Tracking of nutrient intakes in adolescence: the experiences of the Young Hearts Project, Northern Ireland

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This study evaluated the tracking of energy and nutrient intakes, assessed by diet history, in a random sample of adolescents (boys *n* 225, girls *n* 230) at baseline (age 12 years), and subsequently at age 15 years. Median energy (MJ/d) and macronutrient (g/d) intakes increased significantly (all $P < 0{\cdot}001$) with increasing age in the boys. The girls' reported energy intake (MJ/d) remained stable over time, despite significant increases in BMI, weight and % body fat. Age-related changes in the girls' macronutrient intakes were inconsistent. When expressed in terms of nutrient density, the diets of both sexes became significantly richer, over time, in total folate (both sexes, $P < 0{\cdot}01$), but poorer in Ca (boys $P < 0{\cdot}01$, girls $P < 0{\cdot}001$) and riboflavin (both sexes $P < 0{\cdot}001$). Vitamin B_6 ($P < 0{\cdot}001$) and Fe ($P < 0{\cdot}05$) densities increased in the boys, while the thiamin density of the girls' diets decreased ($P < 0{\cdot}001$). Tracking, defined as maintenance of rank over time, was summarised using weighted kappa statistics (κ). There were some significant changes in intakes at the group level; however, tracking of energy and nutrients in both sexes was only poor to fair ($\kappa < 0{\cdot}40$), indicating substantial drift of individuals between classes of intake over time. Particularly poor tracking was evident for % energy from sugars (κ 0·09) and total fat (κ 0·09) in the girls' diets. In conclusion, the poor to fair tracking observed in this cohort suggests that individual dietary patterns exhibited at 12 years of age are unlikely to be predictive of energy and nutrient intake at age 15 years.

Adolescents: Nutrient density: Nutrient intake tracking: Northern Ireland

It is widely accepted that physiological risk factors for IHD, such as unfavourable lipid and blood pressure profiles, are likely to 'track' from early life into adulthood (Lauer *et al.* 1988; Webber *et al.* 1991; Porkka *et al.* 1994; Raitakari *et al.* 1994; Twisk *et al.* 1997*b*). Tracking has been defined as the maintenance of relative position in rank of behaviour over time, such that subjects who rank highly for unfavourable risk profiles at a young age are likely to maintain their ranks through into adulthood (Kelder *et al.* 1994; Twisk *et al.* 1997*a*).

The evidence that dietary patterns formed in early life may track into adulthood, and thus influence the progression of chronic disease, has been cited as the rationale for targeting 'healthy eating' programmes at children and adolescents (Kelder *et al.* 1994; Boulton *et al.* 1995; Singer *et al.* 1995). While moderate tracking of selected nutrients has been observed in younger children (Stein *et al.* 1991; Boulton *et al.* 1995; Singer *et al.* 1995), there is limited and inconsistent evidence for similar tracking in adolescents (Boulton *et al.* 1995; Welten *et al.* 1997). The majority of studies concerning nutrient intakes in older children have been cross-sectional (Adamson *et al.* 1992; Crawley, 1993; Anderson *et al.* 1994; Strain *et al.* 1994; Samuelson *et al.* 1996; Hurson & Corish, 1997).

Consequently, the aim of the present study was to use longitudinal data from the Young Hearts Study, conducted

Abbreviations: EAR, estimated average requirement; EI, energy intake; κ, weighted kappa value.

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in Northern Ireland, UK, to evaluate the extent of tracking of energy and nutrient intakes reported at baseline by a random sample of adolescents aged 12 years, and 3 years later at follow-up.

Methodology

Subjects

The Young Hearts Project is an ongoing longitudinal study of the prevalence of risk factors for IHD in a random sample of subjects from Northern Ireland. The baseline survey of 1015 randomly-selected schoolchildren (251 12-year-old boys, 258 12-year-old girls, 252 15-year-old boys and 254 15-year-old girls) was completed in 1990 with a response rate of 78 %. The resulting cohort accounted for a 2 % sample of each of the two respective age populations in Northern Ireland. Sampling procedures are described fully elsewhere (Boreham *et al.* 1993). In 1992–3, subjects from the original 12-year-old group (then aged 15 years), were reassessed. Ethical approval was obtained from the Medical Research Ethical Committee of The Queen's University of Belfast, and written consent was obtained from parents or guardians, and all participating subjects.

