Tracking of obesity-related behaviours from childhood to adulthood: a systematic review

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ABSTRACT

Obesity in childhood carries a wide range of physical, psychological and social disbenefits and also increases the risk of adult obesity with its well-recognised, enhanced risk of several common complex diseases as well as adverse socioeconomic and psychosocial sequelae. Understanding the tracking of the two key modifiable behaviours, food consumption and physical activity, between childhood and adulthood may illuminate the childhood determinants of adult obesity and contribute to the development of effective interventions.

We performed a systematic review of the available literature on tracking of both physical activity and of dietary intake between childhood and adulthood by searching MEDLINE, EMBASE, CINAHL, PSYCInfo, Google and Google Scholar. For inclusion, studies had to report baseline measurements when the children were less than, or equal to, 18 years and to report follow-up for at least 5 years to any age over 18 years.

After removal of duplicates, 9625 search hits were screened by title and/or abstract and 79 potentially relevant papers were identified and full papers obtained. In total 39 papers were included in this analysis. Of these, 11 papers (from 5 studies) reported data on tracking of diet from childhood to adulthood and 28 papers (from 16 studies) reported data on tracking of physical activity or inactivity.

Despite the diversity of study design and measurement methodology, we found evidence of tracking of both physical activity and of diet between childhood and adulthood with estimates of strength of tracking of a similar order for both behaviours. Because of the inherent methodological difficulties in quantifying habitual behaviour, it is likely that the reported estimates of strength of tracking under-estimate the true degree of tracking. The evidence of tracking reported here may give greater impetus to the development of interventions aimed to prevent the persistence of obesity from childhood into adulthood and its attendant adverse socioeconomic, psychosocial and health sequelae.

1. Introduction

Obesity in childhood carries a wide range of physical, psychological and social disbenefits for the child. In addition, being overweight or obese as a child increases the risk of adult obesity [1] with its well-recognised, enhanced incidence of, and risk of premature death from, several common complex diseases [2]. The adverse consequences of childhood obesity which is sustained into adulthood are much wider than those of physical health, e.g. obese females who were obese as children are less likely to have gainful employment or a current partner [3].

Individual children may be genetically susceptible (or resistant) to the development and persistence of obesity [4] and recent genome-wide association studies (GWAS) have identified several genetic variants which are positively (or negatively) linked with obesity [5]. Obesity results from sustained positive energy balance i.e. when energy intake (from food and drink) exceeds energy expenditure (from basal metabolism and physical activity) over relatively long time periods. As a consequence, attempts have been made to determine whether obesity-related genetic variants influence food intake and/or physical activity. Children carrying the obesity-related A allele, the *FTO* single nucleotide polymorphism (rs99393609), had reduced satiety responsiveness scores [6] and ate significantly more than those carrying the "protective" T allele [7]. However, this *FTO* variant did not appear to be involved in the regulation of energy expenditure in children [8]. As with adiposity, the heritability of voluntary physical activity appears relatively high [9] but a recent GWAS found that the heritability of leisure time exercise behaviour is likely to be accounted for by multiple genetic variants each with small effect sizes [10]. Higher physical activity attenuates the genetic predisposition to obesity [11] and there is evidence that interventions targeting eating behaviour and/or physical activity can be effective in preventing or treating childhood obesity [12, 13].

Understanding the tracking of the two key modifiable behaviours, dietary intake and physical activity, between childhood and adulthood may illuminate the childhood determinants of adult obesity. Such evidence of tracking may inform the development of interventions [14, 15] aimed to prevent the persistence of obesity from childhood into adulthood and its attendant adverse socioeconomic, psychosocial and health sequelae. This paper describes the first systematic review of tracking of both dietary and physical activity behaviours from childhood to adulthood. For this purpose tracking is defined "as a tendency of individuals to maintain their rank or position in a group over time" [16].

2. Methods

This systematic review was conducted according to a pre-defined protocol.

2.1 Inclusion criteria for the review

We searched for cohort studies (prospective, retrospective) or controlled trials with longitudinal follow-up of a cohort from at least one arm of the study. Studies were eligible for inclusion only if they reported male or female participants of any ethnic origin, aged less than or equal to 18 years at baseline and followed up for at least 5 years to any age over 18 years. Participants needed to have at least one measure of diet, physical activity or inactivity measured at baseline and at follow-up and to be living in the community. Eligible participants included those who were healthy, those with diagnosed disease and those with risk factors for disease.

Tracking of any type or component of physical activity, inactivity or diet was eligible for inclusion. For example, sports, physical training, organised physical activity, day to day 'lifestyle' physical activity e.g. walking, cycling or sedentary behaviour e.g. TV watching were included. Tracking of any aspects of diet were included including assessment of the whole diet, dietary patterns and individual dietary components. However studies were only included if tracking was based on a quantitative measure at both baseline and follow-up. For example, studies that reported tracking based on 'membership of a sports club' were not included as membership does not give a clear quantitative measure of how much physical activity occurred. No limitations were applied to the methods of measurement used to assess diet or physical activity/inactivity.

The main outcome was a measure of 'tracking' of diet, physical activity or inactivity from childhood (aged less than 18 years) to adulthood (aged over 18 years). Any parameter used to measure tracking was included. Examples of such parameters include a correlation coefficient, regression coefficient, or a measure of agreement such as Cohen's kappa, and a measure of uncertainty around that coefficient.

2.2 Search methods for identification of studies

The following electronic databases were searched: MEDLINE, EMBASE, CINAHL, PSYCInfo, Google and Google Scholar. A full search strategy combining both MeSH headings and text-words as appropriate was developed for MEDLINE (Appendix) and adapted for each of the other databases as required. A standard filter for finding cohort studies was used for MEDLINE and EMBASE. Studies were limited to those in the English language. The reference lists of all included studies were also hand checked to identify potentially relevant additional studies.

2.3 Identification of included studies and data extraction

The abstract, title or both sections of every record retrieved were screened by one reviewer and all potentially relevant articles were obtained as full text. Two reviewers independently assessed potentially relevant full-text articles for inclusion. Differences between reviewers' results were resolved by discussion or by consultation with a third reviewer. Data were extracted by two reviewers independently. Any differences between reviewers were resolved by discussion or by a third reviewer.

In the case of duplicate publications and companion papers of a primary study, we evaluated all available data. In cases of doubt, the original publication (usually the oldest version) took priority. Data were extracted at all available follow-up time-points in the study to maximise the information available about the tracking profile.

2.4 Data synthesis

As there was considerable heterogeneity of the data in terms of length of follow-up, ages of children/adults in the studies, the statistical methods used and reported measure for tracking, formal statistical pooling of results was not attempted. A descriptive, narrative review of the data and tabulation of key study characteristics and tracking outcomes is presented.

3. Results

MEDLINE, EMBASE and PSYCInfo were searched through Ovid. CINAHL was searched through EBSCO Host. The MEDLINE, EMBASE, PSYCInfo and CINAHL searches found 5953, 7204, 348 and 67 search hits respectively (Figure 1). After importing into Endnote, combining and removal of duplicates, there were 9625 search hits. After screening by title and/or abstract, 79 potentially relevant papers were identified and full papers obtained. After screening the full papers, 40 papers were excluded because they did not meet the inclusion criteria and 1 paper could not be located through international library searches within the timescale of the review. In total 38 papers were included in this analysis. Of these, 11 papers (from 5 studies) reported data on tracking of diet from childhood to adulthood and 27 papers (from 16 studies) reported data on tracking of physical activity or inactivity. Some studies reported data at successive time-points over several different papers, or reported the data in duplicate publications or different tracking analyses in different papers.

Two further potentially relevant papers were found by screening the reference lists of included studies; neither of these was included.

3.1 Study characteristics for physical activity tracking data

The characteristics of the population samples studied, tracking outcomes reported and measures of physical activity utilised in the 27 papers from 16 different cohorts included in this review are described in Table 1. Of these, 6 report duplicate findings from the same cohorts so have not been considered separately in this analysis. However, several papers report results of different analyses within the same cohort (e.g. with different baseline age and/or length of follow-up), so the findings from each analysis have been considered separately.

All studies were published between 1993 and 2011; 10 were European, 3 Canadian, 2 American and one Australian. Most had recruited their participants through schools, the exceptions being two birth cohorts (British and Northern Finnish), the Quebec Family Study, which recruited through the local media, the Cardiovascular Risk in Young Finns study, which recruited randomly through the national population register, and the Canada Fitness Study, which did not report their recruitment methods. All studies were carried out with both males and females, with approximately equal proportions of each, although the results of the Leuven Longitudinal Study are published for males

[17] and females [18] separately. Ages at baseline ranged from 8 to 19 (all mean ages <18 years), with follow-up duration ranging in length from 5 to 55 years.

Outcomes were largely measured by questionnaire, or interview based on a questionnaire, with only one using a 3-day physical activity record [19] and one using an activity diary (baseline only) [20-23]. Methods utilised were generally consistent between baseline and follow-up (i.e. questionnaire used at both time-points), with one exception where a diary was used at baseline and a questionnaire at follow-up. However, the content of the questionnaires often varied between time-points, usually reflecting the age-specific adaptations required, e.g. referring to 'work' rather than 'school'.

Objectively measured activity (by triaxial accelerometer) was reported in one study [17], but it was additional to a self-report questionnaire and had not been measured at baseline. Outcomes were reported inconsistently, the majority referring to all leisure activity, but some only reporting sports participation [17, 18]. Frequently, outcomes were reported as a product of frequency, intensity and duration (in terms of total time spent in moderate to vigorous physical activity, daily energy expenditure or as a physical activity score), although some reported only frequency of activity [24, 25] or intensity [26] at either or both time-points.

3.2 Associations between physical activity levels at baseline and at follow-up

Correlation coefficients and partial correlation coefficients calculated between baseline and follow-up (Table 2) were positive in all cohorts except four from one Canadian study [27] (11 year old males followed up for 7 and 22 years, 11 year old females followed up for 7 years, and 17 year old males followed up for 22 years), and in the females of one British study [24] (11 year olds followed up for 31 years).

In general, the correlation coefficients tended to be stronger in the European studies (ranging from -0.01 to 0.47), compared with Canadian (-0.1 to 0.24), US (0.01 to 0.17) or Australian studies (0.04 to 0.07), but this interpretation is limited by the relatively small number of studies reporting these statistics in the non-European countries, particularly Australia and the United States.

