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Tracking of fruit and vegetable consumption from adolescence into adulthood and its longitudinal association with overweight

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The objective of the present study was to assess to what extent fruit and vegetable intakes track over a 24-year time period and to assess longitudinal associations between fruit and vegetable intakes and (change in) BMI and sum of skinfolds. Dietary intake and anthropometrics were repeatedly assessed for 168 men and women between the ages of 12 and 36 years. Linear general estimating equations analyses were applied (1) to estimate tracking coefficients, (2) to estimate predictability for meeting the national recommendation for fruit and vegetable intake and for being in the highest quartile for fruit and vegetable intake, and (3) to estimate the association between fruit and vegetable intake and BMI and sum of skinfolds. We found that tracking coefficients were 0·33 ($P<0·001$) for fruit intake and 0·27 ($P<0·001$) for vegetable intake. Mean fruit intake decreased over a 24-year period. For fruit intake, predictability was higher in men than in women (OR 6·02 ($P<0·001$) and 2·33 ($P=0·001$) for meeting the recommendation for men and women respectively). After adjustment, fruit intake was not associated with BMI, but being in the lowest quartile of fruit intake was significantly associated with a lower sum of skinfolds. Women in the lowest quartiles of vegetable intake had significantly higher BMI and sum of skinfolds and also greater positive changes in these parameters. In conclusion, tracking and predictability for fruit and vegetable intake appear to be low to moderate, which might indicate that fruit and vegetable promotion should be started at an early age and continued into adulthood. Despite the fact that we only observed beneficial weight-maintaining effects of vegetable intake in women, promoting vegetables is important for both sexes because of other positive properties of vegetables. No evidence was found for promoting fruit intake as a means of weight maintenance.

Fruit: Vegetables: Tracking: Overweight

There is ample evidence that adequate fruit and vegetable intakes contribute to the prevention of CVD and certain cancers[1,2]. Furthermore, some evidence suggests that fruit and vegetable intakes may be relevant for weight management[3,4]. However, in most industrialized countries, including the Netherlands, intake of fruit and vegetables is below the recommended levels both in adults and children[5,6]. This has led to several campaigns promoting fruit and vegetable intake, especially among children[7–9], assuming that increased intakes in childhood will be maintained to a significant extent. However, only very few studies report the longitudinal trends or tracking of fruit and vegetable intake[10,11]. Studies assessing dietary habits in general suggest that habits acquired in childhood persist into adulthood[12–15]. However, tracking of dietary behaviour is assessed in many different ways. Kelder *et al.*[12] and Lien *et al.*[11] analysed the stability in rank at the group level. Lien *et al.*[11] additionally calculated the proportion of participants that stayed in the same group in the final measurement. These statistical techniques have the disadvantage of using only two measurements, while sometimes more than two repeated measurements are available. An alternative method is calculating a tracking coefficient using all available longitudinal data as suggested by Twisk *et al.*[16–20] By applying this advanced statistical technique on longitudinal fruit and vegetable intake data, more evidence-based insight will be obtained in the actual tracking of fruit and vegetable intake.

In the Amsterdam Growth and Health Longitudinal Study (AGAHLS), data on fruit and vegetable intake are available from age 13 to 36 years, including a maximum of eight repeated measurements. Moreover, anthropometric measurements were repeatedly conducted. These data allow the assessment of (1) to what extent fruit and vegetable intakes track from adolescence into adulthood and (2) to assess whether fruit and vegetable intakes are associated with changes over time in BMI and fat mass.

We hypothesized that the tracking coefficients for fruit and vegetable consumption over a 24-year period are comparable with tracking coefficients of micronutrients, as earlier reported by Post *et al.*[21] (i.e. range 0·28–0·45). We further

Abbreviations: AGAHLS, Amsterdam Growth and Health Longitudinal Study.

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hypothesized that higher fruit and vegetable intake is associated with lower BMI and fat mass.

Methods

Design and sample

The AGAHLS is an observational cohort study started in 1976 with a group of healthy boys and girls. Pupils from a secondary school were invited to participate for all eight repeated measurements (longitudinal school) between 1976 and 2000. The study's main objective was to describe the natural development of growth, health, fitness and lifestyle in teenagers[22,23].

