Is the transition from primary to secondary school a risk factor for energy balance-related behaviours? A systematic review

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Abbreviations

PA	Physical Activity
SB	Sedentary Behaviour
MVPA	Moderate-to-vigorous Physical Activity
TPA	Total Physical Activity
LPA	Light intensity Physical Activity
MPA	Moderate Physical Activity
VPA	Vigorous Physical Activity
SSB	Sugar Sweetened Beverages

Abstract

Objective: The substantial changes in the physical and social environment during the transition from primary to secondary school may significantly impact adolescents' energy balance-related behaviours (i.e. dietary behaviour, sedentary behaviour, sleep behaviour, and physical activity). This is the first review systematically summarising evidence on changes in four energy balance-related behaviours of adolescents across the school transition from primary to secondary school.

Design: For this systematic review the electronic databases Embase, PsycINFO and SPORTDiscus were searched for relevant studies from inception to August 2021. PubMed was searched for relevant studies from inception to September 2022. Inclusion criteria were: i) longitudinal studies reporting ii) one or more energy balance-related behaviours iii) across the school transition i.e. with measurement(s) during both primary and secondary school.

Setting: Transition from primary to secondary school

Participants: Adolescents across the transition from primary to secondary school.

Results: Thirty-four studies were eligible. We found strong evidence for an increase in sedentary time, moderate evidence for a decrease in fruit and vegetable consumption, and inconclusive evidence for a change in total, light, and moderate-to-vigorous physical activity, active transport, screen time, unhealthy snack consumption, and sugar sweetened beverages consumption among adolescents across the school transition.

Conclusions: During the transition from primary to secondary school, sedentary time and fruit and vegetable consumption tend to change unfavourably. More high-quality, longitudinal research is needed specifically on changes in energy balance-related behaviour across the school transition, especially regarding sleep behaviour. (Prospero registration: CRD42018084799)

Keywords: Adolescents; obesity; physical activity; sedentary behaviour; sleep behaviour; dietary behaviour

Introduction

The number of adolescents with overweight and obesity is growing worldwide and this public health problem is currently one of the most serious challenges of the 21st century(1). Adolescents with overweight and obesity are at increased risk of various lifestyle-related diseases later in life, including hypertension, hypercholesterolemia, diabetes mellitus type 2, and cardiovascular diseases(2-4). Additionally, due to stigmatization, adolescents with overweight and obesity tend to have lower self-esteem(5), which can result in loneliness, sadness, and tenseness(6). It is therefore important to prevent overweight and obesity during childhood. Childhood overweight and obesity are caused by different behaviours that interact and influence each other(7), including an unhealthy diet, reduced sleep duration, low levels of physical activity (PA), and excessive screen time(8-10). During adolescence obesity prevalence is higher among 12-19-year olds than 4-11-year-olds(11, 12). The transition from primary to secondary school might contribute to this increase in obesity prevalence.

Previous reviews on the age period of the transition showed that adolescents' PA levels decreased while their sedentary behaviour (SB) and screen time increased(13, 14). Other studies in the United Kingdom and the United States showed that dietary patterns from adolescents in secondary schools are more unfavourable (i.e. an increase in sugar sweetened beverages intake and a decrease in fruit and vegetable intake)(15-17). In addition, when adolescents grow older they tend to increase their screen time(18). Which is unfavourable since a systematic review showed that screen time was associated with reduced sleep duration and increased sleep problems among adolescents(10).

There are several explanations for the change towards unfavourable energy balance-related behaviours when adolescents transition from primary to secondary school. For example, when adolescents grow older changes in the biological regulatory processes occur that are known to cause a biological delay in the timing of sleep onset(19). Additionally, parents generally set less rules regarding for example screen time when their children grow older(20). The transition in school environment also results in changes in intrapersonal factors and social- and physical environmental factors(21-24), including changes in sports facilities, academic expectations, and self-judgement of PA skills(23, 24). Furthermore, adolescents experience more freedom, receive more pocket money that both enables them to buy high energy foods and drinks(25-27). On top of that, this period is associated with an increase in travel duration and adolescents experiencing social stress due to the school transition(28, 29).

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Currently, no systematic review studied dietary behaviour across the transition from primary to secondary school. Furthermore, no recent systematic review examined PA, SB, sleep behaviour and dietary behaviour during the school transition. A combined review is of interest because these behaviours are connected and influence each other, for example more screen use leads to more unhealthy snacking, less PA, and lower sleep quality(30). Therefore, this systematically review summarized the evidence on changes in four energy balance-related behaviours (i.e. PA, SB, sleep behaviour, and dietary behaviour) of adolescents in the transition from primary to secondary school.

Methods

This systematic review was conducted following the PRISMA statement for reporting systematic reviews (31). The review protocol is registered in the International Prospective Register for Systematic Reviews (registration number CRD42018084799 at www.crd.york.ac.uk/prospero/).

Search strategy

The search strategy included terms related to PA, SB, sleep behaviour, and dietary behaviour and the transition from primary to secondary school. We searched for relevant studies in four electronic databases (PubMed, Embase, PsycINFO, and SPORTDiscus) from inception until August 2021. In addition, we manually searched the reference lists of included studies for relevant studies.

Inclusion criteria

Studies were included if they had a longitudinal design and examined one or more energy balance-related behaviours across the transition from primary/elementary school (hereafter referred to as primary school) to secondary/middle school (hereafter referred to as secondary school), with at least one measurement in adolescents attending the final grades of primary school and one in the same adolescents attending the first grades of secondary school. Only full-text studies published in English in peer-reviewed journals were included.

Identification of relevant studies

First, one author (HE) performed the search in co-operation with a search specialist from the library of the Vrije Universiteit Amsterdam. Second, two authors independently checked potentially relevant studies by screening the titles and abstracts (HE and CD/TA); when

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abstracts were not available the studies were included for full-text screening. Third, two authors (HE and CD/TA) independently screened full-text studies to determine whether the inclusion criteria were met. Any discrepancies between the authors were resolved through discussion. A third reviewer (TA/CD) was consulted when consensus could not be reached.

Data extraction

Two authors (HE and CD/TA) independently extracted data from all included studies, using a structured data extraction form. Information was extracted regarding participant characteristics (i.e. ethnicity and gender), study characteristics (i.e. type of energy balance-related behaviour, length of follow-up, measurement of energy balance-related behaviours) and the study results. To reach consensus for a uniform data extraction procedure two authors (HE and CD/TA) independently extracted data from the first three studies, before continuing with all other included studies. Discrepancies were resolved through discussion. A third reviewer (TA/CD) was consulted when consensus could not be reached.

Quality assessment

To assess the methodological quality of the included studies we used the 14-item NIH Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies(32). We included the following quality items: having a clearly stated research question, a clearly specified study population, a representative sample, non-biased recruitment of subjects, justification of sample size, valid and reliable assessment tool, an adequate follow up rate, and statistical analysis adjusted for potential confounders (for the details see Table 1). Three of the included items were informative, and only the five validity/precision items were included in the quality score(33). Six quality items of the tool were not applicable for our research question and study design and were therefore excluded including exposure of interest, sufficient timeframe, different levels of exposure, exposure measures and assessment, and blinding for exposure outcomes.

Quality items were scored following a ‘yes’, ‘no’, ‘cannot be determined’, ‘not applicable’, or ‘not reported’ answering format. Two assessors (HE and TA/CD) independently assessed the quality items of the included studies. Discrepancies were resolved through discussion. A third reviewer was consulted when consensus could not be reached (CD/TA). Studies that included multiple energy balance-related behaviours, used multiple outcomes for one behaviour e.g. MVPA and active transport or used multiple measurement tools for one

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behaviour (e.g. objective and self-reported) received multiple scores. A study was considered '*strong*' when scoring 80-100% of the validity/precision criteria points, '*moderate*' when scoring 40-79% of the validity/precision criteria points and '*poor*' when scoring 0-39% of the validity/precision points.