Protocol

As part of the test protocol, measurements of height, weight and skinfold thicknesses were made. Subjects, wearing light indoor clothing and no shoes, were weighed to the nearest 0·1 kg using scales (Weylux balance model 424J London, UK; 160 kg × 50 g), and height was measured to the nearest mm using a free-standing, portable stadiometer (Holtain, Crymych, Wales, UK). Skinfold thicknesses were measured to the nearest mm using calipers at four sites (biceps, triceps, subscapular and suprailiac), and used to estimate body fatness (Durnin & Rahaman, 1967). At follow-up, anthropometric data were obtained for 222 boys and 229 girls (88 % and 89 % of original cohort respectively). Maturational stage at both time points was assessed using the Tanner index of pubertal development (Tanner, 1962). Nutritional data were collected from 225 boys and 230 girls (90 % and 89 % of the original cohort respectively) by the diet history method with open-ended interview (van Staveren *et al.* 1985), and using food photographs to assist in the determination of portion sizes (Lee & Cunningham, 1990). The diet history was used for two reasons. First, it has been shown, in this age group to provide more valid estimates of energy intake at the group level than weighed records (Livingstone *et al.* 1992). Second, given that a diet history can be obtained from a subject in approximately 1 h, it was the most feasible and cost-effective method for obtaining dietary information from a school-based cohort of this size. Energy and nutrient intakes were calculated using a computerised database as previously described (Strain *et al.* 1994). The BMR of each subject was predicted using equations based on height and weight (Schofield *et al.* 1985). The same methods were used to assess diet and anthropometric status at both time points.

Statistical analyses

In an earlier paper (Strain *et al.* 1994), the advantages of using the median, rather than the arithmetic mean, to describe dietary intakes were outlined. Consequently, to maintain consistency in the present study, dietary data are summarised by medians, with the 25th and 75th percentiles included as a measure of variation. These percentiles are also used to describe body composition data. The Wilcoxon matched-pairs signed-ranks test was used to test for significant differences between median values at ages 12 and 15 years at a 5 % significance level.

In the present study, daily energy or nutrient intake would be considered to track well over time if 12-year-old subjects with 'low', 'medium' or 'high' intakes maintained their ranking when 15-years-old. Basing the method on ranks was preferred to a method based on actual intakes because of its simplicity, its ability to show the rates of transitions between the three classes (low, medium or high) and also to deal with the problem of under- or over-reporting of intakes. For example, in order to study the tracking of energy intakes (EI) of boys from aged 12 years to aged 15 years, the group of 225 boys aged 12 years was divided into three classes by EI: lowest 25 % (L1); middle 50 % (M1); highest 25 % (H1). In effect, the classes were defined by the first and third empirical quartiles, and not by pre-determined fixed values. When aged 15 years, the group was divided into three similar classes: L2, M2 and H2. Using these two classifications, a 3 × 3 tracking matrix was constructed: the entry in a specific cell being the number of subjects belonging to the corresponding classes at age 12 and 15 years (examples are given in Fig. 1). Such a matrix provides a broad picture of the relative changes in intake of the group over the 3 year period. A matrix with relatively small off-diagonal elements provides evidence of 'good' tracking. The degree of tracking was summarised by a weighted kappa value (κ) (Altman, 1991), calculated from the matrix. The interpretation of the κ value obtained has been defined by Altman (1991) as follows: $\kappa < 0{\cdot}20$, poor; 0·21–0·40, fair; 0·41–0·60, moderate; 0·61–0·8, good; 0·81–1.0, very good. In addition, 95 % confidence limits for κ were calculated. This procedure was undertaken for intakes of energy, macronutrients and selected micronutrients.

Results

The physical characteristics and reported EI of the Young Hearts cohort at age 12 years and 15 years are presented in Table 1. The body weight and BMI of both boys and girls increased significantly ($P < 0{\cdot}001$) with increasing age. At age 12 years and 15 years, the boys were heavier than the 50th centile value for weight for the equivalent UK population (2·7 % and 4·4 % heavier respectively) (Department of Health, 1991). At both 12 years and 15 years, the girls were approximately 5·5 % heavier than the population reference values (Department of Health, 1991). The median percentage body fat for boys decreased by 9 % (in relative terms) from age 12 years to 15 years ($P < 0{\cdot}001$), whereas that of the girls increased by a similar magnitude ($P < 0{\cdot}001$). In terms of maturational stage (not presented in

(a)

	L2	M2	H2
L1	21	26	9
M1	27	61	25
H1	8	26	22

κ 0·18

(b)

	L2	M2	H2
L1	21	32	4
M1	32	59	25
H1	4	25	28

κ 0·24

(c)

	L2	M2	H2
L1	21	27	8
M1	26	60	27
H1	9	26	21

κ 0·17

(d)

