Title: Tracking of physical activity and sedentary behaviour from adolescence to young adulthood: A systematic literature review.

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Abstract:

Purpose: The transition from adolescence to young adulthood is categorised by substantial changes in one's activity behaviours which may have important implications for health. To date, no reviews have systematically investigated the evidence of tracking for both physical activity (PA) and sedentary behaviour (SB) specifically during this transition period.

Methods: Web of Science, PubMED, SPORTDiscus, PsycINFO and CINAHL were searched for papers that examined the tracking of PA and SB in adolescents (aged 9-18 years) through young adulthood (aged 19-25 years) published between the years of 2000-2018. Studies were also compared on methodologic quality.

Results: Sixteen studies met the inclusion criteria. The tracking correlations for both the frequency and duration of PA were low-to-moderate. Gender differences were observed in the tracking of PA frequency and duration. Studies that examined the tracking of SB were less frequent, making it difficult to determine how SB tracks from adolescence to young adulthood.

Conclusions: Generally, PA was shown to track moderately from adolescence through young adulthood. The lack of studies reporting on the tracking of SB indicates that this area should be a target for future research. Future tracking studies should consider appropriate gold-standard objective methodologies and statistical analysis techniques that report fixed outcomes.

Keywords: *tracking, physical activity, sedentary behaviour, adolescence, young adulthood*.

Implications and Contribution.

Unhealthy activity behaviours are associated with increased risk for chronic-illness. The degree to which PA and SB track from youth into adulthood is poorly researched but critical when examining the impact of interventions to modify adolescent activity behaviour. Accurate measurement of longitudinal activity behaviour is warranted to guide future intervention.

Regular participation in moderate-to-vigorous physical activity (MVPA) is key for long-term health [1-3]. With this, national and international physical activity (PA) guidelines promoting the health benefits of regular participation have been developed [4]. Despite these recommendations, global levels of MVPA are low, with one in three adults and four in five adolescents not achieving the minimum recommendations of PA for health [5].

In recent years, technological advancements in personal transportation, screen-based entertainment and communication have decreased the demand for PA and dramatically increased the amount of time spent sedentary [6]. Moreover, excessive sedentary time plays an important role in the development of risk factors for many chronic diseases [7]. In spite of this knowledge, the volume of sedentary time accumulated continues to increase, with the majority of people spending up to 10 hours of their waking day sedentary [8-9]. The amount of time spent in sedentary behaviours (SB), coupled with the likelihood of this to increase due to further technological developments, highlights SB as a significant public health issue [10]. Before one can begin to inform the development of public policy to modify these behaviours; there is a need to monitor and better understand how both PA and SB patterns change throughout important stages of life.

Early adulthood (defined here as 19-25 years) is a critical period for establishing lifestyle behaviours and is thus gaining recognition as an important time to implement health promotion strategies [11]. Specifically, the transition from adolescence to young adulthood is a poorly understood period, where many physiological and psychological changes occur that can influence one's lifestyle and activity behaviours [12]. It is speculated that understanding

how PA and SB track between these time periods may illuminate adolescent determinants of adult activity behaviours [13]. The rationale for this is that, if good activity behaviours are practiced early in life, there is a higher likelihood they will persist later in life [14]. This concept, known as tracking, refers to the "tendency of individuals to maintain their rank or position within a group over time" [15]. Thus, tracking provides the opportunity to predict subsequent observations on the basis of earlier values.

Many researchers have investigated the tracking of PA. Because tracking of PA is likely to vary during different phases of life, information on the tracking of these behaviours during specific transitional life periods is warranted. Information relating to the tracking of SB is sparse [16]. Studies that have observed the tracking of sedentary patterns and behaviours have reported highly variable findings and have mainly relied on subjective methods (i.e. self-reported TV viewing time), despite their repeated demonstration of considerable inaccuracies.

A systematic review of the evidence for the tracking of both PA and SB from adolescence through to young adulthood is required. This transition period coincides with major life events that may include changes to one's social, academic and/or employment status. It is relatively unclear if such changes affect health-related behaviours. With that, the purpose of this paper is to systematically review the available evidence on the tracking of PA and SB in both males and females from adolescence to young adulthood. The findings of this review will serve to strengthen our existing limited knowledge and will be used to unveil information

96 that will inform targeted interventions to improve the current activity behaviours and health
97 sequelae of young adults.

98

Review of Relevant Literature:

Search Strategy:

Search strategies were developed around three groups of keywords: type of activity behaviours, study design and type of measures used. The following electronic databases were systematically searched to identify potentially relevant studies: Web of Science, PubMED, SPORTDiscus, PsycINFO and CINAHL. The search strategy included the following terms: ("sedentary behaviour" OR "sedentary behavior" OR "sitting time" OR "physical activity") AND ("longitudinal" OR "prospective" OR "tracking" OR "cohort") AND ("activity monitor" OR "activity monitoring" OR "motion sensor" OR "motion sensing" OR acceleromet* OR pedomet* OR "heart rate monitoring" OR "heart rate monitor" OR "global positioning system" OR "self-report" OR "logs" OR "diaries" OR "questionnaires"). The final search on the included databases was completed in November 2018.

Study Inclusion and Exclusion Criteria:

Studies were considered eligible for inclusion if i) they examined males and/or females, ii) participants were aged between 9 and 18 years at baseline and iii) participants were followed through young adulthood (aged between 19-25 years at follow-up) and iv) they were prospective, longitudinal or tracking in design. The studies had to be published in peer-reviewed journals since the year 2000 and written in the English language. Studies were included if they assessed the tracking of at least one PA and/or SB variable at a minimum of two time points.

Exclusion criteria:

Studies were excluded if they i) included children <9 years or adults aged >18 years at baseline, or adults aged <19 years at follow-up, ii) examined tracking of sport participation or membership of a sports club/facility only, iii) focused on clinical cohorts, iv) were commentaries, conference proceedings or v) were cross-sectional or intervention studies.