For the present study, pupils for whom valid data were obtained on the initial measurement (age 13 years) and the last measurement (age 36 years), plus valid data on at least two of the first 4 follow-up years (age 13, 14, 15 and/or 16 years), plus at least on one of the three measurements in between (age 21, 27 and/or 33 years) were included in the analyses. The initial sample comprised 350 pupils, of which 168 pupils fulfilled the inclusion criteria for the present study. During the preparations of the AGAHLS no sample-size calculations were performed. Drop-out has been extensively assessed in the AGAHLS[24]. A serious drawback of longitudinal studies is the high rate of drop-out from the original sample. During the first years of follow-up, loss to follow-up was mainly because pupils left school. For the longer-term follow-up, drop-out was mainly due to participants starting to live on their own, and thus changing addresses. No selective drop-out effects for the first 4 years regarding anthropometrics, and physiological and nutritional variables were found[24]. Also no selective drop-out effects were found for the fifth measurement regarding participants' characteristics measured at the first measurement[24]. For the present study we again assessed the possibility of selective drop-out by fruit and vegetable intake, skeletal age, height and weight at age 13 years. From the initial 350 pupils, 323 pupils had valid data on fruit and vegetable intake on the first measurement and 168 of them did participate in enough follow-up measurements to meet the inclusion criteria for the present paper. All others (*n* 155) were considered as drop-outs.

Procedure

During the first 4 years of follow-up (1976–9) a mobile research unit was placed during each school year near the school to perform most of the measurements during school hours. During the adult period participants were invited to come to the university, where all measurements were performed. The research centre covered travel costs and during the adult period, participants received small rewards.

Measures

For the present study, data are used from the dietary interview, measurement of anthropometrics, a physical activity interview, smoking questionnaire, X-ray photographs of hand and wrist and calendar age.

Dietary assessment

The usual food intake was measured by means of a detailed cross-check dietary history interview[25–27]. In this interview the previous 4 weeks were used as a reference period. The amounts were reported in household measures or g. Models were used to illustrate common portion sizes. Plastic samples of fruit and potatoes were used to facilitate the estimation of weights of those food items. During the final measurement, when participants were 36 years of age, a newly developed interviewer-administered computer-assisted cross-check dietary history interview method was introduced. Computer questions and interview structure were based on the original face-to-face interview. A comparison between the two methods was previously made and showed that this newly introduced method caused a reduction of interviewer bias and that its quality is as good as the initial method; however, introducing a new method in a running study must be considered with care[28].

From the data retrieved by the dietary interviews, food groups were created for fruit and vegetables according to the Dutch Food Composition Table (NEVO)[29]. Potatoes were not included, since in the Netherlands potatoes are usually eaten as staple foods and not as root vegetables. Only fresh fruit was considered and dried or canned fruit was excluded.

In the tracking analyses *Z*-scores of the fruit and vegetable intakes was used instead of absolute values (see data analyses section). For the predictability analyses, besides using recommended intake levels as a cut-off criterion, the population was divided into quartiles, which is also a relative measure not influenced by systematic changes.

Anthropometrics

Body height and weight were measured according to standard procedures using the same equipment throughout the longitudinal period. BMI was calculated as weight divided by height squared. Skinfold thicknesses at triceps, biceps, subscapular and supra-iliac level were measured to the nearest 0·1 mm using a Harpenden caliper (Holtain, UK). The sum of these four skinfolds was used as a measure of body fatness.

Potential covariates

Skeletal age. During the adolescent period, biological age, as a measure of maturation, was determined using X-rays of the left hand, according the Tanner–Whitehouse II method[30].

Total energy intake and fibre intake. Total energy intake and fibre intake were available from the dietary assessment.

Physical activity. A structured interview based on a physical activity questionnaire was used to investigate the daily physical activities. The questionnaire comprises questions about duration, frequency and intensity of all physical activities during the 3 months preceding the interview and covered the following areas: organized sports activities, unorganized sports activities, other leisure-time activities, active transportation, and activities at home, and at work. Only those activities with a minimal duration of 5 min and an intensity level of four times BMR (metabolic equivalents) were taken into account. This information was used to calculate a total weighted activity score (expressed in metabolic equivalents per d)[31].