In general, tracking, as assessed by the magnitude of the correlation coefficient or partial correlation coefficient, tended to be stronger for males than for females (Figures 2 and 3), was greater with increasing age at baseline assessment (Figure 2) and became weaker with increasing length of follow-up (Figure 3). In males coefficients varied between -0.1 [27] (non-significant, at 22 year follow-up) and 0.47 [28] ($p<0.001$ for frequency of activity over 8 years). In females these ranged between -0.04 [27] (non-significant over 7 years) and 0.37 [29-32] ($p<0.001$ over 6 years). These between gender differences appeared to reduce with increasing age at baseline (Figure 2), and to mediate the strength of the associations found in those studies which combined their data, correlation coefficients ranging from 0.06 [26] (non-significant over 50 years) to 0.20 [25] ($p<0.05$ over 24 years).

To incorporate all longitudinal data collected rather than comparing activity at only two time-points, the Amsterdam Growth and Health Longitudinal Study (AGAHLS) calculated 'stability coefficients' (possible range 0 to 1) using Generalised Estimating Equations (Table 2). Participants 13 years old at baseline were followed up after 14 years [20-22] and 20 years [23]. The stability coefficient for physical activity over 14 years of 0.34 (95% CI 0.19-0.49) was considered by the authors to be 'low', particularly in comparison with the higher coefficients for energy intake relative to body mass (0.55; 0.45-0.64) and fat mass (0.63; 0.45-0.71). A similar coefficient of 0.35 (no confidence intervals given) was found over 20 years. Data were not provided for males and females separately. Tracking analyses were also reported for activity by intensity at 20 year follow-up. Stability coefficients were 0.26 for light activity (4-7 METs), 0.14 for moderate (7-10 METs) and 0.43 for heavy activity (>10 METs). The significance levels of these coefficients were not reported.

Kappa statistics were reported for 4 cohorts in two studies [28, 33] with baseline ages of 13-16, followed up for a relatively short period of 5-7 years (Table 4). As a guide, K≤0.20 can be considered poor tracking, 0.21-0.40 fair; 0.41-0.60 moderate, 0.61-0.8 good and 0.81-1.0 very good [34]. Kappa statistics were significant, but 'poor' in all four cohorts of males (ranging from 0.14 to 0.38). In females the relationships were even weaker, ranging from 0.02 to 0.18, with only the two stronger associations found to be statistically significant.

Regression analyses were carried out in 4 studies reporting the findings of 5 cohorts with baseline ages between 11-18 years and follow-up lengths of 5 to 18 years (Table 3). Graham et al [35] reported moderate to vigorous physical activity (MVPA) in males and females aged 11-18 years (mean 14.9 years) to be a significant predictor of MVPA both 5 and 10 years later (β=0.20 and 0.11, respectively). As with the correlation analyses, stronger regression coefficients were found for males compared with females in three of the four studies. For example, in the three remaining studies with baseline ages between 15 and 19 years and 11 to 18 years follow-up β values ranged from 0.08 to 0.69 in males and from no association to 0.49 in females [18, 29-32].

3.3 The probability of being physically active at follow-up according to activity at baseline

Four studies reported the probability of being physically active in adulthood using odds ratios [20-22, 29-32, 36, 37] (Table 5). However a comparison of their findings is complicated by the variation in categories utilised in their analyses.

The AGAHLS [20-22] reported general daily physical activity: those in the lowest quartile for daily physical activity at 13 years old were 3.6 times more likely (95% CI 2.4-5.4) to be in the lowest quartile 14 years later than those in the 3 higher quartiles at baseline. The remaining studies reported activity in terms of sports participation. In the Leuven Longitudinal Study on Lifestyle, Fitness and Health [18] those 'less active' at 16 years were 2.0 (95% CI 0.9-4.3) times likely to be 'less active' 24 years later. The Northern Finland 1966 birth cohort (NFBC) [36, 37] and Cardiovascular Risk in Young Finns (CVRYF) [29-32] reported their analyses by gender. The NFBC reported that in males participating in sports daily at 14 years old the odds of being 'inactive', 'active', or 'very active' at 31 years old were 0.57, 3.0 and 4.0 respectively, whereas if they were participating in sports 2-3 times a week the odds reduced to 0.70, 2.0 and 1.7 respectively. The corresponding odds ratios for females were 0.53, 2.4 and 2.8 for daily participation and 0.69, 1.8 and 1.5 for participation 2-3 times per week. In the CVRYF study the odds of males having a 'high' rather than a 'low' level of activity at 30-39 years old was 3.25 (95% CI 1.76, 5.97) if at 9-18 years old they participated in sport-club training sessions once a week, and 5.11 (95% CI 2.88, 9.08) if they participated 'many times' compared with if they participated less than once a week. The corresponding odds ratios for females were 1.64 (95% CI 0.88, 3.06) for 'once a week' and 6.00 (95% CI 2.38, 15.14) for 'many times'.

3.4 Maintenance of relative position – physical activity

Three studies reported the degree to which participants maintained their relative position in the distribution over 6 separate cohorts (Table 6). Over 5-8 years follow up from adolescence between 44% and 59% maintained their tertile position for activity, with higher proportions for males than for females [28, 38, 39]. In the CVRYF study participants, the probability of 9-18 year olds remaining active 6 years later (44% of all participants) was significantly weaker than the probability of remaining sedentary (57% of all participants) (p=0.002) [29-32]. When genders were considered separately, this difference was no longer significant for males (45% vs. 57%), but was significant for females (43% vs. 57%). A similar follow-up of only those who were 18 years old at baseline found significantly higher proportions remaining sedentary (61% males, 60% females) than active (54% males, 57% females) [29-32].

3.5 Study characteristics for dietary tracking data

We found fewer papers reporting tracking of dietary intake than of physical activity behaviour and all were published in 1997-2009. Of the 11 papers considered here (Table 7), 4 were from the Amsterdam Growth and Health Longitudinal Study (AGAHLS), 2 each from the Northern Ireland-based Young Hearts, England-based ASH30 and Cardiovascular Risk in Young Finns (CVRYF) projects and 1 from the European Youth Heart Study. The AGAHLS which started in the 1970s and followed an initial sample of 500 healthy 13-year-old boys and girls from two secondary schools had the greatest number of follow up investigations. During ages 12-17 years, these students had annual measurements of lifestyle characteristics including physical activity and diet. Likewise, the ASH30 study followed up as adults (age 32 years) a group of 405 children initially aged 11–12-year olds in 1980 attending 7 schools in Northumberland, North East England. In contrast, in 1989/1990 the Young Hearts study recruited a random sample of 1015 adolescents (12 and 15 years old boys and girls) from post-primary schools which represented a 2% sample of each of the two age populations in Northern Ireland. For the Swedish part of the European Youth Heart Study, >1000 children (mean age 9 years) were recruited from 42 schools in southern Stockholm and Örebro in 1998-99. Approximately 50% of 3596 children initially aged 3, 6, 9, 12, 15 and 18 years participated in dietary aspects of the multi-centre CVRYF Study.

3.6 Methods of dietary assessment

Retrospective methods of dietary assessment were used in most studies including dietary history methods in the AGAHLS and Young Hearts studies and 24h and 48h recall methods in the European Youth Heart Study and CVRYF studies respectively (Table 7). In contrast, the ASH30 study used a prospective method in which actual dietary intake was recorded for 3d on 2 separate occasions at each age. In the main, the same or similar methodology was used at follow-up as was used at baseline but with some changes due to e.g. "improvements" in methodology such as use of a photographic food atlas instead of food models to estimate portion sizes in the ASH30 study follow up and use of a computer-assisted cross check dietary history interview methodology at age 36 years in the AGAHLS.

3.7 Associations between dietary intake at baseline and at follow-up

Because of our focus on obesity-related behaviours, this analysis has been restricted to consideration of tracking of intakes of foods, food groups and energy yielding macronutrients. We have not considered tracking of micronutrients or of other food constituents. Correlation coefficients and partial correlation coefficients calculated between baseline and follow-up (Table 8) were positive in all cohorts and ranged from a low of r=0.009 for tracking of intake of foods containing fat and/or sugar over a 20 years period in the ASH30 study to 0.66 for tracking of intake of milk and milk products by males over 6 years in the AGAHLS. In the one study only which reported separate values for the sexes (the 6, 12 and 20 year follow ups within the AGAHLS) tracking coefficients tended to be lower for females than for males [40, 41]. Where tracking of macronutrient intakes were reported, correlation coefficients were quite similar for carbohydrate, fat and protein and for total energy intake on a MJ/d basis (approximately 0.35). However, when scaled for body mass (MJ/kg), tracking of energy intake appeared higher (0.52).

Kappa statistics were reported for both the Young Hearts Project and the European Youth Heart Study (Table 9). Using the same criteria for strength of tracking as noted above for physical activity (i.e. K≤0.20 poor tracking, 0.21-0.40 fair; 0.41-0.60 moderate, 0.61-0.8 good and 0.81-1.0 very good [34]) Kappa statistics, although often significant, were 'poor' for almost all dietary components investigated in both studies. The highest Kappa (κ=0.33) was for energy intake from fat (kJ/kg/d) by females in the Young Hearts project [42].

3.8 Using Odds Ratios to report the probability of having dietary intakes which met specific criteria

The AGAHLS used odds ratios (OR) to report the probability of i) having dietary intakes at follow-up which met nationally recommended intakes, ii) remaining in a specific quartile of intake between baseline and follow-up or iii) having intakes consistent with being "at risk" at both baseline and follow-up [22, 43] (Table 10). For males, the OR for meeting national recommended intake of fruit was much higher (6.02) than for females (2.33) as was the OR for remaining in the highest quartile of fruit intake between baseline and follow-up (5.30 and 2.07 for males and females respectively) [43]. Using the "at risk" cut offs of ≤50% and ≥35% of energy from carbohydrate and fat, the AGAHLS reported OR of 3.4 and 2.6 of remaining in the "at risk" category between baseline and follow-up for all study participants [22].

3.9 Maintenance of relative position – dietary intake

In the AGAHLS, the likelihood of remaining in the same quartile of intake of dairy foods was relatively high (Table 11). The percentages of those in the lowest quartiles of intake at baseline who remained in that quartile at 6 years follow-up were 63.2% and 68.4% (for males) and 69.6% and 56.5% (for females) for cheese and milk and milk products respectively. Similarly, the percentages of those in the highest quartiles of intake at baseline who remained in that quartile at 6 years follow-up were 50% and 57.9% (for males) and 50% and 27.3% (for females) for cheese and milk and milk products respectively [40]. After 12 years follow-up, most of these relationships weakened but the percentages remained above 25% (the proportion expected by chance) and in the case of females in the lowest quartile of intake for cheese at baseline, the proportion remaining in this quartile increased to 75% [40]. In the Cardiovascular Risk in Young Finns Study, Mikkila et al (2005) used Principal Components Analysis to derive dietary patterns with "pattern 1" characterised by positive correlations with intakes of rye, potatoes, milk, butter, sausages and coffee but negative correlations with intakes of fruit, berries and other dairy products. For those aged 3-12 years at baseline, the proportions in the lowest and highest quintiles of "pattern 1" as baseline who remained in the same extreme quintiles after 21 years follow-up were 28% and 28% respectively ($p=0{\cdot}045$). For those aged 15-18 years at baseline, the proportions in the lowest and highest quintiles as baseline who remained in the same extreme quintiles after 21 years follow-up were 27% and 41% respectively ($p<0.001$) [44].