Best evidence synthesis

We applied best evidence synthesis to draw conclusions regarding the evidence for a change in energy balance-related behaviours across the transition from primary to secondary school. This evidence synthesis is in line with previous reviews(33-35), taking the number of studies, the methodological quality of the studies, and the consistency of the findings into account. The level of evidence was defined as:

- Strong evidence: consistent findings in more than two strong quality studies.
- Moderate evidence: consistent findings in one study of strong methodological quality and at least one study of moderate methodological quality or consistent findings in two or more studies of moderate methodological quality.
- Inconclusive evidence: only one study available, or inconsistent findings in two or more studies.

We considered the results within a study consistent when at least 75% of the outcomes (e.g. TPA, MVPA, or transport) within the same behaviour (e.g. PA) showed statistically significant ($P<0.05$) results in the same direction. Publications based on the same data were only counted once in the best evidence synthesis, i.e. combining the results from those publications. When studies described changes in energy balance-related behaviours without testing whether these changes were statistically significant, we contacted the authors by email and requested additional analyses or the necessary data to conduct the analyses ourselves. We contacted the authors of seven studies of which two provided the requested information or dataset. These results of these studies were included in the evidence synthesis(36, 37), the other studies could not be included. We considered the results across studies consistent when at least 75% of the studies showed results in the same direction, which was defined by significance ($P < 0.05$). Studies with a poor quality rating are included in table 2 but were not included in the evidence synthesis.

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Results

Search results

After removing duplicates, the search yielded 3,495 unique hits (see Figure 1). Screening of titles and abstracts resulted in 107 potentially eligible studies. Full-text screening resulted in 31 studies that met the inclusion criteria. Three additional studies were included after a manual search of reference lists. This resulted in the inclusion of in total 34 studies.

Study characteristics

Table 2 presents the characteristics of the included studies, which were conducted in the United States, Australia, United Kingdom, Belgium, Finland, Japan, Korea, the Netherlands and Norway. Eighteen studies focused on PA(21, 28, 37-52), eight on PA and SB(22, 53-59), one on SB(60), one on PA, SB and dietary intake(36), five on dietary intake(15, 16, 61-63) and none on sleep behaviour. In total 24 studies used data from cohort studies, including the CHIC, PEACH, TRACK, SPEEDY, PASS, APPLES, CATCH, ECLS-K, CLAN, KCYPS, and HEAPS studies. All studies were published between 1998 and 2021 with sample sizes ranging from 99 to 7,445 participants. The average participant age at the time-point at primary school ranged from 10 to 12 years old and follow-up from five months to four years. Table 3 summarises 19 strong and moderate quality studies reporting evidence on energy balance-related behaviours (i.e. PA, SB, sleep behaviour, and dietary behaviour) across the transition from primary to secondary school.

Physical activity

PA was assessed using accelerometers(21, 22, 28, 36, 38, 40, 41, 43, 46, 47, 49-52, 54-56, 59, 64), self-report questionnaires(21, 28, 37, 38, 42, 44, 45, 48, 50, 53, 55), pedometers(57, 58), parent-reported questionnaires(50), activity logs(39), Global Positioning System (GPS), loggers and Geographical Information Systems (GIS) data(51). Fourteen studies examined multiple PA measures(21, 22, 28, 38, 43, 48, 50, 51, 54-58, 64) and fourteen studies examined one PA measure: total physical activity (TPA), MVPA, level of PA (duration and intensity of 16 activities), active/non-active classification (active defined as having a score of at least 3 out of 5 points on the Physical Activity Questionnaire for Older Children), Perceived Physical Education Activity, active transport, and number of vigorous activities(36, 37, 39-42, 44-47, 49, 53, 59). Eight studies received a strong methodological quality rating(38, 43, 46, 49, 51, 54, 56, 64). Three studies received a strong methodological

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quality rating for the accelerometer-based data and a moderate quality rating for the questionnaire-based data(21, 28, 55). Twelve studies received a moderate quality rating(22, 36, 37, 40, 41, 47, 48, 50, 52, 57-59) and five studies received a poor quality rating(39, 42, 44, 45, 53). Sixteen studies were included in the evidence synthesis(21, 28, 36, 37, 40, 43, 45, 46, 49, 51, 52, 54-56, 58, 64).

Seven studies examined the change in TPA across the transition from primary to secondary school. One study with moderate quality rating for the questionnaire-based data and strong quality rating for the accelerometer-based data showed a significant decrease in questionnaire-based TPA (min/day), but no change in accelerometer-based TPA or MVPA (min/day)(21). Three strong quality studies based on the TRACK data showed a significant decrease in overall TPA (min/hour)(46, 49), TPA during school time, TPA after school time and TPA during evening time(43). One moderate quality study showed a significant decrease in TPA among boys with a healthy weight, but not among boys with overweight or girls with or without overweight(58). The last moderate quality study examined TPA in various times of the day, the study showed a significant decrease in the number of adolescents classified as active and decrease in TPA during recess and lunchtime, but no changes were found in physical education, PA after school time, PA in the evenings, and PA in the weekends(45).

Five strong quality studies examined the change in LPA(51, 54-56, 64), of which two studies showed a significant decrease in LPA (min/day)(54, 55), one study showed no changes(64), and one study showed a significant decrease among boys but not among girls(56). One study showed a significant decrease in LPA during and after school time (min/day), but no changes before school time and on weekend days. Context-specific results showed a decrease in LPA before school time at home, during school time at school, and after school time at sports grounds and other locations (51). There was a significant increase in LPA during school time at other locations (e.g. at friend's homes or at parks). No changes were found for weekend days (51).

Ten studies examined the change in MVPA of which two studies examined moderate physical activity (MPA) and vigorous physical activity (VPA)(21, 28, 36, 43, 51, 52, 54-56, 64). We combined findings of the MPA and VPA studies with those of the studies examining MVPA, as results for these behaviours were in the same direction. Four studies with a strong quality rating showed a significant decrease in total MVPA(54, 55, 64) and MVPA during

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recess and lunchtime(56). Two moderate quality studies showed a significant decrease in MVPA of which one among girls only(36, 52). Two studies with strong quality rating showed a significant increase in weekday MVPA(21, 28). One study, with a strong quality rating, examined MVPA during various times in the day and showed a significant decrease in MVPA during school time among boys and girls, during the evening among girls only, but no changes in MVPA after school time(43). The last study, with a strong quality rating showed a significant decrease in MVPA after school time, but no changes before school time, during school time, and on weekend days(51). Context-specific data showed a decrease in MVPA after school time at school and at other locations, a significant increase in MVPA during school time at other locations, while no changes were found before school time and on weekend days(51).

One study with strong quality rating(51) and four studies with a moderate quality rating examined the change in active transport(21, 37, 40, 55). The strong quality study showed a significant increase in active transport-related LPA before school time and a decrease in passive transport-related LPA before school time, after school time and during weekends, but no changes in active and passive transport-related MVPA(51). Three moderate quality studies showed a significant increase in active transportation to/from school (min/day)(21, 37) or MVPA when commuting (min/day)(40), of which one showed no change in active transport to leisure time destinations(37). The last study with moderate quality showed a significant decrease in times per week cycling or scooting to/from school, while no changes were found for walking to/from school(55).

Two studies with a moderate quality rating did not fit the previous categories. One study found a significant decrease in extracurricular PA(21). Another study found a significant decrease in school-related PA among boys with a healthy weight, and leisure time PA among boys and girls with a healthy weight, but no changes among boys and girls with overweight(58).

Overall, based on inconsistent findings, we found inconclusive evidence for a change in TPA, LPA, MVPA, and active transport of adolescents across the transition from primary to secondary school.