Smoking. Information on tobacco use was retrieved by a questionnaire about the participants' use of cigarettes. Tobacco smoking was expressed in total g/week (one cigarette = 1 g)[32].

Data analyses

Descriptives and drop-out analyses were performed in SPSS version 11 (SPSS Inc., Chicago, IL, USA). Selective drop-out was assessed by logistic regression analyses with drop-out as a dependent variable (yes/no) and participant characteristics at the first measurement as independent variables.

Tracking of fruit and vegetable consumption was assessed by linear generalized estimating Default (GEE) analyses as described by Twisk *et al.*[17,19,20] and following the equation presented in Appendix 1 (equation 1) using an exchangeable correlation structure. Generalized estimating equations analysis is comparable with linear regression analyses; it is more sophisticated because it takes into account that in a longitudinal design the observations within one subject are correlated.

Since *Z*-scores for fruit and vegetable consumption were used, the regression coefficient (β_1) for fruit or vegetable intake at the initial measurement equals the standardized regression coefficient. This regression coefficient can be interpreted as a tracking coefficient. Values close to 1 indicate high tracking. The strength of the tracking coefficient depends on the time period and measurement error.

The model also gives the possibility to adjust for time-dependent covariates (for example, total energy intake) and time-independent covariates (for example, sex). The major advantage of this method is that all available data for the eight repeated measurements are used and that it takes into account that repeated measurements within an individual are correlated.

Since tracking coefficients do not give information on predictability, that is, how well adequacy of baseline intake levels predicts adequacy of intake at later follow-up, additional analyses were done using dichotomous outcomes of fruit and vegetable intake. Two methods of categorization were applied. First, subjects were categorized based on whether or not they met the national guidelines recommending daily intake levels of at least two pieces of larger fruits (or 200 g fruit) and 150 g vegetables in adolescence and 200 g fruit and 200 g vegetables in adulthood[33]. Second, subjects were categorized based on whether or not they were in the highest quartile of fruit or vegetable intake.

Using logistic generalized estimating equations analyses, OR were calculated for meeting these recommendations during follow-up for participants that met these recommendations at the initial measurement (compared with subjects who did not) or being in the highest quartile during follow-up for participants that were in the highest quartile at the initial measurement[34].

In order to investigate associations between quartiles of fruit and vegetable intake and BMI and fat mass two models were used: a time-lag and an autoregression model (equation 2, Appendix 1). The time-lag model estimates the association between the predictor variable at a previous measurement ($t-1$) and the outcome variable at a subsequent measurement (t)[35]. The autoregression model includes the outcome variable at time point $t-1$ as a covariate; therefore results reflect associations between predictor and change in the outcome variable.

Sex-specific quartiles of fruit and vegetable intake (with highest quartile as a reference) were used to reduce error caused by using different methods.

For all analyses interaction by sex was assessed and results were reported separately in case of significant interaction. For the tracking, predictability and autoregression analyses, adjustments were made for sex, skeletal age at the first measurement and total energy intake (kJ) as a time-dependent variable. All analyses with BMI and fat mass as dependent variables were, besides total energy intake and skeletal age, additionally adjusted for fibre intake, physical activity and tobacco use.

All tracking, predictability and autoregression analyses were performed with STATA® 8·2 (StataCorp LP, College Station, TX, USA). We used the $P<0·05$ level to indicate statistical significant associations. For interaction terms we used the $P<0·1$ level, because an interaction term is a multiplication of two variables which both include measurement error. When multiplying these two variables, this results in a multiplicative error with a subsequent high standard error.

Results

As presented in Table 1, the majority (76 %) of the included 168 participants participated in all eight measurements; this proportion was higher for women (80 %) than for men (71 %). Of the present sample, 16 % participated in seven or six measurements and 8 % participated in four or five measurements. Participants considered as drop-outs did not differ from the participants included in the present study regarding height, weight, skeletal age, and fruit and vegetable intake at age 13 years. Means and standard deviations for the key variables are also presented in Table 1. Fruit intake was higher at age 13 years than at age 36 years, while for vegetable intake it was the other way around.