	L2	M2	H2
L1	22	24	11
M1	24	60	32
H1	11	32	14

κ 0·09

Fig. 1. Tracking of energy intake (MJ) and % energy from fat in diets of the Young Hearts cohort from age 12 to 15 years (boys *n* 225, girls *n* 230). Nutrient intakes were estimated by the diet history method with open-ended interview (van Staveren *et al.* 1985) using food photographs to assist in determination of portion sizes (Lee & Cunningham, 1990) and a computerised database (Strain *et al.* 1994) Matrices are shown for energy (MJ) in (a) boys and (b) girls, and Fat (% energy) in (c) boys and (d) girls. L1 and L2 represent the lowest 25 % of the sample cohort for intakes at age 12 and 15 respectively; M1 and M2 represent the middle 50 % of the sample cohort for intakes at age 12 and 15 respectively; H1 and H2 represent the highest 25 % of the sample cohort for intakes at age 12 and 15 respectively. Weighted kappa values (κ) were calculated and interpreted as described on p. 542. 95 % CI were κ±0·1 throughout.

table), the majority (96 %) of the boys at age 12 years were at Tanner stage I–III for pubertal development. By the age of 15 years, 91 % were at Tanner stage IV–V. In the girls, 72 % were at Tanner stage I–III at age 12 years, but by age 15 years, 98 % were at Tanner stage IV–V.

While total daily EI reported by the boys increased significantly ($P < 0{\cdot}001$) with increasing age, the median EI reported by the girls remained stable, despite increases in weight, BMI and % body fat. However, when normalised for body weight (kJ/kg per d), EI reported by boys and girls was significantly lower at age 15 years than at age 12 years ($P < 0{\cdot}001$, both sexes). The EI:predicted BMR ratio also decreased significantly over time in both groups, but the magnitude of change was greater for the girls than for the boys ($P < 0{\cdot}001$, $P < 0{\cdot}05$ respectively). A fair degree of tracking was found over the study period for EI expressed per kg body weight (κ 0·37, 0·40 for boys and girls respectively), and for EI:BMR (κ 0·27, 0·22 for boys and girls respectively).

Over the 3 years, concomitant with the increase in reported EI, median macronutrient intakes (g/d) of the boys increased significantly ($P < 0{\cdot}001$ for all macronutrients; Table 2). However, when expressed as a percentage contribution to EI, there were no significant changes in intakes of sugars or monounsaturated fatty acids reported at the group level. Small but statistically significant increases in intakes of % energy derived from protein ($P < 0{\cdot}001$) and polyunsaturated fatty acids ($P < 0{\cdot}05$) were observed, whereas % energy contributed by total carbohydrate, total fat and saturated fatty acids in the boys' diets all decreased significantly over time ($P < 0{\cdot}001$, $P < 0{\cdot}05$, $P < 0{\cdot}001$ respectively). The reported polyunsaturated:saturated fatty acid ratio also increased ($P < 0{\cdot}001$) from age 12 years (median 0·33) to age 15 years (median 0·39). Changes in the girls' intakes of macronutrients (g/d) were inconsistent. Despite the fact that median EI reported by the girls did not increase with age, intakes of protein (g/d) and carbohydrate (g/d) did increase significantly over time ($P < 0{\cdot}05$). Similarly to the boys, the median polyunsaturated:saturated fatty acid ratio and the median percentage contribution made by protein to EI also increased ($P < 0{\cdot}01$, $P < 0{\cdot}001$ respectively), whereas the percentage contributions made by carbohydrate and saturated fatty acids to EI were significantly lower ($P < 0{\cdot}001$, $P < 0{\cdot}01$ respectively) at age 15 years. Only ten boys and two girls reported drinking alcohol at age 12 years (data not shown). For consumers at age 15 years, the median (25th, 75th percentile) intakes of

Table 1. Physical characteristics and energy intakes (EI) of the Young Hearts cohort of boys and girls at baseline (aged 12 years) and at follow-up (aged 15 years)

(Median values with 25th and 75th percentiles)

	Boys				Girls			
	12-years-old (*n* 225)		15-years-old (*n* 222)†		12-years-old (*n* 230)		15-years-old (*n* 229)†	
	Median	25th, 75th percentile	Median	25th, 75th percentile	Median	25th, 75th percentile	Median	25th, 75th percentile
Body weight (kg)	40·9	36·1, 48·0	59·0***	53·2, 67·2	43·2	37·3, 50·0	55·4***	50·0, 62·1
BMI (kg/m^2)	18·0	17·0, 20·4	20·3***	18·8, 22·3	18·8	17·1, 21·0	21·3***	19·4, 23·8
Body fat (%)	18·2	15·5, 22·4	16·6***	14·4, 19·7	25·2	22·6, 29·0	27·4***	25·0, 29·8
EI (MJ/d)‡	10·9	9·1, 13·4	13·3***	11·1, 15·1	9·0	7·7, 10·7	9·0	7·6, 10·6
EI (kJ/kg per d)‡	262	215, 333	217***	182, 259	214	160, 265	159***	132, 198
Energy requirements (kJ/kg per d)§	237		195		196		169	
EI:BMR‖	1·87	1·55, 2·29	1·81*	1·55, 2·10	1·72	1·40, 2·08	1·51***	1·28, 1·80

Group median values were significantly different from the group median values at 12-years-old (Wilcoxon matched-pairs signed-ranks test): *$P < 0{\cdot}05$, ***$P < 0{\cdot}001$.