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Sedentary behaviour

SB was assessed using accelerometers(22, 36, 54-56, 59, 60, 64) and questionnaires(53, 55, 57, 58, 60). Three studies received a strong methodological quality rating(54, 56, 64) and one study received a strong methodological quality rating for the accelerometer-based data and a moderate quality rating for the questionnaire-based outcomes(55). Six studies received a moderate methodological quality rating(22, 36, 57-60) and one study received a poor quality rating(53). Six studies could be included in the evidence synthesis(36, 54-56, 58, 64).

Five studies examined the change in sedentary time, of which four studies showed a significant increase across the transition from primary to secondary school. Two of these studies received a strong quality rating(54, 64), one a strong quality rating for the accelerometer-based data(55), and one a moderate quality rating(36). One study with a strong quality rating found a significant increase in the proportion of sedentary time during recess and lunchtime(56).

Two studies with a moderate quality rating examined the change in self-reported screen time across the school transition. One of the studies showed a significant increase in screen time for homework and leisure time during the week, but not during the weekend(55). The other study showed a significant increase in screen time in boys with a healthy weight but no changes in girls or boys with overweight(58).

Overall, we found strong evidence for an increase in SB of adolescents across the transition from primary to secondary school. We found inconclusive evidence for a change in screen time across the transition due to inconsistent results.

Dietary behaviour

Dietary behaviours were assessed using 24-hour recalls(16, 36), food frequency questionnaires(61-63), and food diaries(15). Two studies examined overall diet quality(36, 63). Four studies examined the consumption of fruit, vegetable, snacks and sugar sweetened beverages (SSBs)(15, 16, 61, 62). Three studies examined additional dietary behaviours, with one study examining breakfast, lunch, milk, and fruit-flavoured beverage consumption(16), one study examining total energy intake and macro- and micronutrient intake(15), and one study examining milk consumption(62). Five studies received a moderate quality rating(15,

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16, 36, 61, 63) and one a poor quality rating(62). Five studies were included in the evidence synthesis(15, 16, 36, 61, 63).

Three studies with a moderate quality rating examined the change in fruit and vegetable consumption across the transition from primary to secondary school, all showing a significant decrease in consumption(15, 16, 61).

Three studies with a moderate quality rating examined the change in unhealthy snack consumption(15, 16, 61). One study showed a significant decrease in the consumption of non-core food items, such as potato chips and chocolate(61). One study showed a significant increase in consumption of fries and confectionary, but no change in the consumption of other savoury snacks(15). The last study showed a significant decrease in the consumption of high-fat salty snacks, but no change in the consumption of overall snacks, and high-fat sweet snacks consumption(16).

Three studies with a moderate quality rating examined the change in consumption of SSBs (15, 16, 61). Two studies showed a significant increase in the consumption of SSBs(15, 16). One of these studies showed a significant decrease in the consumption of fruit juice(16). A third study showed a significant decrease in the consumption of SSBs(61).

Three studies with a moderate quality rating did not fit the previous categories. Two studies based on data from the TRACK study showed a significant decrease in total diet quality(36, 63) and one study showed a significant decrease in the consumption of milk(16). The last study showed a significant increase in total energy intake and dietary fibre intake and a significant decrease in total daily energy intake from sugars and the intake of saturated fatty acids(15). In this study no significant changes were found for daily energy percentages from protein, carbohydrates, and fat(15).

Overall, we found moderate evidence for a decrease in fruit and vegetable consumption of adolescents across the primary to secondary school transition. Studies on unhealthy snack and SSBs consumption showed inconsistent results leading to inconclusive evidence. The outcomes in studies that did not fit the previous categories were only reported once, leading to inconclusive evidence.

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Discussion

This systematic review summarized the evidence on changes in energy balance-related behaviours (i.e. PA, SB, sleep behaviour, and dietary behaviour) of adolescents across the transition from primary to secondary school. We found strong evidence for an increase in SB, moderate evidence for a decrease in fruit and vegetable consumption, and inconclusive evidence for a change in TPA, LPA, MVPA, active transport, screen time, unhealthy snack and SSBs consumption. No studies were identified examining the change in sleep behaviour across the transition from primary to secondary school.

Our results regarding inconclusive evidence for a change in TPA, LPA and MVPA across the transition from primary to secondary school is in contrast with previous literature. A review on PA change during adolescence (e.g. age-related literature not specifically focused on the school transition) found evidence for a decrease in PA (combining various outcomes of PA) in growing adolescents(65). Another study found a decline in TPA and MVPA when adolescents grow older(66). We found inconsistent results for a change in MVPA across the transition from primary to secondary school. Most of the included studies examining MVPA showed a significant decrease in total MVPA(54, 55), MVPA during recess and lunchtime(56), and MVPA during school time but not after school time(43). Remarkably, two studies showed a significant increase in weekday MVPA(21, 28). Our findings corresponds with a recent review showing that changes in 24-hour movement behaviours across the school transition largely depend on the time segments of the day or week(13). The increase in weekday MVPA across the transition might be explained by an increase in active transport. Although we found inconclusive evidence for an increase in active transport in the current review, three out of five studies showed a significant increase in MVPA during commuting(40) and active transportation to/from school(21, 37). One study found an increase in active transport-related LPA during weekdays and a decrease during weekend days across the school transition(51). Generally, the distance to/from school increases as adolescents transition from primary to secondary school, which can result in an increase in active transport(28). Conversely, an increased distance to/from school can also result in an increase in SB due to using passive, public transportation(28).

The finding of an increase in SB across the transition from primary to secondary school is consistent with previous studies in adolescents that showed an increase in SB when adolescents grow older(54, 67), and with a review that found an increase in SB across the

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primary to secondary school transition(14). However, our finding of inconclusive evidence for a change in screen time across the transition is in contrast to the findings of the review by Pearson et al. who showed an increase in screen time across the school transition(14). Different inclusion criteria regarding the transition from primary to secondary school might explain this difference. In the present review, studies had to describe clearly that at least one measurement was taken in adolescents attending primary school and one in the same adolescents attending secondary school. Five studies included in the review of Pearson et al. did not meet our inclusion criterion because they did not mention a transition from primary to secondary school.

We found moderate evidence for a decrease in fruit and vegetable consumption and inconclusive evidence for a change in unhealthy snack and SSBs consumption. This is partly confirmed in one cross-sectional study that found a decrease in fruit consumption and no change for vegetable consumption with increasing age(68). A review including age-related studies found a lack of evidence for many potential determinants of fruit and vegetable consumption in children and adolescents, especially for determinants related to the physical and social school environment(69). Studies on determinants of fruit and vegetable consumption across the transition from primary to secondary school are currently lacking. Based on previous studies we expected a significant increase in unhealthy snack and SSBs consumption due to adolescents experiencing more freedom and receiving more pocket money across the school transition from primary to secondary school(25-27, 70). An important remark regarding studies examining dietary behaviour is the use of many different self-report measures often of unknown validity and reliability(71). Consequently, the studies included in the present review examining dietary behaviour received a low quality rating resulting in inconclusive evidence.

No studies on sleep behaviour were available that met our inclusion criteria. However, as mentioned in the introduction we do expect changes in sleep behaviour across the transition from primary to secondary school. A study in Australian children showed that the majority of 10-11-year-olds met the minimum sleep requirements on school nights (9-11 hours), while a quarter of 12-13-year-olds did not meet the minimum sleep requirements on school nights (8-10 hours)(72). More research is needed to investigate sleep behaviour across the primary to secondary school transition.