***Article Screening*:**

Once database searches were complete, all identified articles were imported to EndNote reference manager (Endnote X8) and duplicates were removed. The title of all articles was screened and articles that were clearly unrelated to the topic were removed. The abstracts of all remaining articles were then reviewed by two independent reviewers. Any discrepancies between the reviewers were resolved by a third reviewer. If abstracts were unavailable or provided insufficient data, the full-text of the article was retrieved and examined to determine if it met the inclusion criteria. The full-texts of all remaining articles were obtained and examined independently using the same review process. Finally, the reference lists of all identified articles were manually screened to identify any additional articles relevant to the review.

***Data Extraction and Quality Assessment*:**

All data were extracted on standardised data extraction tables by the lead author and reviewed by an independent researcher. Data extracted from each article included; general information, study characteristics, participant characteristics, outcome measures/behaviour characteristics, statistical analysis and results**.** Included articles in this review were assessed for methodologic quality using a 19 item scale (Supplementary Table 1). This scale combines relevant and appropriate questions from both the modified version of the "criteria list for assessment of the methodological quality of prospective and historical cohort studies" [17]

and the "quality criteria list for observational longitudinal studies" [18]. The methodological quality of each article was assessed under five criteria; 1) study population and participation rate, 2) study attrition, 3) data collection, 4) outcome measurement and 5) data analysis.

Two independent reviewers scored each criterion as positively (+), negatively (-) and insufficiently/not described (?) for each article. For a positive score, each item needed to be sufficiently explained so that the researcher could identify whether the criterion was met. If the study reported inadequate information about the criterion, it received a negative score. To score the methodologic quality of the included studies, the positive scores were summed and converted to a percentage, ≥75% was considered to be high quality, 70-74% was considered moderate and <70% was considered to be low methodological quality.

Evidence Synthesis:

Article Identification:

The search strategy yielded 11,652 potentially relevant articles (Web of Science=4,371; PubMED=3,542, SportsDiscus, CINAHL and PsychInfo=3,739) (Figure 1). When references from all databases were exported to Endnote and all duplicates removed, a total of 9,042 articles remained. All article titles and abstracts were screened resulting in 43 full-text articles for review. In addition, 14 articles were identified from the reference lists of the full-text articles and a further 11 articles were retrieved from database updates. Of the 68 identified articles, only 16 articles were considered eligible for this review. Of the included studies, ten were conducted in Europe, five in the USA and one in Canada. Twelve papers assessed the tracking of PA only, one paper assessed the tracking of screen-time only and three papers assessed the tracking of both PA and SB. Most studies assessed PA and/or SB through the use of questionnaires (n=12), while four studies used objective measures to determine PA and/or SB. A description of the article numbers included and excluded at different levels of this review is provided in Figure 1. Descriptive information for each included study is provided in Table 1.

Quality Assessment & Data Synthesis:

The quality assessment score of each individual article can be found in Supplementary Table 2. The twelve papers that reported outcomes on the stability of PA only, scored between 73.6% and 100%. The three studies that reported on both PA and SB outcomes scored between 68.4-94.7% on the methodological quality assessment tool. The only study using objective methods to assess both PA and SB had a moderate methodologic quality score of 78.9% [12]. One study [19], reporting solely on screen time as a surrogate measure of SB,

was deemed to have a high methodologic quality score (89.4%). As there was considerable heterogeneity of the data in terms of analysis methods, age of adolescents and adults participating in the studies and length of follow-up, statistical pooling of the results were not possible. To facilitate comparison amongst studies, a description of the key study characteristics and tracking outcomes (where possible) are included, with papers grouped according to the statistical analysis methods used.

***Studies which employed a tracking coefficient*:**

Studies that included correlational statistics predominantly used tracking coefficients to observe the stability of activity over time. Table 2 presents information on tracking the frequency and/or duration of PA using correlational statistics. To allow for comparison between studies, tracking coefficients were extracted from each article and classified as low (<0.30), moderate (0.30-0.60) or high (>0.60) [15].

***Frequency of PA*:**

Four studies used correlation coefficients to track the frequency of PA from baseline to follow-up and showed that the tracking for frequency was low to moderate from adolescence to young adulthood [20-23]. The tracking of PA between boys and girls were inconsistent. Rauner and colleagues showed that the frequency of overall PA (*defined as the number of days during the last seven, and during a typical week spent in moderate PA of at least 60 minutes per day*) showed low tracking for both girls (r=0.201) and boys (r=0.198). Despite being stronger for females, the correlations did not differ significantly between boys and girls [22]. Similarly, Kjonniksen, Torsheim and Wold [21] observed that females when compared to males showed a slightly stronger association (0.23 versus 0.21) between the number of

physical activities engaged in at age 15 and leisure time PA at age 23. Two studies showed the stability of PA to be significantly stronger for males [20, 23] (Table 2). Overall, the tracking of the frequency of PA appears to be greater with increasing baseline age and shorter follow-up periods.

***Duration of PA*:**

Two studies used correlation coefficients to track the duration of PA [20, 22]. Tracking the duration of PA appeared to be low-to-moderate from adolescence to young adulthood and appeared stronger for males (Table 2). The tracking coefficient for youth aged between 12-13 years at baseline ranged from 0.43-0.72 for males and 0.10-0.35 females over a follow-up period of 3-8 years respectively. Using a combination score of activity behaviour (PA index: frequency, intensity, duration and participation in organised sport), Telama and colleagues revealed that tracking coefficients varied from low-to-moderately high; and were significantly stronger for females (0.61, $p<0.01$) than males (0.37, $p<0.01$) over a shorter follow-up period and a higher baseline age [24].

