)	2171.4 (34.1)	2305.6 (108.1)	1984.0 (53.8)	1987.3 (70.4)	2093.5 (75.2)	2035.6 (42.4)	0.019	0.11	0.45
Saturated fatty acids (g/j)	**34.5 (0.7)**	**35.5 (1.9)**	**33.2 (1.2)**	**28.6 (1.5)**	**27.7 (1.1)**	**29.1 (0.8)**	**< 0.001**	**< 0.001**	**0.004**
Sodium (mg/j)	**2597.0 (53.1)**	2604.4 (132.7)	2569.8 (80.8)	**2284.6 (98.7)**	2334.7 (84.7)	2492.0 (62.0)	**0.005**	0.087	0.445
Sugar (g/j)	**129.0 (3.3)**	149.6 (25.8)	95.5 (3.8)	**108.2 (4.4)**	112.2 (5.6)	99.3 (3.5)	**< 0.001**	0.159[b]	0.456
Fiber (g/j)	**16.6 (0.3)**	16.4 (0.7)	16.6 (0.5)	**14.6 (0.4)**	15.6 (0.6)	16.4 (0.4)	**0.001**	0.363	0.731

Statistically significant results at level $P < 0.017$ (Bonferroni correction) are presented in bold

FSAm-NPS-DI Food Standard Agency modified Nutrient Profiling System Dietary Index, numbers in parentheses are Standard Errors of the Mean (SEM)

[a] *t* test between the two survey years in each age group

[b] *t* test for unequal variances

us to understand the score increase. Indeed, SFA intake improved in all age groups. Moreover, the 15−18-year olds decreased their SSB, sugar, and sodium intakes, but also their fiber intake between the two surveys.

The weighted mean daily FSAm-NPS-DI prior to the transformation [from − 15 (most favorable diet) to 40 (poorest diet)], was 8.6 (SEM: 0.2) to 9.7 (0.4) in 2004, and 7.8 (0.2) to 8.4 (2.5) in 2014, depending on the age group. This was slightly higher than observed in other settings. For instance, the mean score was 6.0 (SD: 2.1) among a cohort of European adults in 1992−2000 [13], and 7.7 (1.5) in a cohort of French men aged 45−60 years in 1994−1996 [11], suggesting a lower diet quality in the Belgian population. A comparison with other youth populations at the same time period would be useful to confirm such a conclusion.

Between 1990 and 2010, among adults, worldwide consumption of SFA remained stable [37], while it decreased in Belgium [38]; worldwide sodium intake increased slightly, while it was stable in Belgium [39]. In Europe, an increase in the consumption of healthy items and a decrease in unhealthy items (a very modest decrease, however), were observed in adults over this 20-year period [40]. In children and adolescents, and based on the same EU-Menu protocol, a slight decrease in total energy and energy from fat intakes was observed between 1998–2000 and 2012–2014 in Spain [41]. In France, between 2006 and 2015, total energy, fat and SFA intakes remained stable and the sodium intake increased [42]. In the past two decades, based on the

Table 4 Weighted mean daily FSAm-NPS-DI according to socioeconomic and cultural characteristics and age group in 2004 and 2014 Belgian food consumption surveys