† For energy intake, *n* 225 for boys and *n* 230 for girls.

‡ Energy intakes were estimated by the diet history method with open-ended interview (van Staveren *et al.* 1985) using photographs to assist in the determination of portion sizes (Lee & Cunningham, 1990) and a computerised database (Strain *et al.* 1994).

§ Food and Agriculture Organization/World Health Organization/United Nations University (1985).

‖ BMR predicted from height and weight using equations of Schofield *et al.* (1985).

Table 2. Intakes of macronutrients in the diets of the Young Hearts cohort of boys and girls at baseline (aged 12 years) and at follow-up (aged 15 years)†

(Median values with 25th and 75th percentiles)

	Boys (*n* 225)				Girls (*n* 230)			
	12-years-old		15-years-old		12-years-old		15-years-old	
	Median	25th, 75th percentile	Median	25th, 75th percentile	Median	25th, 75th percentile	Median	25th, 75th percentile
Protein (g/d)	71·2	60·2, 85·9	92·2***	78·8, 107·8	59·2	49·8, 70·8	62·6*	51·7, 74·7
% Energy from protein	11·0	9·9, 12·1	11·9***	10·7, 13·1	10·8	9·7, 12·3	11·5***	10·3, 12·9
Total CHO (g/d)	347·6	281·3, 429·4	404·1***	337·0, 466·4	281·4	239·6, 337·0	277·2*	228·4, 319·6
% Energy from CHO	49·4	46·7, 52·1	47·7***	44·6, 50·0	49·3	46·4, 52·6	47·9***	45·0, 50·6
Sugars (g/d)	137·4	110·9, 182·6	158·8***	123·7, 200·1	118·8	94·6, 149·4	115·0	90·0, 150·0
% Energy from sugars	20·3	16·7, 23·3	19·4	16·3, 22·6	20·6	17·7, 23·7	20·3	17·1, 23·8
Total fat (g/d)	112·0	89·3, 140·1	130·1***	110·5, 155·3	93·0	75·8, 114·2	92·9	76·5, 111·4
% Energy from fat	39·0	36·0, 41·6	38·2*	35·2, 40·8	38·4	35·7, 41·8	39·1	36·3, 41·6
SFA (g/d)	45·1	35·3, 58·3	51·8***	41·0, 61·7	35·7	28·4, 46·2	34·8	28·4, 42·6
% Energy from SFA	15·9	13·8, 17·8	14·4***	12·9, 16·6	15·1	13·3, 17·1	14·3**	12·8, 16·6
MUFA (g/d)	36·3	28·1, 46·3	43·5***‘	35·4, 53·2	29·4	24·1, 36·5	29·9	24·0, 35·6
% Energy from MUFA	12·7	11·5, 13·7	12·5	11·2, 13·9	12·3	11·1, 13·4	12·3	11·0, 13·7
PUFA (g/d)	15·4	11·5, 20·2	19·6***	14·6, 25·8	14·4	10·6, 18·9	14·9	10·8, 18·9
% Energy from PUFA	5·1	4·2, 6·4	5·7*	4·4, 7·1	5·9	4·7, 7·3	6·0	4·8, 7·8
P:S ratio	0·33	0·24, 0·47	0·39***	0·29, 0·53	0·38	0·29, 0·53	0·43**	0·31, 0·57

CHO, carbohydrate; SFA, saturated fat; MUFA, monounsaturated fat; PUFA, polyunsaturated fat; P:S ratio, polyunsaturated:saturated fatty acid ratio.

Group median values were significantly different from the group median values at 12-years-old (Wilcoxon matched-pairs signed-ranks test): *$P < 0·05$, **$P < 0·01$, ***$P < 0·001$.

† Macronutrient intakes were estimated by the diet history method with open-ended interview (van Staveren *et al.* 1985) using photographs to assist in the determination of portion sizes (Lee & Cunningham, 1990) and a computerised database (Strain *et al.* 1994).

ethanol for boys (*n* 84) and girls (*n* 68) were 8·8 (4·5, 14·8) g and 4·3 (2·6, 9·9) g respectively.