***Studies which employed statistical modelling techniques*:**

Five studies used statistical modelling techniques to investigate the change in PA over time [12, 21, 25-27]. Comparison of the findings is difficult due to the range of variables measured. Fuller, Sabiston, Karp, et al. [25], using a multilevel general linear model method (adjusted for BMI, sex, mothers' education and school socioeconomic status) reported a significant ($p<0.001$) decline in total PA (β (Standard Error (SE)):-12.5 (0.3)) and frequency of moderate (β (SE):-7.8(0.3)) and vigorous intensity PA sessions (β (SE) (-4.2 (0.1)) from 12 years to 20 years. Using self-reported global leisure time PA as an indicator in a multivariate multilevel model of change, Kjonniksen, Torsheim and Wold [21] identified a stronger

224 average decline in leisure time PA for males (β (SE) (-0.17 (0.01)) when compared to females
225 (β (SE) (-0.09 (0.1)) from 13-23 years.

226

227 Young, Cohen, Koebnick, et al. [27], using a generalised linear model reported a significant
228 decline in objectively measured MVPA from 20.7 (10.40) minutes/day at 14 years of age to
229 16.4 (14.99) mins/day at the age of 23 in a group of female adolescents. Similarly, Walters,
230 Barr-Anderson, Wall, et al. [26] showed a significant decline in weekly MVPA of 1.7 hours
231 ($p<0.001$) per week for males and 2.6 hours ($p<0.001$) for females (adjusted for race and
232 stratified by gender) who previously participated in school sports at 15 years. For those who
233 did not participate in organised sport during high school, MVPA did not significantly change
234 during young adulthood for males, but declined by 0.8 hours ($p<0.001$) for females.
235 Moreover, Simons, Rosenberg, Salmon, et al. [28] reiterated that the time spent in leisure
236 time PA declined by 1.21±3.36 hours per week after leaving high school (N=374). Using
237 objective measures of activity and a similar statistical analysis approach , Ortega, Konstabel,
238 Pasquali, et al. [12] looked at the longitudinal changes in activity behaviour and illustrated
239 that MVPA significantly decreased by 2.2 $min.day^{-1}$ per year ($p<0.001$) for males, while the
240 decline was less for females (0.8 $min.day^{-1}$).

241

242 Kappa Statistics were reported in three studies [20, 22, 29]. A kappa coefficient of ≤ 0.20 is
243 considered to be poor, 0.21-0.40 fair, and 0.41-0.60 moderate [30]. The studies had baseline
244 ages ranging from 13.3–17.0 years with participants followed for 5-8 years. Kappa statistics
245 for all studies can be considered, poor to fair for males (k=0.14-0.38, significant) and weaker
246 relationships were evident for females (0.08-0.02).

Studies which employed odds ratio analysis:

Supplementary table 3 presents information on the odds of achieving recommendations for PA or screen-time at follow-up based on baseline levels. The guidelines for physical activity were measured based on achieving 60 minutes of MVPA on 7 days of the week. Screen-time was measured based on the current Canadian SB guidelines for youth (maximum 2 hours/day of screen-time) [31]. Two studies reported on the probability of being physically active in young adulthood based on adolescent activity behaviour [24, 32]. Again, a comparison of the findings is difficult due to the variation in variables examined. Telama and colleagues reported that continuous PA throughout adolescence presented higher probabilities of being active during young adulthood for both males and females, with odds ratios (OR) of 19.2 (95% CI, 6.2, 59.1) and 6.1 (95% CI, 1.5, 24.4) respectively [24]. Using binary logistic analysis, Owens, Crone, De Ste Croix, et al. [32] reported that female adolescents were 42.4% less likely than males to change from meeting the recommendations for PA during baseline (aged 14-17 years) to not meeting the guidelines two years post compulsory education (OR, 0.576, 95% CI, 0.335, 0.989). One study reporting solely on the tracking of screen-time, identified the tracking of screen-time was only evident in boys (Table 3) [19].

Studies which employed percentage change analysis:

Table 3 presents studies reporting the percentage change in activity according to one's relative position at baseline and follow-up. Li, Haynie, Iannotti et al. [33], using objective methods to assess MVPA, identified that < 9% (N=561) of their participants achieved the minimum recommended 60 minutes MVPA per day as they transitioned to young adulthood. In addition, male participants (25-36 minutes/day) were significantly more active than their female counterparts (13-23 minutes/day; $p<0.001$) on both weekdays and weekends respectively. Kimm, Glynn, Kriska, et al. [34], identified that weekly habitual PA (MET-

271 times.wk^{-1}) declined by 83% over ten years. Of the included studies, the majority of
272 participants were not meeting the recommendations for PA and SB at baseline or follow-up.
273 Owens, Crone, De Ste Croix, et al. [32], reported that only 3.9% of the total population
274 enrolled in their study (N = 886) met the guidelines for PA both at baseline and follow-up.
275 Similarly, Gordon-Larsen, Nelson and Popkin [35] identified that only 5.9% of the males and
276 2.7% of the females participating in their study (N_{total}=13,030) achieved the guidelines at
277 baseline and follow-up. In general participants moved from meeting the recommendations for
278 PA at baseline to not meeting them at follow-up. Rauner, Jekauc, Mess, et al. [22], showed
279 that more than half (58.9%) of the study population went from fulfilling the recommendations
280 for MVPA at baseline to not fulfilling them at follow-up. Furthermore, Owens, Crone, De Ste
281 Croix, et al. [32] reported a smaller (10.1%) but similar trend.

282

283 Using a surrogate measure of SB, Gordon-Larsen, Nelson and Popkin [35], investigated the
284 relative position of ones' activity using the Canadian ST guidelines (maximum 2 hours/day of
285 ST). Over a 6 year period, 43.9% of males and 29% of females maintained ≤14 hours.wk^{-1} of
286 TV viewing and computer game use from baseline to follow-up. Additionally, 18.4% of
287 females and 16.4% of males moved from meeting the guidelines at baseline to not meeting
288 them at follow-up [35].