Survey year	2004						2014					
	15–18 years, $n=639$		19–25 years, $n=136$		26–39 years, $n=241$		15–18 years, $n=404$		19–25 years, $n=143$[b]		26–39 years, $n=327$	
Characteristics	Mean[a] (95% CI)	*P*	Mean[a] (95% CI)	*P*	Mean[a] (95% CI)	*P*	Mean[a] (95% CI)	*P*	Mean[a] (95% CI)	*P*	Mean[a] (95% CI)	*P*
Sex		0.07		**< 0.01**		**< 0.01**		**0.001**		0.06		0.18
Male	55.9 (55.3–56.6)		**57.7 (55.8–59.7)**		**58.1 (57.1–59.0)**		**58.0 (57.2–58.9)**		58.8 (57.6–59.9)		59.0 (58.2–59.9)	
Female	55.1 (54.5–55.7)*		53.9 (52.1–55.7)*		56.1 (55.2–57.0)*		56.0 (54.8–57.2)*		57.1 (56.0–58.3)*		58.1 (57.1–59.1)*	
Household type		0.78		0.25		**< 0.001**		0.84		0.07		0.08
Single	–		–		**55.2 (53.6–56.8)**		–		–		**56.5 (54.3–58.6)**	
Single-parent family	55.4 (54.6–56.3)		53.7 (50.6–56.8)		**60.5 (58.6–62.5)**		56.9 (55.8–58.0)		**56.3 (54.9–57.7)**		57.3 (55.2–59.4)	
Couple without children	–		57.2 (53.7–60.6)		56.5 (54.4–58.5)		–		57.5 (55.5–59.5)		59.0 (57.5–60.4)	
Two-parent family	55.6 (55.1–56.0)*		56.2 (55.2–57.3)*		57.2 (56.4–57.9)*		57.1 (56.1–58.1)*		58.6 (57.5–59.7)*		59.0 (58.3–59.7)*	
Highest education level in the household		**< 0.01**		0.84		**< 0.05**		0.24		0.51		0.15
Secondary education or lower	**54.9 (54.3–55.5)**		55.4 (53.7–57.1)		**56.0 (55.0–57.1)**		56.8 (55.2–58.4)		57.5 (56.4–58.6)		58.4 (57.3–59.6)	
Bachelor's degree or equivalent	55.5 (54.7–56.4)		56.0 (54.3–57.7)		58.0 (56.8–59.1)*		56.6 (55.4–57.8)		57.9 (56.2–59.7)		59.3 (58.2–60.4)	
Postgraduate education	56.5 (55.7–57.3)*		55.9 (53.7–58.1)*		57.3 (56.4–58.3)		57.7 (57.0–58.5)*		58.4 (57.3–59.5)*		58.0 (57.2–58.8)*	
Region of residency		0.10		0.78		**0.001**		0.14		0.50		**< 0.05**
Flanders	55.8 (55.2–56.3)*		55.8 (54.3–57.3)*		57.5 (56.6–58.4)*		57.7 (56.5–58.8)*		57.9 (57.0–58.8)*		59.2 (58.4–60.0)*	
Brussels	56.1 (55.3–56.9)		54.7 (50.9–58.5)		58.9 (57.5–60.3)		56.5 (54.5–58.4)		59.4 (56.2–62.5)		58.5 (56.2–60.9)	
Wallonia	55.0 (54.2–55.7)		56.1 (54.6–57.6)		**55.6 (54.5–56.7)**		56.1 (55.0–57.3)		57.4 (56.1–58.7)		**57.4 (56.4–58.3)**	

FSAm-NPS-DI Food Standard Agency modified Nutrient Profiling System Dietary Index

[a]Adjusted for total energy intake and other variables included in the multiple linear regression model; [b]One influent outlier excluded

*Reference category; bold: category for which consumption statistically significantly differed from reference category ($P<0.05$; F test corrected for the sampling plan)

– Category not relevant

Health Behaviour in School-Aged Children (HBSC) survey, 11−15-year-old adolescents improved their daily consumption of fruits and vegetables in most European countries, including Belgium [18], and of SSB and sweets in Nordic countries [15, 43]. In the United States, between 2003 and 2010, total energy, energy from solid fat, added sugar, and SSB intakes significantly declined while whole fruit consumption increased [16, 17]. Among American 12−18-year olds, SSB, sweet, and salty snack consumption decreased between 2003 and 2014 [44]. These trends are in line with ours, except regarding the absence of change in fruit and vegetable consumption in the 15−18-years olds. Of note, HBSC trends showed that if daily fruit and vegetable intake increased between the 2002 and 2006 European surveys, it stabilized thereafter until 2010 [18]. Such an unfavorable trend in the frequency of fruit and vegetable intake among adolescents from 2006 must be confirmed in future surveys, especially since mean fruit, vegetable and fiber intakes are still far below the recommendations, i.e., half the recommended 400 g/day of fruits and vegetables [45, 46] and half the recommended 30 g/day [45] of fiber.

In the Belgian FCS 2014, adolescents and young adults were identified as the age groups having the highest energy intake from nutrient-poor foods (an aggregated group including SSB, alcoholic drinks, biscuits and pastries, confectionary and chocolates, salty and fried snacks, etc.), with no difference between 2004 and 2014 in the total sample [5]. In our analyses, 15−18-year olds significantly reduced their SSB consumption during this period, though the amounts consumed remained high, suggesting a change in the dietary habits in adolescents, but not in older groups. In the total FCS sample, the change in energy-dense snack consumption, as well as in the other food groups identified as main providers of SFA, sugar and sodium [47], may contribute to understand the observed decreases in the indicators used in adolescents. For instance, in the whole Belgian sample, among such food groups, the consumption of red meat and spreadable and cooking fats decreased significantly between 2004 and 2014 [5], supporting the change in SFA intake among adolescents.