The tracking coefficient covering a 24-year period for fruit intake was 0·33 (95 % CI 0·25, 0·41) and for vegetable intake this was slightly lower (0·27 (95 % CI 0·19, 0·36)). The coefficients were hardly influenced by adjustments for skeletal age and total energy intake, therefore only the coefficients estimated in the fully adjusted model are presented.

Predictability for meeting the national guideline for fruit intake and being in the highest quartile of intake was higher in men than in women (interaction terms $P=0·029$ and $P=0·048$ respectively); see Table 2. In men, OR were higher after adjustment for skeletal age and total energy intake (in unadjusted model, OR 4·91 for recommendation and OR 4·23 for highest quartile). In women, OR were only slightly influenced by the adjustments for skeletal age and total energy intake (data not shown).

Regarding vegetable intake, no significant differences in predictability according to sex were found, and adjustment for bone age at age 13 years and energy intake influenced the estimated OR only slightly (only adjusted for sex, meeting guideline OR 4·17, highest quartile OR 2·45).

Fruit intake appeared not to be associated with BMI or with changes in BMI. However, being in the lowest quartile for

Table 1. Descriptives of fruit and vegetable intake and anthropometrics for the first and last measurements
(Mean values and standard deviations)

	First measurement				Last measurement			
	Boys (*n* 76)		Girls (*n* 92)		Men (*n* 76)		Women (*n* 92)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Eight valid measurements								
n	–		–		54		74	
%	–		–		71·1		80·4	
Age (years)	13·0	0·67	13·0	0·61	36·5	0·61	36·6	0·66
Skeletal age (years)	12·9	1·17	12·8	1·00	–		–	
Height (m)	1·58	0·07	1·60	0·08	1·83	0·06	1·70	0·06
Weight (kg)	43·0	6·4	45·6	8·8	83·3	10·5	68·0	10·0
BMI (kg/m^2)	17·0	1·4	17·8	2·3	24·8	2·6	23·6	3·2
Sum four skinfolds (mm)	27·2	9·2	36·6	14·0	45·7	15·3	56·2	20·1
Fruit intake (g/d)	137·8	77·3	178·4	92·4	66·6	56·7	59·8	64·2
Vegetable intake (g/d)	103·7	44·5	93·8	38·1	154·2	84·2	161·4	76·6
Total energy intake (kJ/d)	11 498	2305	9406	1833	12 129	3184	9703	2255
Fibre intake (g/d)	24·6	5·6	22·7	5·8	27·7	7·7	25·9	5·9
Physical activity (MET/week × 1000)	4·9	1·8	3·9	1·5	3·8	2·1	5·0	2·9
Smokers								
n	0		4		14		17	
%	0		4·3		18·4		18·5	
Smokers' tobacco use (g/week)	–	–	4·3	4·0	64·7	72·9	64·6	54·4

MET, metabolic equivalents.

fruit intake at $t-1$ was associated with a lower sum of four skinfolds at the next measurement (time-lag model), but not with change in the sum of four skinfolds (autoregression model) (Table 3). The associations between vegetable intake with (changes in) BMI and skinfolds differed by sex (interaction all P values $<0{\cdot}02$, except for association with BMI; $P=0{\cdot}178$), therefore all models with vegetable intake as a predictor were stratified by sex. In men, no significant differences were found between the quartiles regarding any overweight indicator. In women, being in the lowest two quartiles for vegetable intake at $t-1$ was associated with higher BMI and higher sum of skinfolds at the next measurement (t) and with higher change in BMI and sum of skinfolds between the subsequent measurements. In all these models, the regression coefficients do not show a stepwise increase from the third quartile (Q3) to the lowest quartile (Q1), which indicates that the association between vegetable intake and BMI and skinfold thickness was not linear.