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The results from this review suggest a worsening in aspects of the energy balance-related behaviours PA, SB and dietary behaviour across the transition from primary to secondary school. Energy balance-related behaviours are connected and strengthen each other, for example an increase in screen time has been associated with an increase in unhealthy snack consumption, a decrease in fruit and vegetable consumption(73) and less sleep(10). Interventions targeting these energy balance-related behaviours during the transition from primary to secondary school therefore seem warranted. In the current review 9 out of 33 included studies examined more than one behaviour, of which eight on PA and SB(22, 53-59), and one on PA, SB and dietary intake(36). In these studies the outcomes of these behaviours were linked as results indicate that PA decreases were often replaced by SB(53-56). However, more longitudinal research is needed on changes in energy balance-related behaviour across the school transition, especially regarding sleep behaviour. Moreover, future research should focus on how energy balance-related behaviours influence each other in the school transition. Furthermore, qualitative research regarding the reasons for changes in behaviours related to the change in school environment is needed in order to develop appropriate interventions. To the best of our knowledge, current interventions do not specifically target the school transition period, but mainly focus on primary or secondary school. Moreover, many school-based interventions targeting PA and dietary behaviour exist, while only a few target healthy sleep behaviour(74).

Seven out of 33 studies included in the present review received a strong methodological quality rating(38, 43, 46, 49, 52, 54, 56). Three studies received a strong methodological quality rating for the accelerometer-based data and a moderate quality rating for the questionnaire-based data(21, 28, 55). Quality items that limited the methodological quality rating of a study included a follow up rate below 70%, not having a representative sample, or not adjusting for potential confounders in the statistical analysis. Future studies should keep these potential sources of bias in mind when designing their study in order to conduct high quality studies.

Strength and limitations

This review is the first summarising changes in dietary behaviour across the transition from primary to secondary school. Furthermore, this is the first review including all four energy balance-related behaviours (PA, SB, sleep behaviour and dietary behaviour) in a systematic review on changes in these behaviours across the school transition, which adds information to

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previous reviews by Pearson et al. and Chong et al. that only included two or three behaviours(13, 14). Other strengths of this review include the broad search strategy, which included four electronic databases without publication data restrictions. Furthermore, two independent reviewers conducted title and abstract screening, quality assessment, and data extraction resulting in the elimination of bias and errors in the methodology. A limitation is that we could have missed relevant studies that did not clearly state that the measurements were taken in adolescents attending primary school and in the same adolescents attending secondary school. We applied this strict inclusion criterion because we were interested in transitions accompanying a change in school environment, as such transitions may influence adolescents' energy balance-related behaviours(55). Another limitation is that only studies published in English were included. Additionally, we did not include grey literature in our search strategy. Furthermore, conducting a meta-analysis was not feasible because of the heterogeneity in outcomes and research methods in the included studies. In this review we found inconsistencies between study results that are due to differences in measurement, setting, and outcome. We recommend to develop and use an agreed set of key outcomes to be measured and reported in all future studies examining changes in energy balance-related behaviours to benefit evidence synthesis from all published studies(75). Furthermore, we recommend future studies to provide more detailed characteristics of the school setting as a difference in setting could explain the different results between studies. For example, one study could have included schools that provided school meals while another study included schools without school meals. This specific information about characteristic in the setting could not be extracted from the included studies. Lastly, the findings may not be generalizable to the adolescents of low and middle-income countries because all studies were conducted in high-income countries.

Conclusion

The current review found strong evidence for an increase in sedentary behaviour and moderate evidence for a decrease in fruit and vegetable consumption of adolescents across the transition from primary to secondary school. There was inconclusive evidence for the other energy balance-related behavioural outcomes, due to inconsistent results and lack of high-quality studies. More longitudinal research is needed specifically on changes in energy balance-related behaviour across the school transition, especially regarding sleep behaviour. These studies should keep potential sources of bias in mind when designing their study in order to conduct high-quality studies.

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References

1. WHO. Facts and figures on childhood obesity 2014 [Available from: http://www.who.int/end-childhood-obesity/facts/en/.

2. Freedman DS, Dietz WH, Srinivasan SR, Berenson GS. The relation of overweight to cardiovascular risk factors among children and adolescents: the Bogalusa Heart Study. Pediatrics. 1999;103(6):1175-82.

3. Kemper H, Post G, Twisk J, 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. 1999;23:S34-S40.

4. Sherry B, Dietz WH. Pediatric overweight: an overview. Handbook of Obesity New York, NY: Marcel Dekker Inc. 2004:117-34.

5. Tang-Péronard J, Heitmann B. Stigmatization of obese children and adolescents, the importance of gender. Obesity Reviews. 2008;9(6):522-34.

6. Strauss RS. Childhood obesity and self-esteem. Pediatrics. 2000;105(1):e15-e.

7. Huang TT, Drewnowski A, Kumanyika SK, Glass TA. A systems-oriented multilevel framework for addressing obesity in the 21st century. Preventing chronic disease. 2009;6(3).

8. Mamun AA, Lawlor DA, Cramb S, O'Callaghan M, Williams G, Najman J. Do childhood sleeping problems predict obesity in young adulthood? Evidence from a prospective birth cohort study. American journal of epidemiology. 2007;166(12):1368-73.

9. Sahoo K, Sahoo B, Choudhury AK, Sofi NY, Kumar R, Bhadoria AS. Childhood obesity: causes and consequences. J Family Med Prim Care. 2015;4(2):187-92.

10. Hale L, Guan S. Screen time and sleep among school-aged children and adolescents: A systematic literature review. Sleep Medicine Reviews. 2015;21:50-8.

11. Hales CM, Carroll MD, Fryar CD, Ogden CL. Prevalence of obesity among adults and youth: United States, 2015–2016. In: National Center for Health S, editor. NCHS data brief; no 288; DHHS publication; no (PHS) 2018–1209. Hyattsville, MD2017.

12. Statistics Netherlands [Internet]. 2020. Available from: https://opendata.cbs.nl/statline/.

13. Chong KH, Parrish A-M, Cliff DP, Kemp BJ, Zhang Z, Okely AD. Changes in physical activity, sedentary behaviour and sleep across the transition from primary to secondary school: A systematic review. Journal of science and medicine in sport. 2020;23(5):498-505.

https://doi.org/10.1017/S1368980023000812 Published online by Cambridge University Press

14. Pearson N, Haycraft E, P. Johnston J, Atkin AJ. Sedentary behaviour across the primary-secondary school transition: A systematic review. Preventive Medicine. 2017;94:40-7.

15. Winpenny EM, Corder KL, Jones A, Ambrosini GL, White M, van Sluijs EMF. Changes in diet from age 10 to 14 years and prospective associations with school lunch choice. Appetite. 2017;116:259-67.

16. Lytle LA, Seifert S, Greenstein J, McGovern P. How do children's eating patterns and food choices change over time? Results from a cohort study. Am J Health Promot. 2000;14(4):222-8.

17. Bleich SN, Wolfson JA. Trends in SSBs and snack consumption among children by age, body weight, and race/ethnicity. Obesity (Silver Spring, Md). 2015;23(5):1039-46.

18. Parent J, Sanders W, Forehand R. Youth Screen Time and Behavioral Health Problems: The Role of Sleep Duration and Disturbances. J Dev Behav Pediatr. 2016;37(4):277-84.

19. Bruce ES, Lunt L, McDonagh JE. Sleep in adolescents and young adults. Clin Med (Lond). 2017;17(5):424-8.

20. Ramirez ER, Norman GJ, Rosenberg DE, Kerr J, Saelens BE, Durant N, et al. Adolescent Screen Time and Rules to Limit Screen Time in the Home. Journal of Adolescent Health. 2011;48(4):379-85.

21. De Meester F, Van Dyck D, De Bourdeaudhuij I, Deforche B, Cardon G. Changes in physical activity during the transition from primary to secondary school in Belgian children: what is the role of the school environment? BMC Public Health. 2014;14:261.