289

Discussion:

The transition from adolescence to young adulthood is now gaining credence as an important period for targeting disease prevention. Despite a large variation in measurement methodologies and activity behaviour outcomes, the studies examined in this systematic review generally support the tracking of activity behaviour from adolescence to young adulthood. However, the tracking correlations (Table 2) for both the frequency and duration of PA were low-to-moderate over a follow-up period of 3-10 years. This finding suggests that relative position within the sample distribution of individuals most likely changed to some degree over the studies follow-up periods. Predictably, activity levels generally declined over the measurement periods. This finding concurs with literature suggesting that PA levels decline across the lifespan, particularly during adolescence [36]. The finding that PA does track to some degree has implications for health-related research as it has been proposed that activity patterns adopted during adolescence track into adulthood and may increase the risk of many chronic diseases including cardiovascular disease, obesity and type II diabetes [37].

Inconsistent gender differences were observed when tracking the frequency and duration of PA. The pronounced differences across studies may be attributed to regional differences, differences in the follow-up periods [12] or the gender-specific adaptations required in both the social environment and newly acquired responsibilities as one transitions from adolescence to young adulthood [38]. It is not within the scope of this review to fully address the inconsistent findings. However, the results reported reinforce the need to i) investigate activity behaviour in a gender-specific manner and ii) design future studies that will provide insight into the factors that influence activity behaviour among males and females during the transition from adolescence to young adulthood.

The results of the present review confirm that the trajectory and direction of one's activity behaviour changes as they transition from adolescence into young adulthood. This can be influenced by changing life events that may occur during this time. To illustrate, one study [28] included in this review tracked the association between life events (moving out of home, working full-time and studying full-time) and changes in leisure time PA after leaving high school. The results demonstrated no significant associations between moving out of home or working full-time with changes in the participants leisure time PA. However, what is interesting to note is that those who continued in full-time education had a smaller decline in leisure time PA ($p<0.10$). Similar findings were observed by Li, Haynie, Iannotti et al. [33] whereby those attending college or living on campus were more likely to engage in MVPA (post high school), compared to those who were not attending college and those who lived at home. These findings are important as they exemplify that continuing full-time education, or living on campus post high school may have a protective effect on one's activity. Due to the limited studies assessing life events in conjunction with objectively measured activity behaviours as one transitions to young adulthood, we suggest that this is an area for future research.

To our knowledge, this is the first systematic review to investigate the tracking of both PA and SB. Of the included studies, studies that examined the tracking of SB were less frequent and only examined surrogates of SB in specific domains (i.e. self-reported TV viewing time and computer use) [19, 32, 35]. None of these studies reported tracking coefficients, making it difficult to determine how surrogate measures of SB track from adolescence to young adulthood. Moreover, only one study used an objective device to measure the longitudinal changes in sedentary time and identified that the time spent sedentary increased from

childhood to adolescence (~ 15 and 20 min.d^{-1} per year for girls and boys respectively), with no significant change observed between adolescence and young adulthood [12]. The findings of this single study are interesting but should be viewed with caution until more studies are available, as the device employed (ActiGraph accelerometer, LLC, Pensacola, Florida) has limited validity when assessing patterns of sedentary accumulation [39]. The findings from studies that examined sedentary time in this review have revealed that the use of different categorisation criteria and analysis techniques to measure and analyse the tracking of SB variables limits the potential for synthesis of information. We recommend that future tracking studies should consider appropriate gold-standard measurement methodologies, for example objective measurement tools, and statistical analysis techniques that report fixed outcomes (for example, minutes of MVPA.wk^{-1}). This will provide researchers with an opportunity to harmonise the evidence collected when different categorization criteria, measurement and analysis methods are used.

The accurate and reliable measurement of lifestyle behaviours is complex [39]. The majority of the included studies (86%) used subjective measurement tools as surrogate measures of activity behaviour. Although subjective measurement tools are easy to use, reduce cost and are less invasive [14], the accuracy of the results obtained remains uncertain due to social desirability bias and individuals having difficulty recalling intermittent habitual activity behaviours. It is worth noting that some of the included studies provided the participants with the same self-report measurement tool during all follow-up periods. As one ages, their pattern of activity diversifies and the nature of their leisure time activity (particularly females) may change, using the same questionnaire to track activity behaviour longitudinally may not provide us with an accurate account of behaviour change. The use of self-report instruments for research in tracking studies should be relied on less and deemed unacceptable if we are to advance this field of research.

The findings from the present review highlight the need for objective measurement in tracking research; as worn devices can capture rich information across the activity spectrum from standing, stepping, light, moderate and vigorous intensities and the patterns of these behaviours. In addition, the use of these objective measures will provide greater reliability and validity [40]. In the present review, only three studies [12, 23, 27] used objective measures to assess PA and/or SB thus we do not have sufficient evidence from these studies to support the tracking of activity behaviour from adolescence to young adulthood. We propose that when selecting a measurement tool for use in tracking studies, careful consideration should be given not only to the feasibility of the tool used but also its validity, reliability and sensitivity to detect changes over time [42].

The present analysis is dominated with studies that only tracked participants over two time-points. The lack of multiple and longer follow-up measurement periods limits our understanding of the timing of changes in PA and SB during the transition to young adulthood. The multiple analysis methods used to assess the tracking of PA and SB in the present review inhibits our ability to draw more statistically powerful conclusions via meta-analysis. Furthermore, the majority of the included studies used statistical analysis that incorporated correlation coefficients. An issue with using this method of analysis is that correlations only identify the strength of association and do not control for confounding variables. An assumption made in tracking is that the activity recording method is consistent. This may not always be the case, particularly when tracking periods do not adjust for seasonal variation or changes in responses to questionnaires with age. Consequently, tracking coefficients should be adjusted to take this variation into account [41]. To improve our

knowledge on the tracking of activity behaviour, the use of objective methods, inclusion of adjustments of tracking correlations for error variance, and multiple measurement periods are required to better understand the timing and quantification of the rate of change of behaviour.