Discussion

The present study presents tracking coefficients of 0·33 and 0·27 for fruit and vegetable intake respectively, covering a 24-year period. We observed a decrease in mean fruit intake over a 24-year period and only a minority met the national guidelines for fruit and vegetable intake. However, the present study showed that fruit and vegetable intakes according to recommendations at a younger age increase the likelihood of

Table 2. Tracking and predictability of meeting recommendations for fruit and vegetable intake*
(Tracking coefficients or odds ratios and 95 % confidence intervals)

	Tracking				Predictability			
	Fruit intake		Vegetable intake		Fruit		Vegetables	
	Tracking coefficient	95 % CI	Tracking coefficient	95 % CI	OR	95 % CI	OR	95 % CI
Tracking								
All subjects	0·33	0·25, 0·41	0·27	0·19, 0·36				
Longitudinal prediction of recommended intake levels†								
Men†					6·02	3·29, 11·0		
Women†					2·33	1·40, 3·86		
All subjects							4·08	2·31, 7·19
Longitudinal prediction of being in the highest quartile of intake								
Men‡	5·30	2·95, 9·53						
Women‡	2·07	1·21, 3·56						
All subjects							2·38	1·58, 3·56

* Models are adjusted for sex, bone age at 13 years, and total energy intake.
† Recommended intake levels: vegetables during adolescence: ≥150 g/d, during adulthood ≥200 g/d, for fruit: two or more pieces per d.
‡ Results are presented separately due to significant interaction ($P<0{\cdot}1$).

Table 3. Longitudinal association between quartiles of fruit or vegetable intake and body mass index and sum of skinfolds

(Regression coefficients and 95 % confidence intervals)

		BMI		Sum of four skinfolds (mm)	
		Coefficient	95 % CI	Coefficient	95 % CI
Fruit intake					
Time-lag model*	Q3	−0·364	−0·864, 0·135	−2·20	−4·53, 0·412
	Q2	−0·336	−0·869, 0·196	−1·52	−4·04, 1·00
	Q1	−0·404	−0·996, 0·189	−3·65	−6·47, −0·83
Autoregression model*	Q3	−0·066	−0·284, 0·153	−0·506	−2·24, 1·22
	Q2	−0·022	−0·244, 0·199	0·100	−1·67, 1·85
	Q1	0·005	−0·224, 0·234	−0·490	−2·33, 1·35
Vegetable intake					
Boys and men†					
Time-lag model*	Q3	0·082	−0·639, 0·803	0·436	−2·63, 3·50
	Q2	0·232	−0·540, 1·00	0·644	−2·70, 3·99
	Q1	0·082	−0·738, 0·901	−0·509	−4·10, 3·08
Autoregression model*	Q3	−0·070	−0·364, 0·224	−0·696	−2·76, 1·37
	Q2	0·024	−0·560, 0·307	0·214	−1·77, 2·20
	Q1	−0·177	−0·461, 0·108	−1·52	−3·51, 0·472
Girls and women†					
Time-lag model*	Q3	0·299	−0·336, 0·934	3·22	−0·070, 6·52
	Q2	0·698	0·039, 1·36	6·25	2·82, 9·68
	Q1	0·596	−0·108, 1·30	4·86	1·17, 8·54
Autoregression model*	Q3	0·092	−0·196, 0·380	0·93	−1·48, 3·35
	Q2	0·474	0·172, 0·775	4·17	1·66, 6·68
	Q1	0·480	0·180, 0·779	4·41	1·89, 6·93

Q3, third quartile for intake; Q2, second quartile for intake; Q1, lowest quartile for intake.
Regression coefficient, representing difference in BMI or sum of skinfolds with the reference category, i.e. highest quartile of intake.
* Adjusted for sex, bone age at 13 years and total energy intake, physical activity, tobacco use, and fibre intake (time dependent).
† Results are presented separately for men and women due to interaction ($P<0·1$).

eating according to recommendations later on in life two- to six-fold; this predictability for fruit intake was higher for men than for women, indicated by significant interaction ($P<0·1$), but predictability for vegetable intake did not differ between the two sexes.