22. Morton KL, Corder K, Suhrcke M, Harrison F, Jones AP, van Sluijs EM, et al. School polices, programmes and facilities, and objectively measured sedentary time, LPA and MVPA: associations in secondary school and over the transition from primary to secondary school. Int J Behav Nutr Phys Act. 2016;13:54.

23. McGaughey T, Vlaar J, Naylor PJ, Hanning RM, Le Mare L, Mâsse LC. Individual and Environmental Factors Associated with Participation in Physical Activity as Adolescents Transition to Secondary School: A Qualitative Inquiry. International journal of environmental research and public health. 2020;17(20).

24. Morton K, Atkin A, Corder K, Suhrcke M, Van Sluijs E. The school environment and adolescent physical activity and sedentary behaviour: a mixed-studies systematic review. Obesity reviews. 2016;17(2):142-58.

25. Brown J, Croxford L, Minty S. Pupils as citizens: Participation, responsibility and voice in the transition from primary to secondary school. Centre for Research in Education Inclusion and Diversity. 2017.

26. Ashton R. Improving the transfer to secondary school: how every child's voice can matter. Support for learning. 2008;23(4):176-82.

27. Li M, Xue H, Jia P, Zhao Y, Wang Z, Xu F, et al. Pocket money, eating behaviors, and weight status among Chinese children: The Childhood Obesity Study in China mega-cities. Prev Med. 2017;100:208-15.

28. Cooper AR, Jago R, Southward EF, Page AS. Active travel and physical activity across the school transition: the PEACH project. Medicine and science in sports and exercise. 2012;44(10):1890-7.

29. Dahl RE, Lewin DS. Pathways to adolescent health sleep regulation and behavior. Journal of Adolescent Health. 2002;31(6, Supplement):175-84.

30. Waterlander WE, Singh A, Altenburg T, Dijkstra C, Luna Pinzon A, Anselma M, et al. Understanding obesity-related behaviors in youth from a systems dynamics perspective: The use of causal loop diagrams. Obesity Reviews. 2020.

31. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;372:n71.

32. NIH Quality assessment Tool for Observational Cohort and Cross-Sectional Studies. National Institutes of Health [Available from: https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools.

33. Chinapaw M, Proper K, Brug J, Van Mechelen W, Singh A. Relationship between young peoples' sedentary behaviour and biomedical health indicators: a systematic review of prospective studies. Obesity reviews. 2011;12(7):e621-e32.

34. van Ekris E, Altenburg T, Singh AS, Proper KI, Heymans MW, Chinapaw MJ. An evidence-update on the prospective relationship between childhood sedentary behaviour and biomedical health indicators: a systematic review and meta-analysis. Obesity reviews. 2016;17(9):833-49.

35. Singh AS, Mulder C, Twisk JW, Van Mechelen W, Chinapaw MJ. Tracking of childhood overweight into adulthood: a systematic review of the literature. Obesity reviews. 2008;9(5):474-88.

36. Dowda M, Taverno Ross SE, McIver KL, Dishman RK, Pate RR. Physical Activity and Changes in Adiposity in the Transition from Elementary to Middle School. Child Obes. 2017;13(1):53-62.

37. Vanwolleghem G, Van Dyck D, De Meester F, De Bourdeaudhuij I, Cardon G, Gheysen F. Which Socio-Ecological Factors Associate with a Switch to or Maintenance of Active and Passive Transport during the Transition from Primary to Secondary School? PLoS One. 2016;11(5):e0156531.

38. Coombes E, Jones A, Page A, Cooper AR. Is change in environmental supportiveness between primary and secondary school associated with a decline in children's physical activity levels? Health and Place. 2014;29:171-8.

39. Garcia AW, Pender NJ, Antonakos CL, Ronis DL. Changes in physical activity beliefs and behaviors of boys and girls across the transition to junior high school. J Adolesc Health. 1998;22(5):394-402.

40. Harrison F, van Sluijs EMF, Corder K, Jones A. School grounds and physical activity: Associations at secondary schools, and over the transition from primary to secondary schools. Health and Place. 2016;39:34-42.

41. Jago R, Page AS, Cooper AR. Friends and physical activity during the transition from primary to secondary school. Med Sci Sports Exerc. 2012;44(1):111-7.

42. Kirby J, Levin KA, Inchley J. Parental and peer influences on physical activity among Scottish adolescents: a longitudinal study. Journal of Physical Activity and Health. 2011;8(6):785-93.

43. Lau EY, Dowda M, McIver KL, Pate RR. Changes in Physical Activity in the School, Afterschool, and Evening Periods During the Transition From Elementary to Middle School. J Sch Health. 2017;87(7):531-7.

44. Shin M, Lee C, Lee Y. Effect of Aggression on Peer Acceptance Among Adolescents During School Transition and Non-Transition: Focusing on the Moderating Effects of Gender and Physical Education Activities. International journal of environmental research and public health. 2019;16(17).

45. Ridley K, Dollman J. Changes in Physical Activity Behaviour and Psychosocial Correlates Unique to the Transition from Primary to Secondary Schooling in Adolescent Females: A Longitudinal Cohort Study. International journal of environmental research and public health. 2019;16(24).

46. Pate RR, Dowda M, Dishman RK, Colabianchi N, Saunders RP, McIver KL. Change in Children's Physical Activity: Predictors in the Transition From Elementary to Middle School. American journal of preventive medicine. 2019;56(3):e65-e73.
47. Pate RR, Schenkelberg MA, Dowda M, McIver KL. Group-based physical activity trajectories in children transitioning from elementary to high school. BMC Public Health. 2019;19(1):323.
48. Dowda M, Saunders RP, Colabianchi N, Dishman RK, McIver KL, Pate RR. Longitudinal Associations Between Psychosocial, Home, and Neighborhood Factors and Children's Physical Activity. J Phys Act Health. 2020:1-7.
49. Clennin MN, Lian M, Colabianchi N, Kaczynski A, Dowda M, Pate RR. Associations among Neighborhood Socioeconomic Deprivation, Physical Activity Facilities, and Physical Activity in Youth during the Transition from Childhood to Adolescence. International journal of environmental research and public health. 2019;16(19).
50. Dowda M, Dishman RK, Saunders RP, Pate RR. Associations between three measures of physical activity and selected influences on physical activity in youth transitioning from elementary to middle school. Sports Medicine and Health Science. 2021;3(1):21-7.
51. Remmers T, Van Kann D, Kremers S, Ettema D, de Vries SI, Vos S, et al. Investigating longitudinal context-specific physical activity patterns in transition from primary to secondary school using accelerometers, GPS, and GIS. International journal of behavioral nutrition and physical activity. 2020;17(1):1-14.
52. Mikalsen HK, Bentzen M, Säfvenbom R, Lagestad PA. Trajectories of Physical Activity Among Adolescents in the Transition From Primary to Secondary School. Frontiers in sports and active living. 2020;2:85.
53. Bradley CB, McMurray RG, Harrell JS, Deng S. Changes in common activities of 3rd through 10th graders: the CHIC study. Med Sci Sports Exerc. 2000;32(12):2071-8.
54. Corder K, Sharp SJ, Atkin AJ, Griffin SJ, Jones AP, Ekelund U, et al. Change in objectively measured physical activity during the transition to adolescence. Br J Sports Med. 2015;49(11):730-6.
55. Marks J, Barnett LM, Strugnell C, Allender S. Changing from primary to secondary school highlights opportunities for school environment interventions aiming to increase physical activity and reduce sedentary behaviour: a longitudinal cohort study. Int J Behav Nutr Phys Act. 2015;12:59.

56. Ridgers ND, Timperio A, Crawford D, Salmon J. Five-year changes in school recess and lunchtime and the contribution to children's daily physical activity. Br J Sports Med. 2012;46(10):741-6.

57. Rutten C, Boen F, Seghers J. Which school- and home-based factors in elementary school-age children predict physical activity and sedentary behavior in secondary school-age children? A prospective cohort study. J Phys Act Health. 2015;12(3):409-17.