While at the group level, some significant changes in energy and macronutrient intakes were observed, it is notable that the tracking of energy and macronutrient intakes at the individual level was only poor to fair. Fig. 1 shows the 3 × 3 matrices and κ obtained for tracking of reported EI and % energy derived from fat. The tracking of EI (MJ/d) was poor for boys, and fair for girls. The matrices demonstrate substantial drift between the classes of intake. For example, 46 % of boys who reported EI in the lowest intake category (L1) at age 12 years, moved into the medium intake category (M2) when assessed at age 15 years, and 16 % of the cohort moved from the L1 category

Table 3. Tracking of energy and macronutrient intakes, as estimated by weighted kappa values (κ), in the diets of boys and girls in the Young Hearts cohort from baseline (aged 12 years) to follow-up (aged 15 years)

	κ*	
	Boys (*n* 225)	Girls (*n* 230)
EI (MJ)	0·18	0·24
EI:BMR	0·27	0·22
EI/kg body weight	0·37	0·40
Protein (g)	0·16	0·25
% Energy from protein	0·25	0·28
Carbohydrate (g)	0·17	0·17
% Energy from carbohydrate	0·16	0·17
Sugars (g)	0·19	0·14
% Energy from sugars	0·18	0·09
Fat (g)	0·18	0·20
% Energy from fat	0·17	0·09

EI, energy intake.

* Weighted kappa values (κ) were calculated as described on p. 542. 95 % CI were ±0·1 throughout.

into the highest intake category (H2). Substantial migration between categories was also apparent for boys' and girls' reported intakes of % energy derived from fat. The κ values for energy and macronutrients are given in Table 3. With the exception of percentage energy derived from protein (κ 0·25, fair tracking), the tracking of EI and macronutrients in boys from age 12 to age 15 years was poor (κ < 0·20). For girls, EI (MJ/d) and protein intake (g/d and % energy) exhibited a fair degree of tracking, but this was not evident for other macronutrients. When expressed as % EI, particularly poor tracking was evident for the girls' reported intakes of sugars (κ 0·09) and total fat (κ 0·09).

Table 4 presents reported intakes of selected micronutrients by the Young Hearts cohort at age 12 years and at follow-up (aged 15 years). The median micronutrient densities (mg/MJ per d or μg/MJ per d) of the boys' diets did not remain consistent with increasing age. Over time, the boys' diets became slightly, but significantly, richer in Fe ($P < 0·05$), vitamin B_6 ($P < 0·001$) and total folate ($P < 0·001$). In contrast, Ca ($P < 0·01$) and riboflavin ($P < 0·001$) densities fell with increasing age. No significant changes in intakes per MJ of the other micronutrients were observed in the boys' diets. The boys' median intakes of total folate (μg/MJ) were lower than estimated average requirements (EAR, expressed as μg/MJ (Department of Health, 1991)), both at age 12 years (−28·4 %) and at age 15 years (−1·5 %). Median intakes of all other micronutrients exceeded the EAR, when expressed in terms of nutrient density. Similarly to the boys, the girls' diets became richer in folate ($P < 0·01$) over time, and poorer in Ca and riboflavin (both $P < 0·001$). The girls' intakes of thiamin (mg/MJ per d) also decreased with increasing age. No changes were observed in median daily intakes of Fe, vitamins A, C and D per MJ

Table 4. Intakes of selected micronutrients in the diets of the Young Hearts cohort of boys and girls at baseline (aged 12 years) and at follow-up (aged 15 years)†

(Median values with 25th and 75th percentiles)