One hypothesis for the improved overall diet quality regards the salt [48] and sugar [49] reduction initiatives implemented in the European region over the last decade. In Belgium in 2009, a large-scale media campaign for salt reduction was launched, combined with a convention held by the food industry and distributors [48]. As a result of this initiative, the salt content of food products such as bread, processed meat, sauces, soups, and cheese would have been reduced by 7.5–36% between 2004 and 2012, according to the manufacturers [50]. Indeed, it has been observed in various contexts that such reformulations could led to a significant decrease in sodium [51, 52] and SFA [52, 53] content in some manufactured products. However, a sodium decline was only observed in the adolescent group in our study, which necessitates further exploration.

Despite the FSAm-NPS-DI improvement in all age groups, nutritional quality changed unevenly according to the socioeconomic characteristics. Educational disparities in the diet quality score were observed in 2004, but not in 2014. Indeed, 15−18-year olds living in less-educated households had less favorable intakes of SSB, fruits and vegetables, and fiber in 2004—a gap that was statistically significant only for SSB in 2014. For 26−39-year olds, the education level disparities in SSB, fruit and vegetable, and fiber consumption were stable over time, while those in sodium intake disappeared in 2014. In a Norwegian 2001−2016 cohort followed from early adolescence to young adulthood, less-educated subjects in adulthood had higher SSB consumption than more educated at all time points [54]. Less-educated adolescents and young adults remain a group at risk of high SSB consumption.

After adjustment, females generally had a lower diet quality score than males in both surveys, which is corroborated by the unexpectedly [55–58] higher SFA intake in females. Without adjustment for total energy intake, SFA intake was higher among males than females (data not shown), but when expressed in % of energy intake, it was higher in females than males in the National report [47]. The literature generally reports adolescent and young adult males as being less healthy eaters than females [59–62], but this is not true in all contexts or for all methods of diet description [63]. Females have been identified as being more likely to be concerned about dieting and healthy eating habits than males [64]. Our findings need to be further explored to determine whether they were specific to these age groups, and which other differences in dietary behavior could explain them.

Finally, independent of the socioeconomic characteristics of the subjects, some regional disparities were observed; among 26−39-year olds, Wallonia inhabitants had lower diet quality scores and fiber intake, and higher SFA intake than the Flemish. Such differences were stable between the two surveys. SSB consumption disparities in 15−18- and 19−25-year olds appeared in 2014 to the detriment of Flanders. Our findings denote a persistent gap in dietary habits between Belgian regions, as previously identified and attributable to several potential causes such as different cultural, socioeconomic and health policy contexts [19].

The strengths of our study lie in the nationally representative samples of adolescents and young adults, following the same methodology of selection and diet collection at intervals of 10 years, as well as the use of a validated repeated 24 h-R method. Nevertheless, the sample size, particularly among the 19−25-year olds, led to a lack of statistical power and a possible under reporting of diet changes and associations in some sociocultural subgroups. In addition, despite the methodological comparability of the two surveys, they only had a few covariates in common. Moreover, the use of an a priori constructed diet quality score presents limits (choices of components, cutoffs, etc.) [65]. However, the FSAm-NPS-DI differs from other a priori quality scores in that it assesses the quality of each food consumed rather than comparing dietary habits with recommendations.

To conclude, diet quality, as evaluated through a nutrient profiling system, improved between 2004 and 2014 among adolescents and young adults in Belgium. Nevertheless, most of the dietary components remain improvable, especially among less-educated subgroups. Along with behavioral change, reformulation by manufacturers is a possible explanation for the observed change in this youth sample. The implementation of a food labeling system to better guide consumers in their food choices, as has been the case in Belgium since 2019, along with the introduction of a "soda tax" in January 2016, is also expected to have some effect. Thus, monitoring the change in dietary quality and behaviors in future surveys is of interest, especially among adolescents and young adults. Whether the changes would be related to the socioeconomic and cultural background is also a question to be addressed in future research.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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