58. Rutten C, Boen F, Seghers J. Changes in physical activity and sedentary behavior during the transition from elementary to secondary school. J Phys Act Health. 2014;11(8):1607-13.

59. Jaakkola T, Hakonen H, Kankaanpaa A, Joensuu L, Kulmala J, Kallio J, et al. Longitudinal associations of fundamental movement skills with objectively measured physical activity and sedentariness during school transition from primary to lower secondary school. Journal of science and medicine in sport. 2019;22(1):85-90.

60. Atkin AJ, Corder K, van Sluijs EMF. Bedroom media, sedentary time and screen-time in children: a longitudinal analysis. International Journal of Behavioral Nutrition and Physical Activity. 2013;10(1):137.

61. Marks J, Barnett LM, Allender S. Change of School in Early Adolescence and Adverse Obesity-Related Dietary Behavior: A Longitudinal Cohort Study, Victoria, Australia, 2013-2014. Prev Chronic Dis. 2015;12:E145.

62. Oza-Frank R, Zavodny M, Cunningham SA. Beverage displacement between elementary and middle school, 2004-2007. J Acad Nutr Diet. 2012;112(9):1390-6.

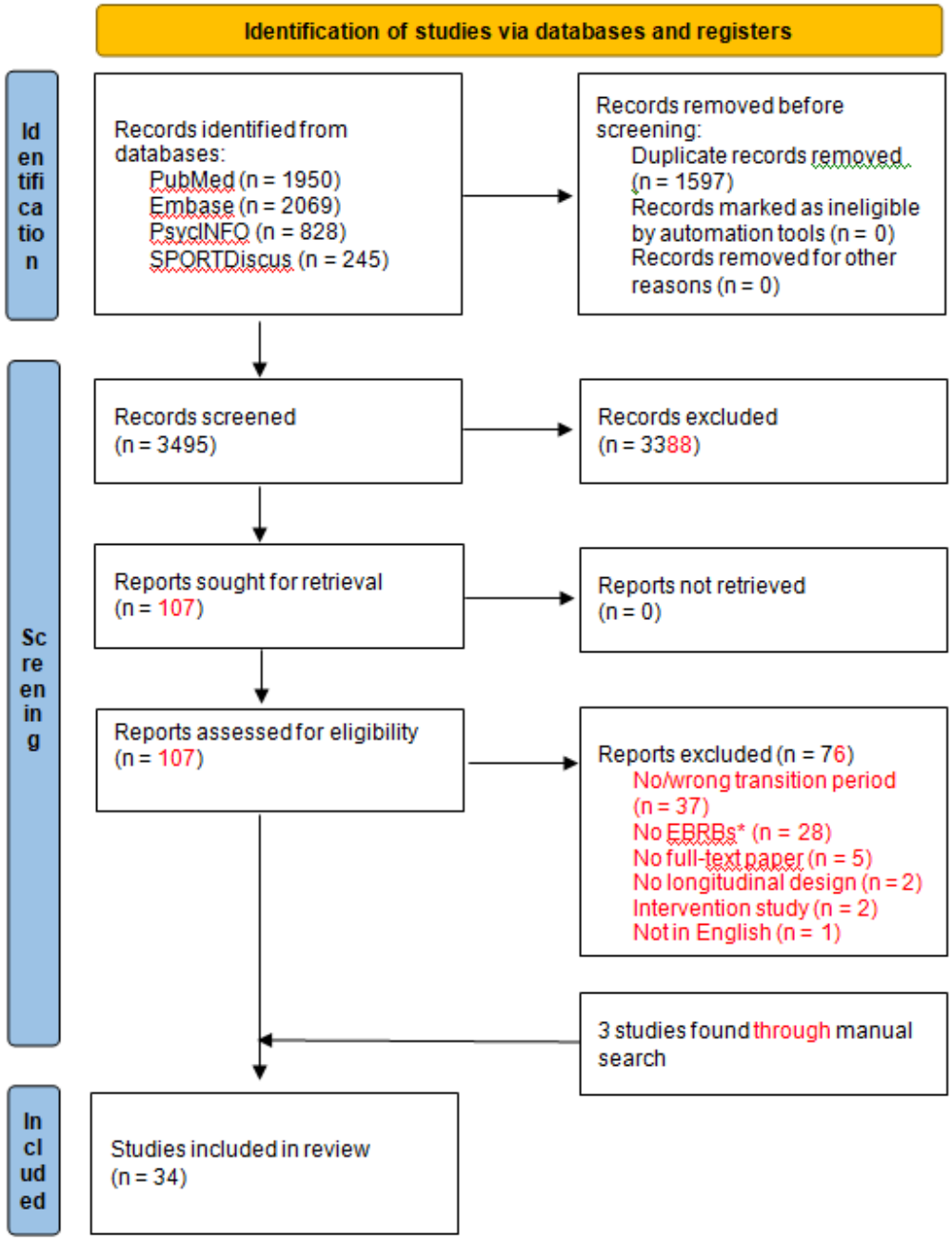
63. Taverno Ross SE, Militello G, Dowda M, Pate RR. Changes in Diet Quality in Youth Living in South Carolina From Fifth to 11th Grade. Journal of nutrition education and behavior. 2020;52(10):928-34.

64. Okazaki K, Koyama Y, Ohkawara K. Changes in physical activity patterns of students from primary to secondary school: a 5-year longitudinal study. Scientific Reports. 2022;12(1):1-9.

65. Dumith SC, Gigante DP, Domingues MR, Kohl III HW. Physical activity change during adolescence: a systematic review and a pooled analysis. International journal of epidemiology. 2011;40(3):685-98.

66. Farooq MA, Parkinson KN, Adamson AJ, Pearce MS, Reilly JK, Hughes AR, et al. Timing of the decline in physical activity in childhood and adolescence: Gateshead Millennium Cohort Study. British journal of sports medicine. 2018;52(15):1002-6.

67. Pate RR, Mitchell JA, Byun W, Dowda M. Sedentary behaviour in youth. British journal of sports medicine. 2011;45(11):906-13.
68. Albani V, Butler LT, Traill WB, Kennedy OB. Fruit and vegetable intake: change with age across childhood and adolescence. British Journal of Nutrition. 2017;117(5):759-65.
69. Rasmussen M, Krølner R, Klepp K-I, Lytle L, Brug J, Bere E, et al. Determinants of fruit and vegetable consumption among children and adolescents: a review of the literature. Part I: quantitative studies. International Journal of Behavioral Nutrition and Physical Activity. 2006;3(1):22.
70. Ludwig DS, Peterson KE, Gortmaker SL. Relation between consumption of sugar-sweetened drinks and childhood obesity: a prospective, observational analysis. The lancet. 2001;357(9255):505-8.
71. Naska A, Lagiou A, Lagiou P. Dietary assessment methods in epidemiological research: current state of the art and future prospects. F1000Research. 2017;6:926.
72. Evans-Whipp T, Gasser C. Are children and adolescents getting enough sleep. Growing up in Australia The longitudinal study of Australian children (LSAC) annual statistical report. 2018.
73. Falbe J, Willett WC, Rosner B, Gortmaker SL, Sonneville KR, Field AE. Longitudinal relations of television, electronic games, and digital versatile discs with changes in diet in adolescents. The American journal of clinical nutrition. 2014;100(4):1173-81.
74. Busch V, Altenburg TM, Harmsen IA, Chinapaw MJ. Interventions that stimulate healthy sleep in school-aged children: a systematic literature review. European Journal of Public Health. 2017;27(1):53-65.
75. de Vries LW, Harrington D, Grooten I, Van't Hooft J, van Deutekom A, Roseboom TJ, et al. Development of a core outcome set for school-based intervention studies on preventing childhood overweight and obesity: study protocol. BMJ open. 2022;12(7):e051726.