		Boys (n 225)				Girls (n 230)			
		12-years-old		15-years-old		12-years-old		15-years-old	
Micronutrient	Unit	Median	25th, 75th percentile	Median	25th, 75th percentile	Median	25th, 75th percentile	Median	25th, 75th percentile
Iron	mg/d	11·0	9·3, 13·8	14·2***	11·5, 16·4	9·73	8·0, 11·9	9·9	8·4, 11·8
	mg/MJ per d	1·00	0·92, 1·11	1·05*	0·93, 1·12	1·06	0·94, 1·19	1·08	1·00, 1·17
Calcium	mg/d	1013	782, 1274	1083***	849, 1384	819	654, 1036	757**	575, 963
	mg/MJ per d	88·6	73·6, 106·8	84·1**	69·5, 101·7	89·0	70·6, 112·1	82·4***	65·8, 102·1
Thiamin	mg/d	1·54	1·17, 1·83	1·75***	1·42, 2·14	1·22	0·97, 1·54	1·06***	0·86, 1·40
	mg/MJ per d	0·13	0·11, 0·16	0·14	0·11, 0·17	0·13	0·11, 0·16	0·12***	0·10, 0·15
Riboflavin	mg/d	1·98	1·47, 2·56	2·15**	1·58, 2·70	1·56	1·20, 1·92	1·21***	0·86, 1·60
	mg/MJ per d	0·18	0·14, 0·22	0·16***	0·12, 0·21	0·17	0·14, 0·21	0·13***	0·10, 0·17
Vitamin B_6	mg/d	1·45	1·19, 1·75	1·86***	1·58, 2·22	1·28	1·05, 1·55	1·29	1·07, 1·53
	mg/MJ per d	0·13	0·12, 0·15	0·15***	0·13, 0·17	0·14	0·12, 0·16	0·14	0·13, 0·16
Total folate	μg/d	133	106, 160	169***	138, 215	116	97, 145	128**	101, 158
	μg/MJ per d	11·6	9·9, 14·5	12·8***	10·7, 15·5	12·8	10·4, 15·6	13·9**	10·8, 17·5
Vitamin A	μg RE/d	638	483, 924	790***	580, 1062	567	413, 816	602	448, 810
	μg RE/MJ per d	60·4	45·3, 80·9	61·2	48·1, 79·1	62·3	46·5, 81·5	67·7	50·3, 88·0
Vitamin C	mg/d	61·7	44·0, 89·5	74·8***	53·3, 104·8	68·2	44·0, 96·2	64·6	40·9, 99·8
	mg/MJ per d	5·50	4·23, 7·59	5·69	3·92, 8·12	7·2	4·89, 10·19	6·81	4·30, 10·99
Vitamin D	μg/d	1·13	0·61, 2·09	1·22	0·49, 2·29	1·13	0·57, 1·97	1·25	0·50, 2·24
	μg/MJ per d	0·11	0·06, 0·19	0·08	0·04, 0·19	0·13	0·07, 0·21	0·14	0·06, 0·24

RE, retinol equivalents.

Group Median values were significantly different from the group median values at 12-years-old (Wilcoxon matched-pairs signed-ranks test): $^{*}P < 0·05$, $^{**}P < 0·01$, $^{***}P < 0·001$.

† Micronutrient intakes were estimated by the diet history method with open-ended interview (van Staveren *et al.* 1985) using photographs to assist in the determination of portion sizes (Lee & Cunningham, 1990) and a computerised database (Strain *et al.* 1994).

in the girls' diets. The shortfall in total folate intakes of the girls, relative to EAR (μg/MJ), was substantial at both time points (−34·0 %, −18·2 % at 12 years and 15 years respectively). Moreover, median Fe intakes (mg/MJ) reported by the girls were lower than the EAR (mg/MJ) at age 12 years (−28·4 %) and at age 15 years (−16·3 %).

Table 5. Tracking of micronutrient intakes as estimated by weighted kappa values (κ), in the diets of boys and girls of the Young Hearts cohort from baseline (aged 12 years) to follow-up (aged 15 years)

		κ*	
Micronutrient	Unit	Boys (n 225)	Girls (n 230)
Iron	mg	0·17	0·21
	mg/MJ	0·21	0·22
Calcium	mg	0·25	0·22
	mg/MJ	0·31	0·29
Thiamin	mg	0·24	0·18
	mg/MJ	0·30	0·25
Riboflavin	mg	0·29	0·23
	mg/MJ	0·29	0·19
Vitamin B_6	mg	0·17	0·16
	mg/MJ	0·14	0·21
Total folate	μg	0·24	0·17
	μg/MJ	0·31	0·26
Vitamin A	μg RE	0·23	0·17
	μg RE/MJ	0·20	0·21
Vitamin C	mg	0·19	0·18
	mg/MJ	0·24	0·20
Vitamin D	μg	0·19	0·23
	μg/MJ	0·13	0·19

RE, retinol equivalent.

* Weighted kappa values (κ) were calculated as described on p. 542. 95 % CI were ± 0·1 throughout.

Median intakes of the other micronutrients reported in this study exceeded EAR. The weighted κ values obtained for the micronutrient intakes are summarised in Table 5. Again, while there were some significant changes at the group level over time in both sexes, micronutrient intakes exhibited only poor to fair tracking. For intakes of Fe (mg/MJ), Ca (mg/MJ), thiamin (mg/MJ), and total folate (μg/MJ), a fair degree of tracking (κ 0·21–0·31) was observed for boys and girls. Intakes of riboflavin and vitamin C, adjusted for EI, exhibited a fair degree of tracking for boys, but not for girls (κ 0·29, 0·24 *v.* 0·19, 0·20 respectively). Poor tracking was observed for boys' intakes of vitamin B_6 (mg/MJ) and vitamin A (μg retinol equivalents/MJ) (κ 0·14 and 0·20 respectively), whereas for girls this was marginally stronger (both κ 0·21). Vitamin D intakes, adjusted for EI, exhibited only poor tracking in both sexes.