Strengths and Limitations:

To the authors' knowledge, the current review is the first and only systematic literature review to specifically investigate the tracking of both PA and SB during the transition from adolescence to young adulthood. The use of an extensive systematic search strategy enabled the inclusion of all relevant studies. In addition, the use of two researchers to conduct data extraction procedures allowed a thorough assessment of each study and synthesis of the findings from each study in an unbiased manner. The inclusion of a novel quality assessment tool, examination of both PA and SB, the use of both subjective and objective measures of activity behaviours enabled an extensive and novel review of this important research area.

The limitations of this review need to be considered. The majority of studies included were based on self–reported measures of activity behaviour. The use of self-report methods tends to ignore the contribution of intermittent habitual activity (e.g. active transport, periods of sitting etc.) and under/overestimate the behaviours being assessed. Different time-frames were utilised across the studies and so seasonal variation could influence the results. The included studies were mainly European, which limits the generalisation of the findings. Due to the small number of studies included, large heterogeneity in the categorization of activity behaviours and limited studies assessing SB, it was not possible to complete a meta-analysis.

Summary and Implications:

Based on appraisal of individual studies, this review found evidence that PA and SB show low-to-moderate tracking during the transition from adolescence to young adulthood. The

findings show a weakening of the strength of tracking over longer time periods, and increased tracking stability with increasing baseline age. Generally, PA declined with age, while SB tended to increase, though the evidence for this is weaker. Conflicting evidence on the strength of tracking in males and females was observed. Not only is the presence of obesity and unhealthy activity behaviours during this transition associated with increased risk for chronic illness, but this also may be a critical time where one can adopt healthy behaviours. The lack of studies reporting on the tracking of SB during this developmental stage indicates that this area should be a target for future research. Such cohort studies are required urgently given that this is a period where participation in PA decreases and is coupled with an increase in SB. A clear understanding of the longitudinal temporal trends of PA and SB across this developmental period is needed to guide government activity recommendations and to enable the effectiveness of activity intervention in adolescence for long term activity change to be evaluated.

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539 **Table 1.** Descriptive information for each of the included articles.

First Author	Year	Country of Origin	Gender (M/F)	Baseline Age (years)	Follow-up Age (years)	Participant (N)	Follow-up Duration (years)	Measurement
Anderssen, Wold and Torsheim [20]	2005	Norway	Male:47% Female: 53%	13.3 ± 0.3	21	557	8 years	Self-report Frequency & time measure questions taken from the WHO Cross-national survey of European schoolchildren & Health behaviour in school children surveys.
Boreham, Robson, Gallagher, et al. [29]	2004	Ireland	Male: 51.5% Female: 48.5%	15	22	476	7 years	Habitual physical activity questionnaire & modified Baecke questionnaire at follow-up.
Busschaert, Cardon, Van Cauwenberg, et al. [19]	2015	Belgium	Males:46.4% Females:53.6%	9.9±.43	19.9±.43	593	10 years	Questionnaire (sedentary behaviour and individual, social, and environmental variables).
Fuller, Sabiston,	2011	Canada	Males:46% Females:64%	12.7 years	20 years	808	8 years	7 day recall adapted from the weekly activity checklist.

Karp, et al. [25]								
Gordon-Larsen, Nelson and Popkin [35]	2005	USA	Male:53% Female: 47%	11-21 (16.0 years, mean age).	18-26 years (22.6 years, mean age)	13,030	6 years	Add Health questionnaire (PA and screen-time).
Kimm, Glynn, Kriska, et al. [34]	2000	USA	Females:100%	9-10 years	18-19 years	2379	10 years	Caltrac activity monitor, 3day diary & habitual patterns questionnaire (HAQ)
Kjonniksen, Torsheim and Wold [21]	2008	Norway	Not reported	13.3	23	630	10 years	Self-report questionnaire (included global & specific types of leisure-time physical activity).
Li, Haynie, Lipsky et al. [33]	2016	USA	Not Reported	16.1	20	561	4 years	Actigraph accelerometer
Ortega, Konstabel, Pasquali, et al. [12]	2013	Spain	Males: 45% Females: 55%	9-15 years	18-25	1800	10 years	Actigraph accelerometer.

Owens, Crone, De Ste Croix, et al. [32]	2013	UK	Not reported	14-17 years	not reported	886	Post Compulsory Education	Self-report questionnaire (based on physical activity & screen-time).
Rauner, Jekauc, Mess, et al. [22]	2015	Germany	Male: 47% Female: 53%	T0: 11-13 years (young group) &14-17 years (old group)	T1: 17 to 19 years (young group) & 20-23 years (old group).	947	6 years	Motorik-Modul physical activity questionnaire (MoMo-PAQ).
Raustorp and Ekroth [23]	2013	Sweden	Males: 52.5% Females: 47.5%	12-14 years	24-25 years	40	10 years	Yamax SW-200 pedometer
Simons, Rosenberg, Salmon, et al. [28]	2015	Belgium	Males: 50.5% Females: 49.5%	Grade 12: 17-18 years	Not reported: Follow-up twice 12 months apart ~ 20 years	374	2 years	Minnesota leisure-time physical activity Questionnaire

Telama, Yang, Viikari, et al. [24]	2005	Finland	Not reported	9 years	39 years	1563	9 years	Short self-report questionnaire
Walters, Barr-Anderson, Wall, et al. [26]	2009	USA	Not reported	15.9	20.4	1709	5 years	Adapted version of Godin leisure time exercise questionnaire
Young, Cohen, Koebnick, et al. [27]	2018	USA	Females 100%	14 years	23 years	428	9 years	Actigraph accelerometer MTI model 7164

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541 **Table 2.** Studies reporting tracking correlation coefficients of physical activity from baseline to follow-up.