* EBRBs are Energy Balance-related Behaviours

Figure 1. Flow chart of the review process

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Table 1. Included quality items from NIH Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies.

Criteria	**Rating**	**I, V/P***
Research question	Studies were rated positively when the research question or objective was clearly stated.	I
Study population	Studies were rated positively when the study population was clearly specified and defined.	I
Representative sample	Studies were rated positively when the target population was adequately represented and more than 50% of the eligible persons participated in the study.	V/P
Recruitment of subjects	Studies were rated positively when participants were selected or recruited from the same or similar populations (including the same time period) and when inclusion and exclusion criteria were pre-specified and applied uniformly to all participants.	V/P
Sample size	Studies were rated positively when the sample size justification, power calculation, or variance and effect estimates were provided.	I
Outcome measures	Studies were rated positively when using an assessment tool with acceptable[1] validity and reliability.	V
Follow up rate	Studies were rated positively when the follow-up rate was at least 70%.	V
Statistical analysis	Studies were rated positively when the analyses adjusted for key potential confounding variables (e.g. baseline, gender) .	V/P

*I = informative criterion , V/P = validity/precision criteria, 1 = acceptable validity or reliability included that 75% of the extracted items had a Cronbach's alpha of above 0.7 and no items were below 0.4

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Table 2. Study characteristics - sorted by energy balance-related behaviour, study name, quality score and alphabetically by first author.

Author (year)	Country / study name	Participants	Energy balance-related behaviour	Length of follow-up	Outcome measurements	Results	Quality assessment
Physical activity							
Clennin et al. (49)	USA / TRACK study	N=660; 10.6±0.5 years; 54% girls; 38.3% non-Hispanic white, 36.1% non-Hispanic black, 9.2% Hispanic, and 16.4% other	Physical activity	2 years	Accelerometer: PA (min/hour)	Decline in PA (β(SE)) -4.5 (0.5) min/hour (P < 0.001) [Regression models]	100%
Dowda et al. (48)	USA / TRACK study	N=555; 10.5±0.5; 56% girls; 41% were black, 36% white, 8% Hispanic, and 15% other	Physical activity	1 year	PAQ-C questionnaire, 5 point Likert scale	- Home PA (mean ±SD) decreased from 4.0±3.0 to 2.8±2.3. - Neighbourhood PA (mean ±SD) decreased from 1.8±2.3 to 1.2±1.8. [No statistical analysis]	60%
Dowda et al. (50)	USA / TRACK study	N=409; 10.6±0.5 years; 53% girls; 35% were black, 38% white, 11% Hispanic, and 17% other	Physical activity	2 years	Accelerometer: MVPA (min/hour) Parent reported of child's PA two items, 5 point Likert scale Child's self-reported PA four items, 5 point Likert scale	Change in accelerometer-based MVPA (mean ±SD) min/hour: 1.6±0.5 to 1.5±0.5 Change in parent report of child's PA (mean ±SD): 3.1±0.9 to 3.2±1.1 Change in self-reported PA (mean ±SD): 3.3±0.7 to 3.3±0.7 [no statistical analysis]	Parent reported child's PA: 40% Self-reported PA and accelerometer-based MVPA: 60%
Lau et al. (43)	USA / TRACK study	5th grade: N=768; 10.6±0.5 years; 54% girls 6th grade: N=751; 50% girls 7th grade N=612; 68% girls	Physical activity	2 years	Accelerometer: TPA and MVPA during different time periods: school (~7:45 to 3:30 pm), afterschool (~2:25 to 6:00 pm), evening (~6:00 to 10:00 pm) (min/h).	Changes in MVPA and TPA in Different Time-Periods (β(SE)): - Boys: -0.7 (0.2) (P<.05) school MVPA, 0.5 (0.34) afterschool MVPA, 0.3 (0.29) evening MVPA, -4.7 (0.6) (p<.0001) school TPA, -1.4 (0.40) (P<.05) afterschool TPA, -3.6 (1.1) (P<.05) evening TPA - Girls: -0.8 (0.1) (p<.0001) school MVPA, 0.3 (0.1) afterschool MVPA, -0.5 (0.8) (P<.05) evening MVPA, -7.5 (0.5) (p<.0001) school TPA, -2.3 (0.3) (p<.0001) afterschool TPA, -2.9 (0.2) (p<.0001) evening TPA [Growth curve analysis]	80%
Pate et al. (46)	USA / TRACK study	N=828; 10.6±0.5 years in 5th grade; 54% girls; 38.3% white, 35.1%	Physical activity	2 years	Accelerometer: PA (min/hour)	Decline in PA (b=-2.9 min/hour; 95 CI= -3.1; -2.6)	80%

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		African American, 9.5% Hispanic, 17.1% other.				[Growth curve analysis]	
Pate et al. (47)	USA / TRACK study	N=652; 10.6±0.5 years in 5th grade; 54% girls; 38.9% white, 36.2% black, 9.2% Hispanic, 15.7% other.	Physical activity	2 years	Accelerometer: PA (min/hour)	Decline in PA (mean ±SD) from 28.3±4.5 min/hr in 5th grade to 24.3±4.5 in 6th grade [no statistical analysis]	40%
Coombes et al. (38)	UK / PEACH project	N=518; 10.9 (10.9; 11.0) years; 56% girls; 60% non-white (vs. white)	Physical activity	1 year	Accelerometer: daily counts per minute Questionnaire: mode of travel to/from school	- No differences in PA [34% of children reported a different mode of travel to school] - Prevalence of walking to school: 79% at primary school and 58% at secondary school - Prevalence of cycling to school: just under 4% at both schools [No statistical analysis]	80%
Cooper et al. (28)	UK / PEACH project	Primary school: N=565; 56% girls Secondary school: N=570; 55% girls	Physical activity	1 year	Accelerometer: weekday MVPA (min/day) Computerised questionnaire: self-reported travel modes to and from school	- Weekday MVPA (mean ±SD): 60.5±22.3 min/day in primary school and 63.4±23.6 in secondary school P=0.017 - Travel mode: walking 77.0% in primary and 60.7% in secondary school; cycling 3.2% in primary and 3.5% in secondary school. [Paired sample t-tests]	Accelerometer 80% Questionnaire 60%
Jago et al. (41)	UK / PEACH project	After school MVPA: Boys N=371; Girls N=439 Weekend MVPA: Boys N=195; Girls N=263 Age 10-11 years	Physical activity	1 year	Accelerometer: after school MVPA (between 3:30 and 8:30 p.m.) and weekend MVPA	- Change in after school MVPA (mean ±SD): -4.6±17.2 min for boys and -2.6±13.1 min for girls; - Change in weekend MVPA (mean ±SD): 4.7±49.0 min for boys and 2.0±29.6 min for girls. [No statistical analysis]	60%
De Meester et al. (21)	Belgium	N=420; 11.1±0.5 years; 50% girls; N=399 data pedometer steps; N=140 accelerometer data	Physical activity	2 years	Accelerometer: total PA in steps/day and total MPVA in min/day Pedometer: weekday step counts Flemish Physical Activity Questionnaire: active travel to/from school (min/day), extracurricular PA (min/day), total PA	Standardized beta's (mean ±SD): - Significant increase in active transportation from/to school (b=5.8±1.2) - Significant decrease in extracurricular PA (b=-10.5±1.3) - Significant decrease in total PA level (b=-8.9±2.6) - No change in accelerometer/ pedometer weekday steps (b=-424.0±255.4) - Significant increase in weekday MVPA (b=4.9±2.4) [Longitudinal multilevel regression analyses]	Accelerometer 80% Questionnaire 60%