Discussion

While at the group level there were some significant changes in nutrient intakes in the Young Hearts cohort between the ages of 12 years and 15 years, it is notable that tracking for most nutrients was only poor to fair. Intuitively, this is not an unexpected finding, as adolescence is a time characterised by considerable physical, cognitive and psychosocial change. However, to date, the evidence for tracking, or otherwise, of nutrient intakes in this age group has been somewhat scarce and inconsistent. In contrast, several studies of younger children have reported fair to moderate tracking of certain nutrients. One study, which examined the extent of tracking of nutrients in the diets of 181 children initially aged 45–60 months, reported tracking coefficients ranging from 0·19 for polyunsaturated fatty acids to 0·71 for Ca (Stein *et al.* 1991). Despite substantial day-to-day variation in intake, the authors concluded that the underlying diets, assessed using repeated 24 h recalls, of the pre-school children did track well over time. A later study, which used a series of 3 d estimated food diaries to assess the diets of seventy-three children from 3–4 years to 7–8 years of age, also found evidence of nutrient tracking in the pre-school years (Singer *et al.* 1995). However, as the subjects in these studies were surveyed at young ages when diet is highly likely to be controlled by parents or guardians, this is probably to be expected.

Existing evidence for the phenomenon of nutrient tracking in older children and adolescents is less consistent. For example, Boulton *et al.* (1995) reported tracking of dietary energy, fat and Ca in an Australian cohort from the age of 1 to 15 years. Diets in that cohort were assessed using 4 d weighed records. Tracking was relatively consistent for boys' Ca intakes from early and mid-childhood, through adolescence. It was also apparent that children who were 'big eaters' at a young age remained so, but that those who had lower energy intakes when younger became more evenly spread across the distribution of intakes over time. Another study, the Amsterdam Growth and Health Study, for which nutrient intake was assessed using the diet history method, also described fair to moderate tracking of Ca intakes in males and females over a 12-year period (Welten *et al.* 1997). More data from the same cohort described 'tracking coefficients' for % energy derived from fat (males 0·33, females 0·04), protein (males 0·32, females 0·04), and carbohydrate (males 0·19, females 0·06) (Twisk *et al.* 1997*b*). These coefficients, computed from data obtained in the first dietary assessment undertaken at age 13 years and the mean of the last two assessments made at age 27–29 years, suggest poor to fair tracking of macronutrient intakes in males, but poor tracking in females.

It is difficult to draw direct comparisons between these studies and the present study, owing to substantial differences in dietary intake methodology, methods of calculating tracking coefficients, ages of the populations studied, and time lapses between periods of assessment. In the present study, tracking was only poor to fair between the ages of 12 and 15 years, demonstrating a marked drift of individuals between classes of intake for most nutrients. In other words, although there were statistically significant changes in intakes of many nutrients at the group level over time, this was not because all subjects reported intakes which increased or decreased proportionately with increasing age.

The lowest κ values in the present cohort were found in the girls for % energy derived from fat (κ 0·09) and % energy derived from sugars (κ 0·09). These values indicate 3×3 matrices with relatively large off-diagonal elements (poor tracking), and are somewhat lower than those reported by the boys (κ 0·17 and κ 0·18 respectively). There are two possible explanations for the particularly poor tracking of these specific nutrients in girls: either the values are an artifact related to 'mis-reporting' of intake, or they reflect real changes in nutrient consumption patterns with increasing age. As previously described (Strain *et al.* 1994), a subject's intake was considered to be implausible (or 'mis-reported') if EI:BMR was less than 1·14 ('under-reporting') or greater than 2·5 ('over-reporting') (cut-offs based on equations derived by Goldberg *et al.* 1991). In the present study, less than 6 % of boys were considered to be 'under-reporters' at both time points. However, 8·3 % of the girls reported implausibly low EI at age 12 years, and this increased to 13·5 % at age 15 years. Possible 'over-reporting' was more common in boys with 19·6 % and 7·2 % of boys, at age 12 and at age 15 years respectively, reporting implausibly high EI. In the girls, 8·3 % and 3·9 % of the cohort (at age 12 years and 15 years respectively) were considered to be 'over-reporters'.