Frequency of Physical Activity							
Author	**N**	**Baseline Age (Years)**	**Length of Follow-up (Years)**	**Correlation Co-efficient (Males)**	**Correlation Co-efficient (Females)**	**Correlation Co-efficient (All)**	**Note**
Anderssen, Wold and Torsheim [20]	557	13.3 ± 0.3	8	0.22***	0.18**		Frequency of activities per week that caused one to sweat or loose ones breath.
		13.3 ± 0.3	6	0.27***	0.15**		
		16	3	0.44***	0.34***		
		16	5	0.47***	0.28***		
Kjonniksen, Torsheim and Wold [21]	630	13.3 years	10	0.21**	0.23***		Number of physical activities participated in at age 15 and frequency of leisure time physical activity at age 23.
Raustorp and Ekroth [23]	40	12	10			0.47	Tracking according to pedometer recommendations.
		15	7	0.21	0.09		Daily step counts.
							Daily step counts.

		12	10	0.21	-0.1		
Rauner, Jekauc, Mess, et al. [22]	947	14-17	6	0.198*	0.201*	0.208*	Overall physical activity, days/week
Duration of Physical Activity							
Anderssen, Wold and Torsheim [20]	557	13.3 ± 0.3	8	0.27***	0.25***		Hours per week spent in activities that caused one to sweat or lose ones breath.
		13.3 ± 0.3	6	0.21***	0.27***		
		16	3	0.43***	0.35***		
		16	5	0.5***	0.3***		
Rauner, Jekauc, Mess, et al. [22]	947	14-17	6	0.072	0.109*	0.102	Leisure time physical activity: min/week
		14-17	6	0.214*	0.239*	0.254*	Sports club physical activity: min/week
		14-17	6	0.200*	0.332*	0.275*	Overall sports index: min/week
Combination							
Telama, Yang, Viikari, et al. [24]	1563	15	9	0.37**	0.61**		Physical Activity Index: Frequency, intensity, duration & participation in organised physical activity.
		12	12	0.33**	0.19**		

	9	15	0.31**	0.21*	

[1]

[1] Boldface indicates statistical significance (*****p<0.05; ******p<0.01**; *****p<0.001).

543 **Table 3.** Percentage of relative change or maintenance of relative position of activity from baseline to follow-up.

Author	N	Baseline Age (Years)	Length of Follow-up (Years)	Males	Females	All	Note
Absolute Percentage: Physical Activity Change (%)							
Kimm, Glynn, Kriska, et al. [34]	2379	9-10	10		-83		Habitual physical activity (MET-times.wk^{-1}).
		9-10	10		-35		Activity diary score (MET-min.d^{-1}).
Population Percentage Change (%)							
Anderssen, Wold and Torsheim [20]	557	13.3 ± 0.3	8	18	21		18% males & 21% females reported increase in frequency of physical activity.
				58	54		Reported frequency decline.
				19	21		Reported increase in duration.
				58	53		Reported decline in duration.
Rauner, Jekauc, Mess, et al. [22]	947	14-17	6			54	LTPA (min.wk^{-1}): moved from being active at baseline to inactive.
						46	LTPA (min.wk^{-1}): inactive at baseline to active.
						58.9	OPA (meeting MVPA recommendations): Fulfilled at baseline to unfulfilled.
						41.1	OPA: unfulfilled at baseline to fulfilled.
Population Percentage: Activity Tertiles (%)							
Anderssen, Wold and Torsheim [20]	557	13.3 ± 0.3	6	41	18		Remained High activity tertile (4-6 times.wk^{-1}) at baseline and 19 years.
		13.3 ± 0.3	8	28	22		Remained High activity tertile (4-6 times.wk^{-1}) at baseline and 21 years.
		13.3 ± 0.3	6	24	30		Remained Medium activity tertile (2-3 times.wk^{-1}) at baseline and 19 years.
		13.3 ± 0.3	8	32	32		Remained Medium activity tertile (2-3 times.wk^{-1}) at baseline and 21 years.
		13.3 ± 0.3	6	73	55		Remained Low activity tertile (1 time.wk^{-1} or less) at baseline and 19 years.
		13.3 ± 0.3	8	63	31		Remained Low activity tertile (1 time.wk^{-1} or less) at baseline and 21 years.

Young, Cohen, Koebnick, et al. [27]	428	14	9		64		Remained in the consistently inactive group at all 3 periods (MVPA decreased at all-time points)
					29		Remained in the decreasingly active group, (MVPA similar during first 2 time points and then decreased).
					7.5		Remained in the Increasingly active group, (MVPA increased at all-time points).
Population Percentage: Recommendations (%)							
Gordon-Larsen, Nelson and Popkin [35]	13030	16.0	6	5.9**	2.7		Achieved 5 or more sessions MVPA at baseline and follow-up.
				52.3**	70.7		Did not achieve 5 or more sessions MVPA in either period.
				37.2**	4.4		Achieved 5 or more sessions MVPA at baseline but not at follow-up.
				4.6**	24		Did not achieve 5 or more sessions MVPA at baseline but did at follow-up.
				43.9*	29.4		Achieved ≤ 14 hr.wk^{-1} TV, video viewing, and computer game use at both periods.
				17.7*	29.8		Did not achieve ≤ 14 hr.wk^{-1} TV, video viewing, and computer game use in either period.
				16.4	18.4		Achieved ≤ 14 hr.wk^{-1} TV, video viewing, and computer game use at baseline but not at follow-up.
				22.1	22.4		Did not achieve ≤ 14 hr.wk^{-1} TV, video viewing, and computer game use at baseline but did at follow-up.
Li, Haynie, Lipsky et al. [33]	561	16.2	4	4.9	13.0	8.2	Meeting PA guidelines at baseline and follow-up during week days
				2.9	13.8	7.4	Meeting PA guidelines at baseline and follow-up during weekends
Owens, Crone, De Ste Croix, et al. [32]	886	14-17	Post compulsory education.	9.7	4.4	14.0	Meeting PA guidelines at baseline.
				6.2	2.7	8.9	Meeting PA guidelines at follow-up.
				81			Not meeting PA guidelines at baseline: not meeting them at follow-up.
				5.0			Not meeting PA guidelines at baseline: meeting guidelines.
				10.1			Meeting PA guidelines at baseline: not meeting guidelines.