4. Discussion

Dietary energy intake and energy expenditure through physical activity are the major modulators of energy balance with positive energy balance sustained over significant time periods being responsible for the deposition of body fat and for the development of obesity. This study aimed to review systematically the evidence for tracking of the two key modifiable behaviours, dietary intake and physical activity, between childhood and adulthood as a contribution to understanding the childhood determinants of adult obesity. There are systematic reviews of the tracking of childhood overweight into adulthood [1] and of the tracking of sedentary behaviours in young people [45] but to our knowledge this is the first systematic review of tracking of both dietary and physical activity behaviours from childhood to adulthood.

We found considerably more studies (27 papers describing 16 cohorts) investigating tracking of physical activity than of dietary intake (11 papers describing 5 cohorts). All but two of the five cohorts which reported dietary tracking (the exceptions were the Swedish component of the European Youth Heart Study and the ASH 30 study) also reported tracking of physical activity. However, despite the fact that tracking of both behaviours was measured in three cohorts, these outcomes were reported separately in most cases and only two out of 38 papers reported tracking of these two important obesity-related behaviours simultaneously. In both cases, the emphasis was on tracking of cardiovascular disease (CVD) risk factors and there is a clear need for further investigation of tracking of these behaviours together in respect of both childhood and adult obesity.

Because the focus of their research was elsewhere e.g. on CVD risk factors, most studies of dietary behaviour reported tracking of dietary patterns e.g. CVRYF study, selected foods or food groups e.g. cheese and other dairy foods in the AGAHLS study or selected nutrients e.g. the Young Hearts project. Only a minority reported tracking of total energy intake [41, 42, 46, 47] which is likely to be of greater direct relevance in understanding the maintenance, or development, of obesity. Likewise, the large majority of reports of tracking of physical activity did not attempt to measure total energy expenditure (the Quebec Family Study was a notable exception) [19]. From the very limited data available it is difficult to gauge whether tracking of total energy expenditure is likely to be stronger or weaker than that of other elements of physical activity. However, as anticipated, the strength of tracking of total energy intake appears to be very similar to that of the major energy-yielding macronutrients.

As might be expected, we found that the strength of tracking of physical activity into adulthood increased with age at which the baseline measurements were made e.g. in later adolescence (Fig. 2). However, the strength of tracking of physical activity declined with duration of follow-up (Fig. 3) so that it is likely that the apparently greater strength of tracking of physical activity with age at which the baseline measurements were made was confounded, at least to some extent, by duration of follow-up. Similar observations have been made in a systematic review of tracking of blood pressure from childhood to adulthood [48].

Studies of tracking of complex behaviours such as food intake or physical activity present measurement challenges which are considerably greater than those required for estimating tracking of phenotypic characteristics such as obesity [1] or blood pressure [48, 49]. For the latter, very well-established, standardised protocols are available and the variable of interest is relatively constant from day-to-day so that single measurements provide a good estimate of the phenotype at that stage in the life-course. In contrast, both physical activity and eating behaviour can be highly variable within and between days for a given individual which presents a challenge in attempts to quantify habitual (or usual) behaviour. Further, several, often quite disparate, approaches to assessment of physical activity and of eating behaviour are in common usage. With larger studies, the assessment method used is often less detailed (to reduce measurement costs and to improve study compliance) and is likely to provide less accurate estimates of a given individual's habitual eating behaviour or physical activity. In addition, it was evident from this review that although authors attempted to use the same measurement tool at follow-up as was used at baseline, this was not always possible. For example, questionnaires used with children had to be modified for use with adults or advances in development of measurement tools meant that a modified tool was used at follow-up. Given these methodological issues, it is perhaps surprising that the estimates of tracking of these behaviours between childhood and adulthood are as strong as are observed here. Indeed it is likely that the reported tracking estimates under-estimate the true degree of tracking.

4.1 Conclusions

To our knowledge this is the first systematic review of tracking of both dietary and physical activity behaviours (the two major determinants of energy balance and hence obesity risk) from childhood to adulthood. Despite the diversity of study design and measurement methodology, this systematic review found evidence of tracking of both physical activity and of diet between childhood and adulthood. Estimates of strength of tracking were of a similar order for both behaviours. Although relatively modest in some cases, because of the inherent methodological difficulties in quantifying habitual behaviour, it is likely that the reported estimates of strength of tracking under-estimate the true degree of tracking. Both food choice and physical activity are modifiable behaviours and changing those towards more healthful behaviours in childhood may lead to more healthful adult behaviours and so to reduced risk of obesity and to obesity-related disease. The evidence of tracking reported here may give greater impetus to the development of interventions [14, 15] aimed to prevent the development of obesity in childhood and the subsequent persistence of obesity from childhood into adulthood and its attendant adverse socioeconomic, psychosocial and health sequelae.

Ethical approval

Ethical approval was not required as this was a secondary data analysis.

Contributors

SAK, AJA and JCM developed the search strategy and undertook study selection. SAK, AMC and AAL extracted data. All authors contributed to drafting of the manuscript.

Competing interest

None of the authors has any financial or personal conflict of interest to disclose.

Provenance

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References

[1] Singh AS, Mulder, C, Twisk, JWR, van Mechelen, W, and Chinapaw, MJM, Tracking of childhood overweight into adulthood: a systematic review of the literature. Obesity Reviews 2008; 9: 474-488.

[2] Prospective Studies Collaboration, Body-mass index and cause-specific mortality in 900 000 adults: collaborative analyses of 57 prospective studies. Lancet 2009; 373: 1083-1096.

[3] Viner RM, and Cole, TJ, Adult socioeconomic, educational, social, and psychological outcomes of childhood obesity: a national birth cohort study. British Medical Journal 2005; 330: 1354-1357.

[4] Bouchard C, Childhood obesity: are genetic differences involved? American Journal of Clinical Nutrition 2009; 89: S1494-S1501.

[5] Willer CJ, Speliotes, EK, Loos, RJF, Li, S, Lindgren, CM, Heid, IM, Berndt, SI, Elliott, AL, Jackson, AU, Lamina, C, Lettre, G, Lim, N, Lyon, HN, McCarroll, SA, Papadakis, K, Qi, L, Randall, JC, Roccasecca, RM, Sanna, S, Scheet, P, Weedon, MN, Wheeler, E, Zhao, JH, Jacobs, LC, Prokopenko, I, Soranzo, N, Tanaka, T, Timpson, NJ, Almgren, P, Bennett, A, Bergman, RN, Bingham, SA, Bonnycastle, LL, Brown, M, Burtt, NLP, Chines, P, Coin, L, Collins, FS, Connell, JM, Cooper, C, Smith, GD, Dennison, EM, Deodhar, P, Elliott, P, Erdos, MR, Estrada, K, Evans, DM, Gianniny, L, Gieger, C, Gillson, CJ, Guiducci, C, Hackett, R, Hadley, D, Hall, AS, Havulinna, AS, Hebebrand, J, Hofman, A, Isomaa, B, Jacobs, KB, Johnson, T, Jousilahti, P, Jovanovic, Z, Khaw, K-T, Kraft, P, Kuokkanen, M, Kuusisto, J, Laitinen, J, Lakatta, EG, Luan, Ja, Luben, RN, Mangino, M, McArdle, WL, Meitinger, T, Mulas, A, Munroe, PB, Narisu, N, Ness, AR, Northstone, K, O'Rahilly, S, Purmann, C, Rees, MG, Ridderstrale, M, Ring, SM, Rivadeneira, F, Ruokonen, A, Sandhu, MS, Saramies, J, Scott, LJ, Scuteri, A, Silander, K, Sims, MA, Song, K, Stephens, J, Stevens, S, Stringham, HM, Tung, YCL, Valle, TT, Van Duijn, CM, Vimaleswaran, KS, Vollenweider, P, et al., Six new loci associated with body mass index highlight a neuronal influence on body weight regulation. Nature Genetics 2009; 41: 25-34.

[6] Wardle J, Carnell, S, Haworth, CMA, Farooqi, IS, O'Rahilly, S, and Plomin, R, Obesity associated genetic variation in FTO is associated with diminished satiety. Journal of Clinical Endocrinology & Metabolism 2008; 93: 3640-3643.

[7] Wardle J, Llewellyn, C, Sanderson, S, and Plomin, R, The FTO gene and measured food intake in children. International Journal of Obesity 2009; 33: 42-45.

[8] Cecil JE, Tavendale, R, Watt, P, Hetherington, MM, and Palmer, CNA, An Obesity-Associated FTO Gene Variant and Increased Energy Intake in Children. New England Journal of Medicine 2008; 359: 2558-2566.

[9] Stubbe JH, Boomsma, DI, Vink, JM, Cornes, BK, Martin, NG, Skytthe, A, Kyvik, KO, Rose, RJ, Kujala, UM, Kaprio, J, Harris, JR, Pedersen, NL, Hunkin, J, Spector, TD, and de Geus, EJC, Genetic Influences on Exercise Participation in 37.051 Twin Pairs from Seven Countries. Plos One 2006; 1.

[10] De Moor MHM, Liu, Y-J, Boomsma, DI, Li, J, Hamilton, JJ, Hottenga, J-J, Levy, S, Liu, X-G, Pei, Y-F, Posthuma, D, Recker, RR, Sullivan, PF, Wang, L, Willemsen, G, Yan, H, De Geus, EJC, and Deng, H-W, Genome-Wide Association Study of Exercise Behavior in Dutch and American Adults. Medicine and Science in Sports and Exercise 2009; 41: 1887-1895.

[11] Li S, Zhao, JH, Luan, Ja, Ekelund, U, Luben, RN, Khaw, K-T, Wareham, NJ, and Loos, RJF, Physical Activity Attenuates the Genetic Predisposition to Obesity in 20,000 Men and Women from EPIC-Norfolk Prospective Population Study. Plos Medicine 2010; 7.

[12] Gonzalez-Suarez C, Worley, A, Grimmer-Somers, K, and Dones, V, School-Based Interventions on Childhood Obesity A Meta-Analysis. American Journal of Preventive Medicine 2009; 37: 418-427.