The higher proportion of girls 'under-reporting' at age 15 years could partially explain the low tracking coefficients obtained for % energy from fat and sugars. It has been suggested that adult 'low-energy-reporters' may selectively 'mis-report' specific nutrients or foods. For example, several studies have shown that subjects who were considered to be low-energy-reporters appeared to obtain less energy from fat (Bingham *et al.* 1995; Crawley & Shergill-Bonner, 1995) and sugars (Pryer *et al.* 1995), than those who were not low-energy-reporters. It is possible that older girls, who are more likely to be preoccupied with body image (Crawley & Summerbell, 1997), may be less inclined to accurately report foods higher in fat and sugar, which they perceive to be 'unhealthy'. This would also help to explain the fact that, at the group level, the reported EI in girls did not increase over time, despite increases in height, weight and % body fat. The highest κ values in the present cohort were obtained for EI when expressed relative to body weight (boys κ 0·37, girls κ 0·40). These values, which are approaching moderate tracking, suggest that to some degree, subjects were more inclined to maintain their rank over time for EI per kg body weight than they were for other nutrients. Work by Price *et al.* (1997) has demonstrated that adults who reported a lower EI on one occasion were likely to do so on another occasion. As yet however, there is no substantial evidence for this phenomenon in adolescents and further work is required in this area.

There are several possible explanations for the relatively low κ values obtained for the majority of the nutrients in the present study. First, the data may simply indicate that adolescence is, indeed, associated with rapidly changing, and erratic, patterns of nutrient intake. Teenagers take increasing control of what, when and where they eat and typically consume a greater proportion of their total food outside the home. Furthermore, intense awareness and concern about body shape and appearance often prompt attempts to alter body size via limiting food intake and other techniques. Second, it is possible that the diet history method is not a suitably robust tool for assessing tracking of nutrient intakes in a cohort of this nature. Järvinen *et al.* (1993) have suggested that the reproducibility of the diet history method is acceptable for epidemiological studies in adults, where eating patterns remain relatively stable. However, there are currently few data concerning the reproducibility of any of the routinely used dietary assessment methods in the age group involved in this study. Although the diet history has been shown to provide good validity at the group level in older children and adolescents, it is prone to significant problems of precision at the individual level (Livingstone *et al.* 1992). Moreover, since it measures memory and perception of usual diet and is vulnerable to socially desirable responding (Livingstone & Robson, 2000), it is entirely possible that the degree of memory and motivation required to complete a diet history may change substantially over time, thereby contributing to the apparently poor tracking observed in this study. However, it seems unlikely that any other method would have provided evidence of stronger tracking in this cohort. One alternative, the weighed record, is particularly prone to increasing negative bias with increasing age in adolescents (Livingstone *et al.* 1992). Furthermore, 24 h recalls and food frequency questionnaires have not been subjected to rigorous validity checks in younger age groups. Thus it remains unclear whether they would be any more suitable than the diet history for assessing tracking of nutrient intakes in adolescence.

In general, adolescent diets are perceived to be relatively high in fat and/or sugars and low in vitamins and minerals. At both 12 and 15 years of age, the diets reported by boys and girls were higher in total fat and saturated fat than currently recommended (Department of Health, 1991). However, it is important to note that the median intakes of these nutrients were of a similar magnitude to the mean intakes observed in British adults (Gregory *et al.* 1990), suggesting that diets with apparently 'unfavourable' lipid profiles are not a phenomenon exclusive to adolescents. Moreover, when the vitamin and mineral intakes of the cohort were expressed as nutrient densities and compared with EAR (Department of Health, 1991), also expressed in terms of nutrient densities, there was apparently less cause for concern than is often thought. For most vitamins and minerals, median intakes were in excess of average requirements. However the data do indicate that, although diets became more rich in total folate over time, the median intakes of boys and girls remained lower than the current EAR (Department of Health, 1991). The girls' Fe intakes (mg/MJ) were also lower than the current EAR. Low Fe and folate intakes have previously been reported in Irish girls aged 12 years and 15 years (Hurson & Corish, 1997). However, as these data were expressed in absolute values, direct comparisons with the present study are difficult. It is evident from the analysis of the current data, that provision of absolute intakes of energy and nutrients does not give an informed base with which to judge properly the nutritional quality of adolescent diets. Therefore, it is recommended that future studies in this area should give serious consideration to describing nutrient intake in terms of nutrient density.

Overall, the data presented in the current study suggest that individual dietary patterns reported at 12 years of age are unlikely to be predictive of energy and nutrient intakes reported at age 15 years. However, these observations are based on the assumption that the reported intakes are representative at both time points. Given the apparent lack of tracking of nutrient intakes in this age group, it is clear that individual subjects cannot, and should not, be targeted for dietary intervention, based solely on data obtained at 12 years of age.

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