		3.9	Meeting PA guidelines at baseline: meeting guidelines.

544 [2]

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[2] Boldface indicates statistical significance (*****p<0.05; ******p<0.01**; *****p<0.001). LTPA: Leisure time physical activity, OPA: Overall physical activity, PA: Physical activity, MVPA: Moderate-to-vigorous physical activity.

546 **Appendix One: Supplementary Table 1:** Methodological Quality Assessment.

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Study population and participation (baseline): the study sample represents the population of interest on key characteristics.		
1	Is the source population adequately described?	Comment required on the source population; the population from which the sample was taken.
2	Is the sampling frame, recruitment methods, period of recruitment and place of recruitment (setting and geographical location) adequately described?	Sampling frame; source material/list from which the study population will be drawn
		Recruitment methods; explanation of methods used to recruit , possibly include methods to identify the sample
		Period of Recruitment; comment required on the dates between which the study was conducted
		Place of recruitment; are the study setting and geographical location adequately described?
3	Is the participation rate at baseline at least 80%, or is the non-response non selective (show that baseline study sample does not significantly differ from population of eligible subjects)?	Comment required on the number of eligible candidates that agreed to take part in the study must be at least 80% of the initial cohort invited to take part.
		Or comment required showing the baseline sample is not significantly different from the population of eligible subjects.
4	Is there an adequate description of the participants beginning the study (baseline study sample) for key characteristics (number of participants, age and gender)?	Comment required on baseline characteristics.
		Number of participants; total number of participants (after screening for eligibility and consent) included in the first stage of data collection.
		Age, gender, activity level; self- explanatory.

Study Attrition: loss to follow-up is not associated with key characteristics (i.e. the study data adequately represent the sample)		
5	Is there provision of the exact number of participants at each follow-up measurement?	Response rate; is the proportion of the study sample completing the study and providing outcome data at each follow-up measurement mentioned?
6	Is follow-up duration mentioned?	Self-Explanatory
7	Is there presentation of data providing not selective non-response during follow-up measurements?	Is there data presented suggesting that during follow-up measurements non-response was not selective?
Data Collection:		
8	Are the methods of data collection adequately described?	Are methods of data collection adequately described; description of tools (surveys, questionnaire, objective measures) and processes (telephone, face-to-face, trained individuals)?
9	Is there adequate description of what measurement tool was used for the assessment of physical activity and/or sedentary behaviour, and is the outcome variable (i.e. self-reported daily MVPA, self-reported EE or average minutes of MVPA over the past month) reported?	Are all measurement tools adequately described? Is the assessment of activity completed in the presence of or by trained personnel by means of standardised protocols? Is the outcome variable reported?

10	Is there a clear description of the cut-points, thresholds or definitions (if self-report) used to define physical activity and/or sedentary behaviour?	Self-explanatory
Outcome Measurement: the outcome of interest is adequately measured in study participants.		
11	Is there a clear definition of the outcome of interest provided?	Is there a clear definition of the outcome of interest provided including length of follow-up and level and extent of the outcome construct?
12	Is the outcome measure and method used adequately valid?	Does the study suggest evidence that the validity was examined against or discussed in relation to a gold standard?
		May include relevant outside sources of information on measurement properties, also, characteristics such as blind measurement and confirmation of outcome with valid results.
13	Is the outcome measure and method used reliable?	Does the study suggest evidence of reproducibility of the tools used?
		May include relevant outside sources of information on measurement properties, also, characteristics such as blind measurement and confirmation of outcome with reliable results.
14	Is the method and setting of measurement the same for all participants?	Self-explanatory
Data Analysis: statistical analysis for the design of the study.		
15	Adequate description of analysed sample (in- and exclusion criteria).	Self-explanatory

16	Does the analysed sample consists of ≥500 participants?	Self-explanatory
17	Is there age- and gender-specific presentation of anthropometric and activity data at baseline and follow-up?	Self-explanatory
18	Is the presentation of "longitudinal" analyses methods stated and adequate for the design of the study?	Longitudinal analyses is defined as those assessing change in outcome over two or more time points and that take into account the fact that observations are likely to be correlated.
19	No selective reporting of results.	Self-explanatory

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Supplementary Table 2: Quality Assessment scoring for individual studies included in this review.

Author & Year	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Score	Quality
Anderssen et al [19]	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+	?	+	+	17	High
Boreham et al. [20]	+	+	+	+	+	+	+	+	+	+	+	-	-	-	+	-	+	+	+	15	High
Busschaert et al. [21]	+	+	+	+	+	+	?	+	+	+	+	+	+	?	+	+	+	+	+	17	High
Fuller et al. [22]	+	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	18	High
Gordon-Larsen et al. [23]	+	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	18	High
Kimm et al. [24]	+	+	+	+	+	+	+	+	+	+	+	-	-	-	+	+	+	+	+	16	High
Kjønniksen et al. [25]	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	19	High
Li et al. [26]	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	-	+	+	+	17	High
Ortega et al. [12]	+	+	+	+	+	+	-	+	+	+	+	-	-	-	+	+	+	+	+	15	High
Owens et al. [37]	+	?	-	+	+	+	-	+	+	+	+	+	-	+	+	+	-	+	-	13	Low
Rauner et al. [28]	+	+	-	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+	17	High