[13] Hesketh KD, and Campbell, KJ, Interventions to Prevent Obesity in 0-5 Year Olds: An Updated Systematic Review of the Literature. Obesity 2010; 18: S27-S35.

[14] Brown T, and Summerbell, C, Systematic review of school-based interventions that focus on changing dietary intake and physical activity levels to prevent childhood obesity: an update to the obesity guidance produced by the National Institute for Health and Clinical Excellence. Obesity Reviews 2009; 10: 110-141.

[15] Summerbell CD, Waters, E, Edmunds, LD, Kelly, S, Brown, T, and Campbell, KJ, Interventions for preventing obesity in children. Cochrane database of systematic reviews (Online) 2005; CD001871.

[16] Telama R, Tracking of physical activity from childhood to adulthood: A review. Obesity Facts 2009; 2 (3): 187-195.

[17] Beunen GP, Lefevre, J, Philippaerts, RM, Delvaux, K, Thomis, M, Claessens, AL, Vanreusel, B, Lysens, R, Vanden Eynde, B, and Renson, R, Adolescent correlates of adult physical activity: a 26-year follow-up. Medicine & Science in Sports & Exercise 2004; 36: 1930-6.

[18] Matton L, Thomis, M, Wijndaele, K, Duvigneaud, N, Beunen, G, Claessens, AL, Vanreusel, B, Philippaerts, R, and Lefevre, J, Tracking of physical fitness and physical activity from youth to adulthood in females. Medicine & Science in Sports & Exercise 2006; 38: 1114-20.

[19] Campbell PT, Katzmarzyk, PT, Malina, RM, Rao, DC, Perusse, L, and Bouchard, C, Prediction of physical activity and physical work capacity (PWC150) in young adulthood from childhood and adolescence with consideration of parental measures. American Journal of Human Biology 2001; 13: 190-6.

[20] Kemper HC, Post, GB, Twisk, JW, and van Mechelen, W, Lifestyle and obesity in adolescence and young adulthood: results from the Amsterdam Growth And Health Longitudinal Study (AGAHLS). International Journal of Obesity & Related Metabolic Disorders: Journal of the International Association for the Study of Obesity 1999; 23 Suppl 3: S34-40.

[21] Twisk JW, Kemper, HC, and van Mechelen, W, Tracking of activity and fitness and the relationship with cardiovascular disease risk factors. Medicine & Science in Sports & Exercise 2000; 32: 1455-61.

[22] Twisk JW, Kemper, HC, van Mechelen, W, and Post, GB, Tracking of risk factors for coronary heart disease over a 14-year period: a comparison between lifestyle and biologic risk factors with data from the Amsterdam Growth and Health Study. American Journal of Epidemiology 1997; 145: 888-98.

[23] Kemper HC, de Vente, W, van Mechelen, W, and Twisk, JW, Adolescent motor skill and performance: is physical activity in adolescence related to adult physical fitness? American Journal of Human Biology 2001; 13: 180-9.

[24] Parsons TJ, Power, C, and Manor, O, Longitudinal physical activity and diet patterns in the 1958 British Birth Cohort. Medicine & Science in Sports & Exercise 2006; 38: 547-54.

[25] Trudeau F, Laurencelle, L, and Shephard, RJ, Tracking of physical activity from childhood to adulthood. Medicine & Science in Sports & Exercise 2004; 36: 1937-43.

[26] Friedman HS, Martin, LR, Tucker, JS, Criqui, MH, Kern, ML, and Reynolds, CA, Stability of physical activity across the lifespan. Journal of Health Psychology 2008; 13: 1092-104.

[27] Herman KM, Craig, CL, Gauvin, L, and Katzmarzyk, PT, Tracking of obesity and physical activity from childhood to adulthood: the Physical Activity Longitudinal Study. International Journal of Pediatric Obesity 2009; 4: 281-8.

[28] Anderssen N, Wold, B, and Torsheim, T, Tracking of physical activity in adolescence. Research Quarterly for Exercise & Sport 2005; 76: 119-29.
[29] Raitakari OT, Porkka, KV, Taimela, S, Telama, R, Rasanen, L, and Viikari, JS, Effects of persistent physical activity and inactivity on coronary risk factors in children and young adults. The Cardiovascular Risk in Young Finns Study. American Journal of Epidemiology 1994; 140: 195-205.
[30] Telama R, Leskinen, E, and Yang, X, Stability of habitual physical activity and sport participation: a longitudinal tracking study. Scandinavian Journal of Medicine & Science in Sports 1996; 6: 371-8.
[31] Telama R, Yang, X, Hirvensalo, M, and Raitakari, O, Participation in organized youth sport as a predictor of adult physical activity: A 21-year longitudinal study. Pediatric Exercise Science 2006; 18 (1): 76-88.
[32] Telama R, Yang, X, Viikari, J, Valimaki, I, Wanne, O, and Raitakari, O, Physical activity from childhood to adulthood: a 21-year tracking study. American Journal of Preventive Medicine 2005; 28: 267-73.
[33] Boreham C, Robson, P, Gallagher, A, Cran, G, Savage, JM, and Murray, L, Tracking of physical activity, fitness, body composition and diet from adolescence to young adulthood: The Young Hearts Project, Northern Ireland. International Journal of Behavioral Nutrition and Physical Activity 2004; 1: 14.
[34] Altman DG, Practical studies for medical research, Chapman and Hall, London, 1991.
[35] Graham DJ, Sirard, JR, and Neumark-Sztainer, D, Adolescents' attitudes toward sports, exercise, and fitness predict physical activity 5 and 10 years later. Preventive Medicine: An International Journal Devoted to Practice and Theory 2011; 52: 130-132.
[36] Tammelin T, Nayha, S, Hills, AP, and Jarvelin, MR, Adolescent participation in sports and adult physical activity. American Journal of Preventive Medicine 2003; 24: 22-8.
[37] Tammelin T, Nayha, S, Laitinen, J, Rintamaki, H, and Jarvelin, MR, Physical activity and social status in adolescence as predictors of physical inactivity in adulthood. Preventive Medicine 2003; 37: 375-81.
[38] Andersen LB, Tracking of risk factors for coronary heart disease from adolescence to young adulthood with special emphasis on physical activity and fitness. A longitudinal study. Danish Medical Bulletin 1996; 43: 407-18.
[39] Andersen LB, and Haraldsdottir, J, Tracking of cardiovascular disease risk factors including maximal oxygen uptake and physical activity from late teenage to adulthood. An 8-year follow-up study. Journal of Internal Medicine 1993; 234: 309-15.
[40] Welten DC, Kemper, HCG, Post, GB, Van Staveren, WA, and Twisk, JWR, Longitudinal development and tracking of calcium and dairy intake from teenager to adult. European Journal of Clinical Nutrition 1997; 51 (9): 612-618.
[41] Bertheke Post G, de Vente, W, Kemper, HC, and Twisk, JW, Longitudinal trends in and tracking of energy and nutrient intake over 20 years in a Dutch cohort of men and women between 13 and 33 years of age: The Amsterdam growth and health longitudinal study. British Journal of Nutrition 2001; 85: 375-85.
[42] Gallagher AM, Robson, PJ, Livingstone, MBE, Cran, GW, Strain, JJ, Murray, LJ, Savage, JM, and Boreham, CAG, Tracking of energy and nutrient intakes from adolescence to young adulthood: the experiences of the Young Hearts Project, Northern Ireland. Public Health Nutrition 2006; 9: 1027-34.
[43] te Velde SJ, Twisk, JWR, and Brug, J, Tracking of fruit and vegetable consumption from adolescence into adulthood and its longitudinal association with overweight. British Journal of Nutrition 2007; 98 (2): 431-438.
[44] Mikkila V, Rasanen, L, Raitakari, OT, Pietinen, P, and Viikari, J, Consistent dietary patterns identified from childhood to adulthood: the cardiovascular risk in Young Finns Study. British Journal of Nutrition 2005; 93: 923-31.

[45] Biddle SJH, Pearson, N, Ross, GM, and Braithwaite, R, Tracking of sedentary behaviours of young people: a systematic review. Preventive Medicine 2010; 51: 345-51.
[46] Mikkila V, Rasanen, L, Raitakari, OT, Pietinen, P, and Viikari, J, Longitudinal changes in diet from childhood into adulthood with respect to risk of cardiovascular diseases: The Cardiovascular Risk in Young Finns Study. European Journal of Clinical Nutrition 2004; 58: 1038-45.
[47] Patterson E, Warnberg, J, Kearney, J, and Sjostrom, M, The tracking of dietary intakes of children and adolescents in Sweden over six years: the European Youth Heart Study. International Journal of Behavioral Nutrition and Physical Activity 2009; 6: 91.
[48] Chen X, and Wang, Y, Tracking of Blood Pressure From Childhood to Adulthood. Circulation 2008; 117: 3171-3180.
[49] Chen X, Wang, Y, Appel, LJ, and Mi, J, Impacts of Measurement Protocols on Blood Pressure Tracking From Childhood Into Adulthood. Hypertension 2008; 51: 642-649.
[50] Cleland VJ, Ball, K, Magnussen, C, Dwyer, T, and Venn, A, Socioeconomic position and the tracking of physical activity and cardiorespiratory fitness from childhood to adulthood. American Journal of Epidemiology 2009; 170: 1069-77.
[51] Hasselstrom H, Hansen, SE, Froberg, K, and Andersen, LB, Physical fitness and physical activity during adolescence as predictors of cardiovascular disease risk in young adulthood. Danish Youth and Sports Study. An eight-year follow-up study. International Journal of Sports Medicine 2002; 23 Suppl 1: S27-31.
[52] Raitakan OT, Porkka, KV, Taimela, S, Telama, R, Rasanen, L, and Viikari, JS, Effects of persistent physical activity and inactivity on coronary risk factors in children and young adults. The Cardiovascular Risk in Young Finns Study. American Journal of Epidemiology 1994; 140: 195-205.
[53] Kjonniksen L, Torsheim, T, and Wold, B, Tracking of leisure-time physical activity during adolescence and young adulthood: A 10-year longitudinal study. International Journal of Behavioral Nutrition and Physical Activity 2008; 5.
[54] Barnekow-Bergkvist M, Hedberg, G, Janlert, U, and Jansson, E, Prediction of physical fitness and physical activity level in adulthood by physical performance and physical activity in adolescence--an 18-year follow-up study. Scandinavian Journal of Medicine & Science in Sports 1998; 8: 299-308.
[55] Glenmark B, Hedberg, G, and Jansson, E, Prediction of physical activity level in adulthood by physical characteristics, physical performance and physical activity in adolescence: an 11-year follow-up study. European Journal of Applied Physiology & Occupational Physiology 1994; 69: 530-8.
[56] Lake AA, Mathers, JC, Rugg-Gunn, AJ, and Adamson, AJ, Longitudinal change in food habits between adolescence (11-12 years) and adulthood (32-33 years): the ASH30 Study. Journal of Public Health 2006; 28: 10-6.
[57] Lake AA, Adamson, AJ, Craigie, AM, Rugg-Gunn, AJ, and Mathers, JC, Tracking of dietary intake and factors associated with dietary change from early adolescence to adulthood: the ASH30 study. Obesity Facts 2009; 2: 157-65.