Furthermore, it appeared that lower fruit intake adjusted for fibre intake was associated with lower fat mass, but not with other indicators of overweight. Contrary, in women only, low vegetable intake was associated with unfavourable effects regarding weight and body fatness.

When interpreting the strength of the tracking coefficients and predictability OR, several issues have to be taken into account. First of all, the present study had a follow-up period of 24 years, which is longer than most other studies that report tracking coefficients on dietary outcomes[11,12]. A high tracking coefficient covering a short time period is not necessarily better than lower tracking coefficients calculated over a longer time period. Second, measurement error negatively influences the tracking coefficient. Post[27] assessed the reproducibility of the dietary history method and concluded that the reproducibility of the method was fairly good. Confounding variables can also attenuate tracking and predictability coefficients.

We adjusted for sex, skeletal age and total energy intake, but it might be that other unknown confounders weakened the observed tracking and predictability. Finally, respondents in the present study received feedback about their health status after each measurement, and this may have caused selective changes in behaviour. It was, for example, shown that participants with high total cholesterol values reduced their fat intake, while participants with normal cholesterol values did not[18]. Comparably, these participants may also have increased their fruit and vegetable intake as part of a healthier diet, resulting in a lower tracking and predictability.

Compared with tracking coefficients and predictability of being in the highest quartile of intake (relative predictability), which reflects the stability of one's rank position over time, the predictability of meeting the guidelines (absolute predictability) may be of additional relevance, since when, for example, everybody decreases their fruit and vegetable consumption over time to inadequate intake levels, tracking coefficients may still be high. The OR for absolute predictability were higher than for relative predictability. This might be due to the fact that defining quartiles is dependent on sample percentiles and arbitrary choices (for instance quintiles or quartiles), which makes the choice of subgroups unstable and can result in lower predictability coefficients (low OR)[18].

Taking these issues into account, it can be concluded that the stability of fruit and vegetable intake is low to moderate (Table 2), but the effect size may have been attenuated. As hypothesized, the tracking coefficients were comparable with tracking of micronutrients (range 0·28–0·45)[21] and other lifestyle behaviours such as physical activity (range 0·17–0·38)[34], but much lower than for biological measures, such as serum cholesterol (tracking coefficient 0·71)[20]. This might be partly due to larger measurement error compared with the measurement error for biological measures. The predictability indicators do show that eating according to guidelines at an early age do improve the chances of eating according to guidelines later in life, especially for fruit intake in men. The observed OR are comparable with the predictive OR found for physical activity (OR 3·6 (95 % CI 2·4, 5·4))[34]. That the predictability for fruit intake was higher in men may have been caused by the fact that fewer boys than girls met the guidelines at age 13 years (17·1 *v.* 33·7 %).

Apart from the AGHALS studies, no other studies report generalized estimating equations tracking coefficients for dietary intake variables, which makes it difficult to compare results. Kelder *et al.*[12] and Lien *et al.*[11] report good tracking of fruit and vegetable intake, but cover a shorter period of time and only use visual measures. Contrary, Lake *et al.*[36] report that between adolescence and adulthood the largest change in intakes was the increase in the contribution to total food weight from fruit and vegetables (change from 14·6 % at age 11·6 years to 25·2 % at age 32·5 years) and that this change was not equal for everybody.

It is generally accepted that adequate fruit and vegetable consumption is associated with a reduced risk for CVD and some cancers, but also is associated with prevention of overweight[1–4]. We only observed that lower vegetable consumption was indeed associated with higher (increase in) BMI and sum of skinfolds in women. Our findings were not confounded by total energy intake or energy expenditure as suggested by others[3]. Others also report that inverse associations between fruit and vegetable intake and overweight or weight gain remain after adjustment for total energy intake[4,37]. It might also be that specific components of vegetables contribute to prevention of gain in weight or fat mass. For instance, the high fibre content of fruit and vegetables may affect fat oxidation and storage through its effects on insulin sensitivity[38]. We also adjusted for fibre intake, and found unexpected results between fruit intake and one body fat indicator. This may be a result of the fact that many fruits also contain a significant amount of sugar and thus energy. Since analyses were adjusted for fibre intake, the sugar content of fruit becomes more relevant. It has been reported previously that fruit and vegetables have different associations with cancer incidence[39] and this may also be true for other diseases, which probably depends on their nutritional profiles, the different consumption patterns and preparation methods. In the Netherlands vegetables are mostly eaten during dinner, while fruits are generally eaten as snacks.