Raustorp and Ekroth [29]	+	+	+	+	+	+	-	+	+	+	+	-	-	-	+	-	+	+	+	14	Moderate
Simons et al. [30]	+	+	?	+	+	+	-	+	+	+	+	+	?	+	+	-	?	+	+	14	Moderate
Telama et al. [31]	+	+	+	?	+	+	-	+	+	+	+	+	+	-	+	+	-	+	+	15	High
Walters et al. [32]	+	+	+	+	+	+	+	+	+	+	+	-	+	-	+	+	+	+	+	17	High
Young et al. [33]	+	+	+	+	+	+	+	+	+	+	+	-	-	+	+	-	+	+	+	16	High

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553 **Supplementary Table 3**: Studies reporting the odds of being physically active or sedentary at follow-up based on baseline levels.[3]

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				Odds Ratio (95% CI)		555
Author	N	Baseline Age (Years)	Length of Follow-up (Years)	Males	Females	Note
Telama et al. [31]	1563	15 & 18 15 & 18	3 6	OR 11.8 (5.1, 27.6) OR 19.2 (6.2, 59.1)	OR 4.4 (1.2, 15.7) OR 6.1 (1.5, 24.4)	Active subjects (highest quartile of physical activity index) versus inactive (lowest quartile physical activity index).
Owens et al. [27]	886	14-17	Post compulsory education.		OR 0.576 (0.335, 0.989)*	Meeting physical activity guidelines at baseline to not meeting them at follow-up.
Busschaert et al. [21]	593	9.9 ± 0.43	19.9 ± 0.43	OR 5.1 (1.778, 14.478)** OR 3.4 (1.792, 6.637)***	1.502 (0.565, 3.995)[NS] 1.165 (0.688, 1.974)[NS]	Exceeded Screentime guidelines at baseline: exceeded at follow-up (weekdays). Exceeded Screentime guidelines at baseline: exceeded at follow-up (weekends).

[3] Statistical significance (*p<0.05; **p<0.01; ***p<0.001). NS indicates non-significant.

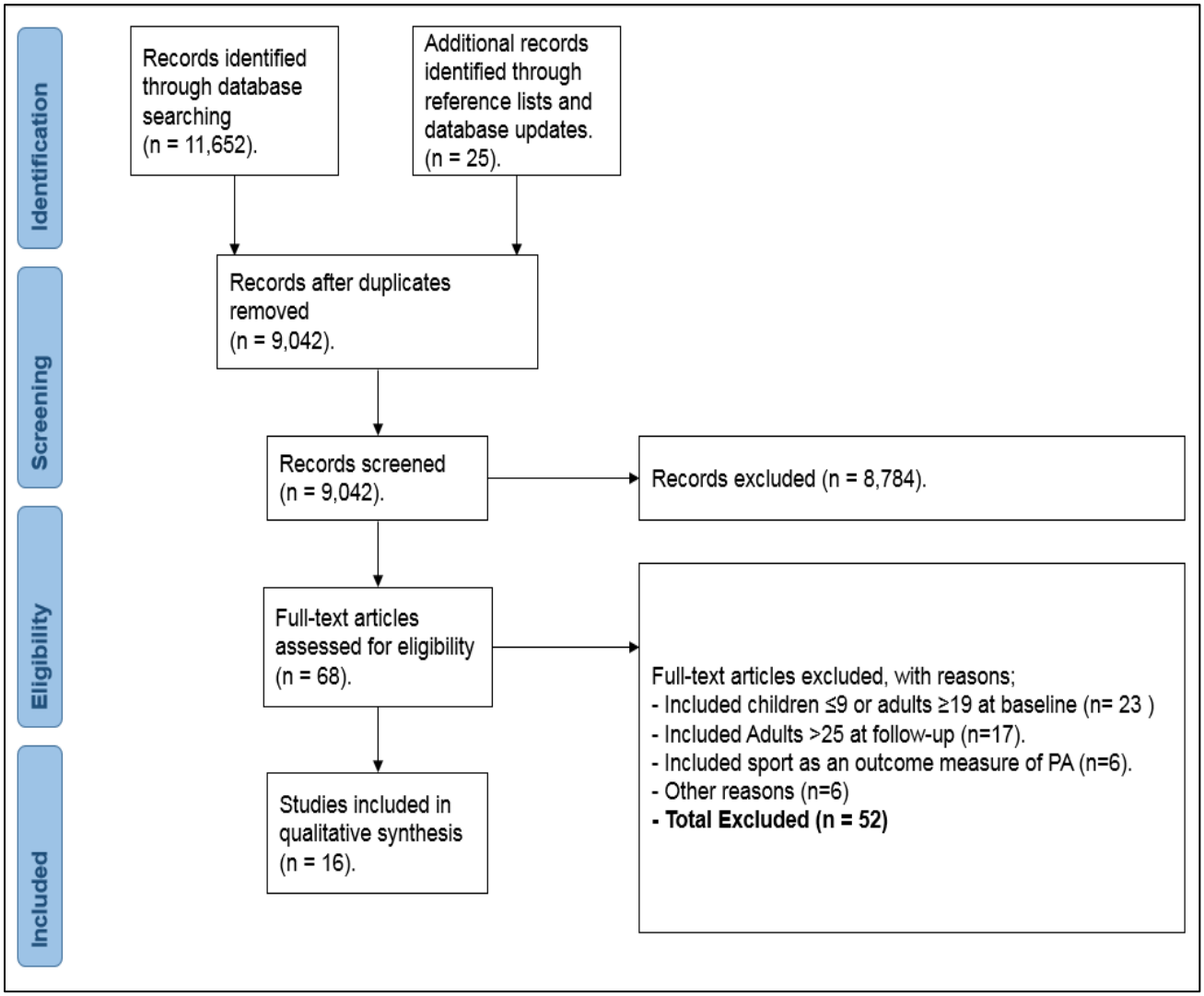

Figure 1. PRISMA flow diagram displaying study selection.