Appendix 1 MEDLINE search strategy

1. track$.ab,ti.

2. traject$.ti.

3. (intercorrelation$ or inter-correlation$).ti.

4. predict$.ti.

5. stability.ti.

6. (relat$ adj3 position).ab,ti.

7. progression.ti.

8. longitudinal.ti.

9. (follow up or follow-up).ti.

10. ((early-life or early life) adj3 determinant$).ab,ti.

11. interval$.ti.

12. maintenance.ti.

13. repeat$ observation$.ab,ti.

14. childhood.ti.

15. exp Cohort Studies/

16. cohort$.tw.

17. controlled clinical trial.pt.

18. *Epidemiologic Methods/

19. prospective.ab,ti.

20. longitudinal.ab,ti.

21. retrospective.ab,ti.

22. historical.ab,ti.

23. Exercise/

24. Physical Exertion/

25. Physical Fitness/

26. Life Style/

27. Sports/

28. Leisure Activities/

29. Sedentary Lifestyle/

30. (physical adj3 (activity or inactivity or training or exercise or resistance or fitness)).ab,ti.

31. sport$.ab,ti.

32. lifestyle$.ab,ti.

33. walking.ab,ti.

34. cycling.ab,ti.

35. running.ab,ti.

36. jogging.ab,ti.

37. gym$.ab,ti.

38. Recreation/

39. recreation$.ab,ti.

40. leisure$.ab,ti.

41. sedentary.ab,ti.

42. television.ab,ti.

43. TV.ab,ti.

44. inactivity.ab,ti.

45. *Diet/

46. Energy Intake/

47. Eating/

48. Food Habits/

49. Nutrition Surveys/

50. Diet Records/

51. Dietary Fats/ad [Administration & Dosage]

52. Dietary Carbohydrates/ad [Administration & Dosage]

53. Micronutrients/ad [Administration & Dosage]

54. Dietary Proteins/ad [Administration & Dosage]

55. saturated fat$.ab,ti.

56. nutrient intake$.ab,ti.

57. or/1-14

58. or/15-22

59. or/23-44

60. or/45-56

61. 59 or 60

62. 57 and 58 and 61

63. limit 62 to (abstracts and animals)

64. 62 not 63

65. limit 64 to english language

Figure legends

Figure 1: Papers identified during the literature search

Figure 2: Tracking correlation coefficients and partial correlation coefficients according to age at baseline and gender

Figure 3: Tracking correlation coefficients and partial correlation coefficients according to length of follow-up and gender

Table 1: Characteristics of the physical activity tracking studies used in the review

Authors	Country	Study name	Description of population	No. and gender	Baseline age (years)	Follow-up time points (yrs)	Baseline methods	Follow-up methods	Tracking outcomes reported
Cleland 2009 [50]	Australia	Australian Schools Health and Fitness Survey/Childhood Determinants of Adult Health Survey	A representative sample of Australian youth aged 7-15 at baseline, from government, Catholic and independent schools.	n=2185: 52% M, 48% F	9-15 years	19.6 years (SD 0.6) at 26-36 years. Mean age at follow-up was 31.9 years (SD 2.1 years).	Questionnaire: Self-report of past weeks duration and frequency of active commuting to and from school, school PE and sport, non-organised PA outside school.	Questionnaire: Self-report of the International PA questionnaire.	Age adjusted physical activity
Beunen 2004 [17]	Belgium	Leuven Longitudinal Study on Lifestyle, Fitness and Health (Leuven Growth Study of Belgian Boys)	Representative sample of Belgian boys from secondary schools between the first and sixth grades.	n=166: 100% M	13-18 years (only data from age 14 used)	26 years (age 40 at follow up)	Questionnaire on sports participation: Sports activities in structured (private or sport school club) and nonstructured (with friends, family or alone) were recorded. PA used was time spent in sports activities (min/wk).	Baecke questionnaire and triaxial accelerometry (Tracmor).	Sports participation: Calculated at 40y from a combination of intensity, amount of time per week, and the proportion of the year in which the sports were played (‘Sport Index’), and at adolescence ‘Sports participation’, i.e. time spent playing sport.

Authors	Country	Study name	Description of population	No. and gender	Baseline age (years)	Follow-up time points (yrs)	Baseline methods	Follow-up methods	Tracking outcomes reported
Matton 2006 [18]	Belgium	Leuven Longitudinal Study on Lifestyle, Fitness and Health (Leuven Growth Study of Belgian Boys)	Representative sample of Belgian girls from secondary schools between 14-18 years of age.	n=138: 100% F	14-18 years Mean age 16.6 years (SD 1.1)	24 years Age 37-43 years at follow up (Mean age 40.5 ± 1.1 yr)	Questionnaire: sports participation over previous 1 year including PA at school as well as leisure-time sports participation. Completed by parent and cross-checked during interview with each girl.	Questionnaire: Asked to select their 3 most important sports from a list of 196 sports and asked to report frequency and duration.	Global average sports participation per week (h/wk) at each time-point. Activity levels (according to sports participation) categorised and maintenance of relative position (e.g. 'active' or 'less active') reported.
Campbell 2001 [19]	Canada	Quebec Family Study	Males and female participants of Quebec Family Study recruited through local media.	n=145: 50.3%M, 49.7%F	8 to 18 years (mean age 13.5)	12 (95% CI 11.6-12.2) years. Mean age at follow-up 25 years.	3 day activity record	As baseline	Daily energy expenditure (DEE). Time spent in moderate to vigorous PA (MVPA). Time spent in inactivity.
Herman 2009 [27]	Canada	Physical Activity Longitudinal Study. (Participants from the Canada Fitness Survey)	Canadian participants in Canada Fitness survey	n=275: 53.1% M, 46.9% F	7-18 years (PA only assessed at 10 years+)	7 years and 22 years (to age 17-25 in 1988 and 32-41 in 2002-2004)	Questionnaire: Self-report, using an adaptation of the Minnesota Leisure Time Physical Activity Questionnaire.	As baseline	Leisure time PA energy expenditure

Authors	Country	Study name	Description of population	No. and gender	Baseline age (years)	Follow-up time points (yrs)	Baseline methods	Follow-up methods	Tracking outcomes reported
Trudeau 2004 [25]	Canada (Quebec)	Trois Rivieres growth and Developmen t Study	Previously involved in a PA intervention study ('enhanced' 5h/wk PA taught by a PE specialist vs 'control' 40 min/wk taught by their normal teacher). Baseline PA for the tracking study was measured at the end of the experimental phase.	n=166: 47.8% M, 52.4% F	10-12	24 years. Mean age at follow-up 34.9 +/- 1.1 years.	Diaries (completed by teachers and students for overall PA) + observation (by research team) for type, intensity and duration.	Questionnaire of PA frequency	Correlation between the frequency of PA as an adult and the times spent during childhood in total PA, intense PA, organised PA, light organised and nonorganised PA.
Andersen and Haraldottir 1993 [39], Andersen 1996 [38]	Denmark	Danish Youth and Sports Study	Randomly selected sample of schoolchildren, 15-19 years from all parts of Denmark	n=202: 43.3% M, 56.7% F	15 to 19 (Mean age 17.1 ± 1.0 years)	8 years	Questionnaire: Leisure PA - type and quantity of organised sports activities in clubs, other leisure sports activity and sports participation at the schools. Also distance of transportation by walking or cycling to school.	As baseline plus PA at work.	Physical activity h/wk reported as sports activities and daily life activities. Correlation, plus maintenance of non-participation in leisure-time sport activities.

Authors	Country	Study name	Description of population	No. and gender	Baseline age (years)	Follow-up time points (yrs)	Baseline methods	Follow-up methods	Tracking outcomes reported
Hasselstrom 2002 [51] (as Andersen 1993 [39]/1996 [38] but different data)	Denmark	Danish Youth and Sports Study	As Andersen and Haraldottir, 1993; Anderson, 1996	n=201 43.3% M, 56.7% F	15 to 19 (Mean age 17.1 ± 1.0 years)	8 years	As Andersen and Haraldottir, 1993; Anderson, 1996	As Andersen and Haraldottir, 1993; Anderson, 1996	Physical activity h/wk reported as sports activities and daily life activities (including PE lessons at school). Age-adjusted associations between PA at baseline and follow-up.
Raitakari 1994 [52], Telama 1996 [30], Telama 2005 [32], Telama 2006 [31] (Data is from same study but at different timepoints)	Finland	Cardiovascular Risk in Young Finns Study	Representative sample of Finnish children and young adults	n=1563: 47% M, 53% F (at baseline)	3, 6, 9,12,15,18	3,6,9,12,21 years	Questionnaire: leisure time PA, intensity, duration and frequency	Questionnaire: PA frequency and intensity, vigorous PA frequency and duration, and participation in organised PA	PA index - product of intensity, frequency and the duration of leisure-time physical activity. Probability of remaining active or sedentary during follow-up by remaining within cut-offs for higher and lower PA. Odds ratios for ‘high’ versus ‘low ‘level of PA in adulthood by sport activity in youth and for ‘being active’ according to participation in sports competitions in 1980.

Authors	Country	Study name	Description of population	No. and gender	Baseline age (years)	Follow-up time points (yrs)	Baseline methods	Follow-up methods	Tracking outcomes reported
Tammelin 2003a [36]	Finland	Northern Finland 1966 birth cohort	1966 birth cohort from the two most northern provinces in Finland.	n=7794: 47.0% M, 53.0 % F	14	17 years (Age 31 at follow-up)	Questionnaire: Frequency of participation in sports after school hours, membership at a sports club outside school, grade in school sports.	Questionnaire: Frequency and duration of light and brisk activities. Classified as 'very active', 'active', 'moderately active' and 'inactive'.	Odds ratios for being 'active' or 'very active' vs 'inactive' at age 31, according to frequency of participation in sports after school hours at age 14 years.
Tammelin 2003b [37]	Finland	Northern Finland 1966 birth cohort	1966 birth cohort from the two most northern provinces in Finland.	n=7794: 47.0% M, 53.0 % F	14	17 years (Age 31 at follow-up)	As Tammelin 2003a	As Tammelin 2003a	Odds ratios for being inactive at age 31, according to frequency of participation in sports after school hours at age 14 years.
Boreham 2004 [33]	Northern Ireland	Young Hearts project	Adolescent boys and girls randomly selected from post-primary schools	n=265: 51.6% M, 48.4% F	15 years	7 years Followed up to age 22 (SD 1.6 y)	Questionnaire: Self-report about extent of activities based around a typical school day. Scored according to frequency, intensity and duration	Questionnaire: modification of the Baecke questionnaire to assess work, sport and non-sports leisure activity. Activity score calculated.	'Physical activity score' A ranking method was employed for tracking of variables because PA was assessed differently at baseline and follow-up.