Finally, it might be that because only a minority complied with the recommendations for fruit and vegetable intake, it was difficult to observe beneficial effects of fruit and vegetable on BMI or fat mass.

It is not clear why we only found significant associations for vegetable intake in women and not in men (assessed by interaction terms, with $P < 0{\cdot}1$ level). Contrary, Bes-Rostrello *et al.*[4] observed stronger associations between fruit and vegetable intake and weight gain in men compared with women.

Regarding the generalizability of the results, it needs to be mentioned that the AGAHLS population is not a representative sample of the Dutch population with respect to socio-economic position. Parental educational and socio-economic position were above average of the total Dutch population at that time[40]. Likewise, only a very few participants from non-Western origin were included. Therefore, the AGAHLS population might be more homogeneous than the general Dutch population, but may still be representative for large proportions of populations in North Western Europe. Drop-out analyses further showed that the included pupils did not differ from the ones who dropped out during the longitudinal study. Moreover, to our knowledge there are no reasons to believe that the association between fruit and vegetable intake and indicators of overweight differ by educational level or socio-economic position.

Taking this all together, we can conclude that tracking and predictability for fruit and vegetable intake appear to be low to moderate. This may indicate that fruit and vegetable intake is not yet stabilized at age 13 years and that during adolescence and young adulthood major life changes occur that may influence dietary intake and would imply that fruit and vegetable promotion should start at an early age and be continued into adulthood. However, nowadays a lot of interventions and campaigns promoting fruit and vegetable intake have been implemented at primary schools[41,42]. Therefore, it should be advised to continue these interventions and campaigns at secondary schools and at worksites in order to reach adolescents and young adults[43]. Furthermore, we observed a decrease in mean fruit intake over a 24-year period and only a minority met the national guidelines for fruit and vegetable intake.

Despite the fact we only observed beneficial effects of vegetable intake as a means of weight maintenance only in women, promoting vegetable intake is important for both sexes because of other than weight-related health-promoting properties of vegetables. No evidence was found for promoting fruit intake as a means of weight maintenance.

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Appendix 1

Tracking analyses

$$Y_{it} = \beta_0 + \beta_1 Y_{\mathrm{it1}} + \beta_2 t + \sum_{J=1}^{J} \beta_{3j} X_{ijt} + \sum_{K=1}^{K} \beta_{4k} Z_{ik} + \varepsilon_{it} \quad (1)$$

Y_{it} is the observations for individual i from t_2 till t_{m} (where m is the number of measurements); β_0 is the intercept; Y_{it1} is the initial observation for individual i at $t1$; β_1 is the standardized regression coefficient used as tracking coefficient; t is time; β_2 is the regression coefficient of time; X_{ijt} is the time-dependent covariate j of individual i; β_{3j} is the regression coefficient of the time-dependent covariate j; J is the number of time-dependent covariates; Z_{ik} is the time-independent covariate k of individual i; β_{4k} is the regression coefficient of the time-independent covariate k; K is the number of time-independent covariates and ε_{it} is the measurement error for individual i.

Time-lag and autoregression models

$$Y_{it} = \beta_0 + \sum_{J=1}^{J} \beta_{1j} X_{ijt-1} (+\beta_2 Y_{it-1}) + \ldots \quad (2)$$

Y_{it} are observations for subject i at time t, β_0 is the intercept, X_{ijt-1} is the dependent variable j for subject i at time $t-1$, β_{1j} is the regression coefficient for independent variable j, J is the number of independent variables, Y_{it-1} is the observation for subject i at time $t-1$, and β_2 is the autoregression coefficient. The model not including Y_{it-1} is the time-lag model. When Y_{it-1} is included, the model assesses the relationship between the predictor variable on the outcome variable, adjusted for the outcome variable at time point $t-1$, i.e. the autoregression model.