Authors	Country	Study name	Description of population	No. and gender	Baseline age (years)	Follow-up time points (yrs)	Baseline methods	Follow-up methods	Tracking outcomes reported
Anderssen et al 2005 [28]	Norway	Norwegian Longitudinal Health behaviour Study	A representative sample of 7th grade students from 22 schools (mean age 13.3 years, SD 0.3) in Western Norway. The schools were systematically drawn from an alphabetical list of schools in the region (every 5th school).	n=557: 47% M, 53% F	13, 16	5,6,8 years	Questionnaire: self-reported frequency and time spent in activities that caused one to sweat or lose one's breath	As baseline	Frequency of and hours per week spent in activities that caused one to sweat or lose one's breath. Correlations, Cohen's kappa and percentage of agreement across time points assessed.
Kjonniksen 2008 [53]	Norway	Norwegian Longitudinal Health behaviour Study	Students from 22 schools (54 classes) which were randomly selected by taking every 5th school from an alphabetic list of schools in Hordaland county in western Norway.	n=630: Approx 55% M, 45% F	13 (mean age 13.3)	10 years Followed up to age 23	Questionnaire: self-reported Global leisure time physical activity, outdoor recreational activity and frequency of participation in a list of 31 activities	As baseline	Tracking of specific types of sport e.g. jogging, cycling, skiing, hiking and ball games. Global leisure time PA. Outdoor recreational PA

Authors	Country	Study name	Description of population	No. and gender	Baseline age (years)	Follow-up time points (yrs)	Baseline methods	Follow-up methods	Tracking outcomes reported
Barnekow-Bergkvist 1998 [54]	Sweden		Randomly selected group of male and female students in their first year of upper secondary school. Schools from 6 geographic areas of Sweden were included.	n=278: 56.5% M, 43.5% F	16.1 (SD 0.33)	18 years (Aged 33.7 (SD 0.74) at follow-up.)	Questionnaire: leisure time sports activity, number of sports activities and membership of sports clubs	Questionnaire: leisure time activity, sports activities, walking / cycling to work.	Participation in leisure-time PA (MET-hours/wk)
Glenmark 1994 [55]	Sweden		A random sample of boys and girls all aged 16 years in their first year of upper secondary school	n=105: 59.0% M, 41.0% F	16	11 years (Age 27 at follow up)	Questionnaire: self-reported frequency and duration of leisure PA, membership of a sports club, attitudes to PA and self-estimated degree of PA.	As baseline	'Activity index' based on frequency and duration of physical exercise during their leisure time, membership of sports clubs and their attitude to PA.
Kemper 2001 [23] (20 yr follow-up data)	The Netherlands	Amsterdam Growth and Health Longitudinal Study	As Twisk 1997/2000/Kemper 1999	n=365 44.9% M, 55.1% F	13	20 years (Age 33 at follow-up)	As Twisk 1997/2000/Kemper 1999	As Twisk 1997/2000/Kemper 1999	As Twisk 1997/2000/Kemper 1999

Authors	Country	Study name	Description of population	No. and gender	Baseline age (years)	Follow-up time points (yrs)	Baseline methods	Follow-up methods	Tracking outcomes reported
Twisk 1997 [22], Twisk 2000 [21], Kemper 1999 [20](repeat same 14 year follow-up data)	The Netherlands	Amsterdam Growth and Health Longitudinal Study	Participants were from the first and second forms from one secondary school in Amsterdam. Socioeconomic level of the pupils was slightly above average for Dutch families in general.	n=365: 45.8% M, 54.2% F	13	14 years (Age 27 at follow-up)	Standardised interview based on questionnaire: Past 3 months organised sports activities (e.g. training, matches), unorganised activities, active transportation (e.g. cycling, walking), and activities at home, school and work.	As baseline	Reported as 'total weighted metabolic PA – light / moderate / heavy' and 'total weighted mechanic PA'
Parsons 2006 [24]	UK	1958 British Birth Cohort	Children born in England, Scotland and Wales in March 1958.	n=4084-5252: Not reported (approx 50% M, 50% F)	11 (other ages but PA tracking data only relevant for age 11 to 42)	22, 31 years (Age 33 and 42 at follow up)	Questionnaire: completed by mother and child on use of parks, recreation grounds, swimming pools, play centers; the child was asked how often he or she played outdoor sport or took part in sport outside school hours.	Questionnaire: single question about frequency of PA activities from a list.	Frequency of leisure PA

Authors	Country	Study name	Description of population	No. and gender	Baseline age (years)	Follow-up time points (yrs)	Baseline methods	Follow-up methods	Tracking outcomes reported
Friedman 2008 [26]	US	Participants from Terman Life-Cycle Study	'Bright, mostly middle class, mostly white boys and girls who were nominated by their teachers as 'gifted'and who were tested to have an IQ of at least 135'.	n=646-1036: 56.6% M, 43.4% F	'School age' 8-18, (mean 11y) in 1922	14, 18, 28, 38, 48, 55 years. (until 1977)	Parental list of 'hobbies and enterprises' – first 3 recorded and coded. Activity intensity score calculated.	Participant list of 'avocational activities and hobbies in recent years' - first 4 recorded and coded. In 1977 self-reported 'level of participation in various activities.' Activity intensity score calculated.	'Activity' and 'activity intensity'
Graham et al 2011 [35]	US	Project Eating and Activity in Teens	Middle and high school students recruited from schools with diverse populations.	n=1902: 43.1% M, 56.9% F	11-18 years. Mean age 14.9 (SD 1.6)	5, 10 years	Questionnaire: Self-reported modified Leisure Time Exercise Questionnaire	As baseline	Moderate to vigorous PA (MVPA)

Table 2: Longitudinal physical activity correlations

Authors	Study name	Age at baseline (years)	No. years follow-up	Correlation coefficient - all	Correlation coefficient - males	Correlation coefficient - females	Notes
Beunen 2004 [17]	Leuven Longitudinal Study on Lifestyle, Fitness and Health	18	22		0.22*		Sports Participation at 18y vs Sport Index at 40y
		18	22		0.15		Sports Participation at 18y vs accelerometry at 40y
		16	24		0.19*		Sports participation at 16y vs accelerometry at 40y
Matton 2006 [18]	Leuven Longitudinal Study on Lifestyle, Fitness and Health	16 (+/- 1)	24			0.13	Sports participation
Herman 2009 [27]	Physical Activity Longitudinal Study	10-12	7		-0.03	-0.04	
		10-12	22		-0.1	0.1	
		13-15	7		0.16	0.02	
		13-15	22		0.18	0.07	
		16-18	7		0.14	0.24*	
		16-18	22		-0.1	0.14	

Authors	**Study name**	**Age at baseline (years)**	**No. years follow-up**	**Correlation coefficient - all**	**Correlation coefficient - males**	**Correlation coefficient - females**	**Notes**
Trudeau 2004 [25]	Trois Rivieres growth and Development Study	10-12	24	0.20*	0.17	0.14	Total PA in childhood vs total weekly time spent in PA in adulthood
Andersen 1996 [38], Andersen 1993 [39]	Danish Youth and Sports Study	16-19	8		0.31***	0.2	
Hasselstrom 2002 [51]	Danish Youth and Sports Study	15-19	8		0.19	0.18	M and F (p<0.1) – check in case typo
Raitakari 1994 [52], Telama 1996 [30], Telama 2005 [32],	Cardiovascular Risk in Young Finns Study	9	12		0.25...	0.05...	PA Index
Telama 2006 [31]		9	21		0.35**	0.17*	
		12	12		0.32...	0.32...	
		12	21		0.33**	0.23**	
		15	12		0.31...	0.26...	
		15	21		0.44**	0.14	
		15	6		0.27**	0.27**	
		18	6		0.43***	0.37***	
		18	12		0.28...	0.36...	
		18	21		0.33**	0.26**	
Anderssen 2005 [28]	Norwegian Longitudinal Health behaviour Study	13	6		0.27***	0.15**	Frequency
		13	8		0.22***	0.18**	Frequency

Authors	Study name	Age at baseline (years)	No. years follow-up	Correlation coefficient - all	Correlation coefficient - males	Correlation coefficient - females	Notes
		16	5		0.47***	0.28***	Frequency
		13	6		0.21***	0.27***	Time
		13	8		0.27***	0.25***	Time
		16	5		0.43***	0.35***	Time
Kjonniksen 2008 [53]	Norwegian Longitudinal Health behaviour Study	13	10		0.21**	0.23***	No of physical activities at age 15 and leisure-time PA at age 23
Parsons 2006 [24]	1958 British Birth Cohort	11	22		0.06*	0.03¦	Frequency of leisure activity
		11	31		0.03¦	-0.01	
		16	17		0.11**	0.06¦	
		16	26		0.09**	0.07**	
Friedman 2008 [26]	Terman Life-Cycle Study	11	18	0.12**	0.13*	0.07	
		11	28	0.11***	0.17***	0.01	
		11	38	0.10**	0.07	0.10*	
		11	50	0.06	0.05	0.03	
		11	55	0.15***	0.14**	0.12¦	
Hasselstrom 2002 [51]	Danish Youth and Sports Study	15-19	8	0.19#	0.18#		Partial correlation coefficents

Authors	Study name	Age at baseline (years)	No. years follow-up	Correlation coefficient - all	Correlation coefficient - males	Correlation coefficient - females	Notes
Campbell 2001 [19]	Quebec Family Study	8-18 (mean 13.5)	12	0.14 MVPA 0.04 DEE 0.25* inactivity	0.22 MVPA 0.22 DEE 0.06 inactivity		Partial correlation coefficents
Cleland 2009 [50]	Australian Schools Health and Fitness Survey/Childhood Determinants of Adult Health Survey	9-16 (mean 12.3y)	19.6	0.07*	0.04		Partial correlation coefficents
Twisk 1997 [22], Twisk 2000 [21], Kemper 1999 [20]	Amsterdam Growth and Health Longitudinal Study	13	14	0.34 (95%CI 0.19, 0.49)			
Kemper 2001 [23]	Amsterdam Growth and Health Longitudinal Study	13	20	0.35† METPA 0.29† MECHPA 0.26† Light METPA (4-7 MET) 0.14† Moderate METPA (7-10 MET) 0.43† Heavy PA (>10 MET)			Generalised estimating equations

#p<0.1, ƒp=0.05, *p<0.05, **p<0.01, ***p<0.001, † No significance value given

MVPA = moderate to vigorous physical activity, DEE= daily energy expenditure, METPA = Total weighted meabolic physical activity, METCHPA = Total weighted mechanical physical activity

Table 3: Physical activity studies reporting tracking according to Kappa statistics

Authors	Study name	Age at baseline	No. years follow-up	Kappa - MALES	Kappa- FEMALES
Boreham 2004 [33]	Young Hearts project, Northern Ireland	15	7	0.202***	0.021
Anderssen 2005 [28]	Norwegian Longitudinal Health behaviour Study	13	6	0.14***	0.08
Anderssen 2005 [28]	Norwegian Longitudinal Health behaviour Study	13	8	0.15***	0.09*
Andersson 2005 [28]	Norwegian Longitudinal Health behaviour Study	16	5	0.38***	0.18***

*p<0.05, **p<0.01, ***p<0.001

Table 4: Physical activity studies reporting linear regression analyses of physical activity at baseline vs. follow-up

Authors	Study name	Age at baseline (years)	No. years follow-up	Linear regression coefficient - all	Linear regression coefficient - Males	Linear regression coefficient - Females
Hasselstrom 2002 [51]	Danish Youth and Sports Study	15-19	8		β=0.08†	β=0.35†
Barnekow-Bergkvist 1998 [54]		16.1 (SD 0.33)	18		β = 0.28*	NS
Glenmark 1994 [55]		16	11		β=0.67†, r=0.48	β=0.49†, r=0.64
Graham et al 2011 [35]	Project Eating and Activity in Teens	11-18 (mean 14.9)	10	β = 0.11***		
Graham et al 2011 [35]	Project Eating and Activity in Teens	11-18 (mean 14.9)	5	β = 0.20***		

*p<0.05, **p<0.01, ***p<0.001, † No significance value given

Table 5: Studies reporting the odds of being physically active at follow-up according to physical activity levels at baseline

Authors	Study name	Age at baseline	No. years follow-up	Outcome in adulthood	Odds ratio - all	Odds ratio - males	Odds ratio - females
Matton 2006 [18]	Leuven Longitudinal Study on Lifestyle, Fitness and Health	16 (+/- 1)	24	To be less active (<1.5 h/wk) in adulthood	2.0 (95% CI 0.9, 4.3) if less active (<3h/wk sports participation)		
Raitakari 1994 [52], Telama 1996 [30], Telama 2005 [32], Telama 2006 [31]	Cardiovascular Risk in Young Finns Study	9-18	21	'High level' of adult activity vs frequency of participation in sports-club training sessions in adolescence		OR =3.25 (95% CI 1.76, 5.97) if once/week OR= 5.11 (95% CI 2.88, 9.08) if many times vs less than once a week	OR =1.64 (95% CI 0.88, 3.06) if once a week; OR = 6.00 (95% CI 2.38, 15.14) if many times
Tammelin 2003a [36]	Northern Finland 1966 birth cohort	14	17	'Active' or 'very active' vs 'inactive' at 31y according to frequency of participation in sport at 14y.		OR=3.0 for 'active', OR=4.0 for 'very active' if daily OR=2.0 for being 'active', OR= 1.7 for being 'very active' if 2-3 times per week	OR=2.4 for 'active', OR= 2.8 for 'very active' if daily OR= 1.8 for 'active', OR=1.5 for 'very active' if 2-3 times a week
Tammelin 2003b [37]	Northern Finland 1966 birth cohort	14	17	'Inactive' at 31 years vs frequency of participation in sports after school		OR=0.57 (95% CI 0.44-0.76) if daily vs 'less than once per week', OR = 0.70 (95% CI 0.54-0.90) if twice a week vs 'less than once per week'	OR = 0.53(95% CI 0.40-0.70) if daily vs 'less than once per week' OR = 0.69 (95% CI 0.55 – 0.86) if twice a week vs 'less than once per week'

Authors	Study name	Age at baseline	No. years follow-up	Outcome in adulthood	Odds ratio - all	Odds ratio - males	Odds ratio - females
Twisk 1997 [22], Twisk 2000 [21], Kemper 1999 [20]	Amsterdam Growth and Health Longitudinal Study	13	14	Staying in lowest vs upper quartile	OR=3.6 (95%CI 2.4, 5.4)		

Table 6: Physical activity studies reporting tracking according to the maintenance of relative position

Authors	Study name	Age at baseline	No. years follow-up	Maintenance of relative position - all	Maintenance of relative position - male	Maintenance of relative position - female
Andersen 1996 [38], Andersen 1993 [39]	Danish Youth and Sports Study	16-19	8		53% remaining in upper quartile	8% remaining in upper quartile
Raitakari 1994 [52], Telama 1996 [30], Telama 2005 [32], Telama 2006 [31]	Cardiovascular Risk in Young Finns Study	9-18	6	% remaining active 44%, % remaining sedentary 57%,**	% remaining Active 45%, % remaining sedentary 57%	% remaining active 43%, % remaining sedentary 57%,*
Raitakari 1994 [52], Telama 1996 [31], Telama 2005 [32], Telama 2006 [31]	Cardiovascular Risk in Young Finns Study	18	6		% remaining Active 54%, % remaining sedentary 61%, P=0.538	% remaining active 57%, % remaining sedentary 60%, P=0.738
Anderssen 2005 [28]	Norwegian Longitudinal Health behaviour Study	13	8		44% maintain tertile position	42% maintain tertile position
Anderssen 2005 [28]	Norwegian Longitudinal Health behaviour Study	13	6		44% maintain tertile position	39% maintain tertile position
Andersson 2005 [28]	Norwegian Longitudinal Health behaviour Study	16	5		59% maintain tertile position	47% maintain tertile position

*p<0.05, **p<0.01 for the probability of remaining sedentary vs the probability of remaining active.

Table 7: Characteristics of the dietary tracking studies used in the review

Authors	Country	Study name	Description of population	No. and gender	Baseline age (years)	Follow-up time points (yrs)	Baseline methods	Follow-up methods	Tracking outcomes reported
Bertheke Post 2001 [41]	Netherlands	Amsterdam Growth and Health Longitudinal Study	From the first and second forms from one secondary school in Amsterdam. Socioeconomic level of the pupils was slightly above average for Dutch families in general.	44.5% M, 55.5% F	13.1 ± 0.8 (SD) years	20 years (Age 33 at follow-up) (Study conducted between 1977 to 1997)	Detailed cross-check dietary history	Detailed cross-check dietary history	Energy, protein, veg protein, animal protein, fat, sat fat, monounsat fat, polyunsat fat (all as g/day and %E), cholesterol, carbohydrate, mono/disaccharides, iron, pyroxidine, Ca, thiamine, riboflavin.
Te Velde 2007 [43]	Netherlands	Amsterdam Growth and Health Longitudinal Study	As Post 2001	45.2% M, 44.8% F	13.0 years	24 years (age 36 at follow-up) (Study conducted between 1977 to 2000)	Detailed cross-check dietary history method.	Detailed cross-check dietary history method.	Fruit intake g/day, Veg intake g/day
Twisk 1997 [22]	Netherlands	Amsterdam Growth and Health Longitudinal Study	As Post 2001	55.8% M, 44.8% F	13 years	15 years (followed up to age 27 years)	Detailed cross-check dietary history method.	Detailed cross-check dietary history method.	Fat intake (%E) Carbohydrate intake (%E) Cholesterol intake (mg/mJ)
Welten 1997 [40]	Netherlands	Amsterdam Growth and Health	As Post 2001	53.9% M, 46.1 % F	13-17 (averaged)	6, 12 years (Followed up to	Detailed cross-check dietary	Detailed cross-check dietary history method.	Calcium intake Dairy intake (cheese, milk and milk products)

Authors	Country	Study name	Description of population	No. and gender	Baseline age (years)	Follow-up time points (yrs)	Baseline methods	Follow-up methods	Tracking outcomes reported
		Longitudinal Study				ages 21, 27)	history method.		
Boreham 2004 [33], Gallagher 2006 [42]	Northern Ireland	The Young Hearts Project Northern Ireland	Adolescents randomly selected from post-primary schools.	51.5% M, 48.5% F	15	7 years (Followed up to age 22 (SD 1.6 y))	Diet history interview	Diet history interview	Total energy intake, protein, carbohydrate, fat, Fe, Ca, thiamin, riboflavin, vitamin B6, folate, VitA, Vit C, Vit D. Protein, total fat, carbohydrate (g/day and %E), energy.
Lake 2006 [56], Lake 2009 [57]	UK - England	The ASH-30 study	Young adolescents from 7 schools in Northumberland, North-East England	40.9% M, 59.1% F	11-12	20 years (age 32-33 at follow up) Followed from 1980 to 2000.	Two 3-day food diaries followed by an interview	Two 3-day food diaries followed by an interview.	Balance of Good Health food groups: Bread; other cereals and potatoes; fruit and veg; meat, fish and alternatives; milk, dairy foods, foods containing fat and/or sugar.
Patterson 2009 [47]	Sweden	The European Youth Heart Study	Adolescents from grade 9, mean age 15 years, sampled from classes selected from 42 schools in Southern Stockholm and Orebro.	38.5%M, 61.5% F	15	6 years (age 21 at follow up)	24h dietary recall + 1 day qualitative food diary	24h dietary recall	For those followed from 15 to 21 years 'Older group' only meet inclusion criteria. **Food groups** Stability coeffs and Cohen's kappa presented for all:

Authors	Country	Study name	Description of population	No. and gender	Baseline age (years)	Follow-up time points (yrs)	Baseline methods	Follow-up methods	Tracking outcomes reported
									Bread; milk, yogurt; cheese; veg; fruit; pasta, rice, potatoes; cereals; meat, meat dishes; spreads and oils; sweets, chocolate; cakes, biscuits; other sweet foods; sweetened drinks. **Nutrients** Energy, protein, fat, sat fat. Carbohydrates, sucrose, fibre, vitamin C, folic acid, iron, calcium, **Energy density**
Mikkila 2004 [46], Mikkila 2005 [44]	Finland	Cardiovascular Risk in Young Finns Study	Representative sample of Finnish children and young adults	47% M, 53% F	3-18	21 years (Baseline data collected in 1980, follow-up data collected in 2001)	48 h dietary recall (parents included)	48 h dietary recall	Energy, protein, fat, sat fat, monounsat fat, polyunsat fat, omega-3 fat, carbohydrate, sucrose, alcohol, fibre, salt, vegetables and fruit.

Table 8: Dietary tracking studies reporting correlations of intake between baseline and follow-up

Authors	Study name, Participants	Age at baseline (years)	No. years follow-up	Food / nutrient	Tracking coefficients: Males and females	Tracking coefficients: Males	Tracking coefficients: Females	Notes
Bertheke Post 2001 [41]	AGAHLS n=164	13	20	Energy kJ Energy kJ/wt Protein g Protein % E Veg protein g Veg protein % E Animal prot g Animal prot %E Fat g Fat %E Sat fat g Sat fat % E Monounsat fat g Monounsat fat %E Cholesterol (g/MJ) Carbohydrate g Carbohydrate %E Mono/di sacch g Mono/di sacch %E Polysacch g Polysacch % E	0.33 (95% CI 0.22, 0.43)* 0.52 (95% CI 0.41, 0.63)* 0.36 (95% CI 0.25, 0.46)* 0.44 (95% CI 0.34, 0.54)* 0.30(95% CI 0.20, 0.39)* 0.38 (95% CI 0.27, 0.50)* 0.38 (95% CI 0.26, 0.51)* 0.41 (95% CI 0.31, 0.52)* 0.38 (95% CI 0.28,0.48)* 0.37 (95% CI 0.28, 0.45)* 0.41 (95% CI 0.32, 0.50)* 0.36 (95% CI 0.28, 0.44)* 0.37 (95% CI 0.27, 0.48)* 0.33 (95% CI 0.25, 0.42)* 0.28 (95% CI 0.18, 0.38)* 0.31 (95% CI 0.20, 0.43)* 0.35 (95% CI 0.25, 0.44)* 0.34 (95% CI 0.24, 0.44)* 0.37 (95% CI 0.27, 0.48)* 0.32 (95% CI 0.20, 0.55)* 0.34 (95% CI 0.23, 0.44)*			GEE
	n=73 Mn=91F			Polyunsat fat g Polyunsat fat %E Ca (mg) Riboflavin (mg)		0.40 (95% CI 0.20, 0.60)* 0.38 (95% CI 0.20, 0.54)* 0.52 (95% CI 0.36, 0.68)* 0.54 (95% CI 0.40, 0.68)*	0.14 (95% CI 0.05, 0.23)* 0.17 (95% CI 0.07, 0.27)* 0.34 (95% CI 0.21, 0.47)* 0.27 (95% CI 0.18, 0.36)*	
Te Velde 2007 [43]	AGAHLS n=168 n=166	13	24	Fruit intake (g/d) Vegetable intake (g/d)	0.33 (95% CI 0.25, 0.41)*** 0.27 (95% CI 0.19, 0.36)***			GEE

Authors	Study name, Participants	Age at baseline (years)	No. years follow-up	Food / nutrient	Tracking coefficients: Males and females	Tracking coefficients: Males	Tracking coefficients: Females	Notes
Twisk 1997 [22]	AGAHLS n=181	13	15	Fat intake (%E) Carbohydrate (%E) Cholesterol intake (%E) Polyunsat/sat fat (g/d)	0.42 (95% CI 0.34-0.50)† 0.37 (95% CI 0.28,0.46)† 0.34 (95% CI 0.26, 0.42)† 0.33 (95% CI 0.21, 0.44)†			GEE
Welten 1997 [40]	AGAHLS n=84 n=98F	13-17 (averaged)	6	Calcium Cheese Milk & milk products		0.39 (95% CI 0.18, 0.57)† 0.66 (95% CI 0.51, 0.77)†	0.42 (95% CI 0.23, 0.57)† 0.35 (95% CI 0.16, 0.52)†	ICC
Welten 1997 [40]	AGAHLS n=84M n=98F		12	Cheese Milk & Milk products Milk and milk products	0.45 (95% CI 0.36, 0.55) 0.45 (95% CI 0.32, 0.57)†	0.43 (95% CI 0.23, 0.59)† 0.55 (95% CI 0.38, 0.69)† 0.60 (95% CI 0.44, 0.75)†	0.54 (95% CI 0.38, 0.69)† 0.22 (95% CI 0.02, 0.40)† 0.29 (95% CI 0.13, 0.44)†	**ICC** GEE
Lake 2006 [56], 2009 [57]	The ASH-30 study n=198	11	20	Fruit and Vegetables[a] Bread, other cereals and potatoes[a] Meat, fish and alternatives[a] Milk and dairy foods[a] Foods containing fat and/or sugar[a]	0.256*** 0.219** 0.158* 0.097 0.009			PCC

*p<0.05, **p<0.01, ***p<0.001, † No p-value given, ^{f}p=0.05

Amsterdam Growth and Health Longitudinal Study (AGAHLS)

Pearson correlation coefficients (PCC), Inter-period correlation coefficients (ICC), Generalised estimating equations (GEE)

Table 9: Dietary studies reporting tracking according to Kappa statistics

Authors	Study name, Participants	Age at baseline (years)	No. years follow-up	Food / nutrient	Kappa statistics: Males and females	Kappa statistics: Males	Kappa statistics: Females
Boreham 2004 [33], Gallagher 2006 [42]	Young Hearts project, n=245M n=231F	15	7	**Macronutrients**			
				Energy (MJ/d)		0.20 (95% CI 0.09, 0.30)	0.21 (95% CI 0.11, 0.31)
				Energy (kJ/kg/d)		0.26 (95% CI 0.17, 0.36)	0.33 (95% CI 0.23, 0.43)
				Protein (g/d)		0.11 (95% CI 0.01, 0.21)	0.25 (95% CI 0.15, 0.35)
				Protein (%E)		0.11 (95% CI 0.01, 0.21)	0.20 (95% CI 0.10, 0.30)
				Carbohydrate (g/d)		0.12 (95% CI 0.02, 0.22)	0.18 (95% CI 0.08, 0.28)
				Carbohydrate (%E)		0.13 (95% CI 0.03, 0.23)	0.11 (95% CI 0.01, 0.21)
				Fat (g/d)		0.15 (95% CI 0.05, 0.25)	0.18 (95% CI 0.08, 0.29)
				Fat (%E)		0.13 (95% CI 0.02, 0.23)	0.16 (95% CI 0.06, 0.26)
						0.06 (95% CI -0.04, 0.16)	0.06 (95% CI -0.04, 0.17)
Patterson 2009 [47]	The European Youth Heart Study	16	6	**Food Groups**			
				Bread	0.06		
				Milk, fil, yoghurt	0.06		
				Cheese	<0		
				Vegetables	0.17		
				Frui	0.23		
				Pasta, rice potatoes	0.14		
				Cereals	0.11		
				Meat, meat dishes	0.06		
				Spreads oils	<0		
				Sweets, chocolate	0.12		
				Cakes, biscuits	0.05		
				Other sweet foods	0.06		
				Sweetened drinks	0.07		
				Nutrients			

Authors	Study name, Participants	Age at baseline (years)	No. years follow-up	Food / nutrient	Kappa statistics: Males and females	Kappa statistics: Males	Kappa statistics: Females
				Energy Protein (%E) Fat (%E) Sat fat (%E) Carbohydrates (%e) Sucrose (%E) Fibre Energy density	0.06 0.16 0.04 0.07 0.03 0.07 0.26 0.16		

Linear weighted kappa value (κ=1 when tracking is perfect. κ<0.20, poor tracking; κ = 0.21-0.40 fair; κ=0.41-0.60 moderate; κ 0.61-0.8 good; κ = 0.81-1.0 very good).

Table 10: Dietary studies reporting tracking according to the odds of having particular dietary intakes in adulthood

Study	Study name	Age at baseline (yrs)	No. years follow-up	Outcome in adulthood	Odds ratios	Odds ratios males	Odds ratios females
Te Velde 2007 [43]	Amsterdam Growth and Health Longitudinal Study (AGAHLS) n=76M n=72F	13	24	Longitudinal prediction of meeting national recommended intake levels (OR) between baseline and follow-up Longitudinal prediction of remaining in the highest quartile of intake between baseline and follow-up (OR)	Vegetables: 4.08 (95% CI 2.31, 7.19) Vegetables: 2.38 (95% CI 1.58, 3.56)	Fruit: 6.02 (95% CI 3.29, 11.0) Fruit: 5.30 (95% CI 2.95, 9.53)	Fruit: 2.33 (95% CI 1.40, 3.86) Fruit: 2.07 (95% CI 1.21, 3.56)
Twisk 1997 [22]	AGAHLS n=158 n=140 n=53 n=47	13	15	Odds ratios for being in 'at risk' category at baseline and maintaining that position at follow-up.	Fat intake (%E) 2.6 (95% CI 1.1, 6.0) Carbohydrate (%E) 3.4 (95% CI 1.9, 6.1) Cholesterol (%E) 2.3 (95% CI 1.5, 3.6) Polyunsat/sat fat (g/d) 1.9 (95% CI 1.1, 3.3)		

Table 11: Dietary studies reporting tracking according to the maintenance of relative position

Study	Study name	Age at baseline (yrs)	No. years follow-up	Description	Maintenance of relative position All	Maintenance of relative position Male	Maintenance of relative position Female
Welten 1997 [40]	Amsterdam Growth and Health Longitudinal Study	13-17 (averaged)	6	Percentage remaining in the lowest vs highest quartile at baseline who remained there at follow-up.		Cheese Low 63.2%, High 50.0% Milk and milk products Low 68.4%, High 57.9%	Cheese Low 69.6%, High 50.0% Milk and milk products Low 56.5%, High 27.3%
Welten 1997 [40]	Amsterdam Growth and Health Longitudinal Study		12	Percentage in the lowest vs highest quartile at baseline who remained there at follow-up.		Cheese Low 47.6%, High 30.0% Milk and milk products Low 47.6%, High 50.0%	Cheese Low 75.0%, High 41.7% Milk and milk products Low 50.0%, High 25.0%
Mikkila 2004 [46] Mikkila 2005 [44]	The Cardiovascular Risk in Young Finns Study	15	21	Percentage remaining in the lowest or highest quintile at baseline or follow-up (21 year follow-up)	Age at baseline (3-12 years); proportion remaining in lowest quintile 28%; highest quintile 28%. Age at baseline 15-18 years; proportion remaining in lowest quintile 27%; highest quintile41%.		