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					(min/day)		
Garcia et al. (39)	USA	N=132; 58% girls; 30.3% African-American and 69.7% European American.	Physical activity	1 year	Child/Adolescent Physical Activity Log (self-report; 16 activities)	- No changes in levels of PA (mean ±SD) from 12.8±11.0 to 11.0±9.6 (=spring activity, weighted by intensity) [Student's t-test]	0%[a]
Harrison et al. (40)	UK / SPEEDY study	N=299; 10.2±0.3 years; 55% girls	Physical activity	4 years	Accelerometer: Mean minutes of MVPA over different time periods (lunchtime, commuting, school day, after school).	- MVPA (min) declined during lunchtime (mean ±SD): from 14.5±5.8 to 10.9±5.7, school day from 28.2±9.9 to 24.4±10.2, and after school from 28.9±14.2 to 19.8±13.5 All P<0.05 - MVPA (min) increased for time spent commuting (mean ±SD): from 15.9±7.1 to 17.9±11.3 P<0.05. [Wilcoxon rank-sum tests]	40%
Kirby et al. (42)	UK / PASS study	N=641; 51% girls	Physical activity	2-4 years	PAQ-C questionnaire, 5 point Likert scale, children are classified as active with a score of 3 or higher.	- Proportion of active pupils decreased over time; 82.1% at baseline for boys and 61.1% for girls, 62.9% for boys at 2nd year secondary school and 30.5% for girls, 41.9% at 4th year secondary school for boys and 16.6% for girls. All P<.001 [Chi square trends]	20%[a]
Mikalsen et al. (52)	Norway / no study name	7th grade: N=306; 12-13 year; 50% girls 9th grade N=160; 14-15 years; 60% girls	Physical activity	2 years	Accelerometer: MVPA	Two trajectories identified showing a significant decline in MVPA per day/year: Average decline in trajectory-1 (prevalence: n = 83, 26% of the total sample): 6.4 min of MVPA/day/year. Average decline in trajectory-2 (prevalence: n = 238, 74% of the total sample): 14.0 min of MVPA/day/year. [Latent growth modelling]	60%
Remmers et al. (51)	Netherlands/ PHASE study	N = 175; 12.1±0.4 years; 49% girls	Physical activity	1 year	Accelerometer: LPA, MVPA (min/day). Global Positioning System (PGS) loggers and Geographical Information Systems (GIS) data: child's LPA and MVPA at home, school, local sports grounds, shopping centres, and other locations.	Changes mean (95% CI): PA across locations/domains: During school time LPA -11.0 (−19.5; − 2.6), after school time LPA −25.0 (− 32.8 ; − 17.3) and MVPA – 8.0 (− 12.1 ; − 3.9). All P<0.05. No changes for before school time LPA and MVPA, during school time MVPA, and weekend days LPA and MVPA. context-specific PA: Before school time: LPA at home −3.4 (−5.3 ; − 1.5). During school time: LPA on school grounds −19.0 (−29.0 ; − 9.5), LPA and	80%

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					Transport related LPA and MVPA. (min/day)	MVPA in other locations 14.4 (8.2 ; 20.6) and 2.4 (0.8 ; 4.0). After school time: MVPA on school grounds −1.1 (− 1.9 ; − 0.2), LPA on sports grounds − 3.5 (−7.1 ; − 0.01), and LPA − 21.2 (− 29.0 ; − 13.4) and MVPA − 5.2 (− 7.3 ; − 3.1) in other locations. All P<0.05. No changes on weekend days for all locations. Transport-related PA: Before school time: LPA for active transport 6.3 (5.3 ; 7.4) and LPA for passive transport −0.4 (−0.7 ; − 0.1). After school time: LPA for passive transport − 1.7 (− 2.9 ; − 0.4). Weekend days: LPA for active transport −15.9 (− 25.2 ; − 6.5). All P<0.05. No changes for LPA during school time and MVPA. [longitudinal multilevel linear mixed models]	
Ridley et al. (45)	Australia	N=99; in 7th grade; 100% girls;	Physical activity	1 year	PAQ-C questionnaire, 5 point Likert scale, children are classified as active with a score of 3 or higher.	- PAQ-C score: 7th grade: 2.9±0.7; 8th grade: 2.5±0.8 (P < 0.0001) Individual PAQ-C components: - Lunch/recess: 3 (2, 4) to 2 (2, 2) (P<0.0001) - No significant difference was found for PE, after school, evenings and weekends. [Paired t-test and Wilcoxon rank order]	20%[a]
Shin et al. (44)	Korea / KCYPS study	N=1947; 12 years; 48% girls	Physical activity	1 year	Perceived Physical Education Activity (PPEA) measured by one item: “how many hours did you spend on your physical activity from physical education in the las week?” 5 point Likert scale (1=none to 5=over four hours)	PPEA (mean ±SD) from 3.1±1.1 to 3.3±1.3. Correlation: 0.29 [Correlation analyses]	0%[a]
Vanwolleghem et al. (37)	Belgium / no study name	N=313; 11.0±0.5 years; 49% girls	Physical activity	2 years	The Flemish Physical Activity questionnaire: transport to school and to leisure time destinations	- Change active transport to school: 65.2% to 65.5%. X^2 9.561, P>.05 - Change active transport to leisure time destinations: 93.9% to 70.0%. X^2 0.133, P<.05 [Chi-Square test]	40%
Physical activity and Sedentary behaviour							
Bradley et al. (53)	USA / CHIC studies	4th/5th grade: N=586; 50% girls; 83%	Physical activity Sedentary	1 year	Activity questionnaire, based	- Percent of youth classified as sedentary increased from 39.5 to 42.1% for female	0%[a]

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		Caucasian, 21% African-American, 6% other. (in 6th/7th grade an additional cohort was added to the study (=first grade middle school))	behaviour		on the Know Your Body Health Habits Survey, including the type and frequency of the activity children usually did the most; MET level assigned to each activity	students and from 25.2 to 26.6% for male students after the transition - Significant decrease in number of vigorous activities (5-8 METs) [Mantel Haenszel chi square tests]	
Corder et al. (54)	UK / SPEEDY study	N=990; 10.3±0.3 years; 58% girls	Physical activity Sedentary behaviour	4 years	Accelerometer: SB, LPA, MPA, VPA, and MVPA (min/day).	- SB increased by 10.6 (95% CI 9.0 to 12.2) min/day/year - LPA decreased by 9.8 (95% CI -10.7 to -8.9) min/day/year - MVPA decreased by 2.9 (95% CI -3.5 to -2.3) min/day/year [Three level mixed effects linear regression]	80%
Morton et al. (22)	UK / SPEEDY study	N=325; 10.2±0.3 years; 52% girls; 97%white	Physical activity Sedentary behaviour	4 years	Accelerometer: proportion of wear time during SB, LPA, MVPA.	- During the school day time spent SB (mean ±SD) increased from 272.9±25.5 to 300.2±29.9 min, time spent LPA decreased from 80.7±16.3 to 64.7±18.9 min, and MVPA day decreased from 30.8±10.8 to 27.4±13.7 min. - During lunchtime there was no change in time spent SB, an decrease in LPA from 17.0±3.5 to 11.3±4.6 min, and a decrease in MVPA from 10.6±4.9 to 6.5±4.7 min. [No statistical analysis]	60%
Jaakkola et al. (59)	Finland, Finnish Schools on the Move project	N=336 students; 49% girls; mean age of 12±0.38 years	Physical activity Sedentary behaviour	1 year	Accelerometer: MVPA (min/day) and SB (%/day)	- MVPA (mean ±SD) in boys decreased from 61.7±26.6 to 57.9±6.4, in girls from 47.5±17.4 to 41.6±18.5. - Sedentary time (mean ±SD) in boys increased from 64.2±6.9 to 66.9±7.1, in girls from 66.4±5.7 to 70.9±6.1. [No statistical analysis]	40%
Marks et al. (55)	Australia / no study name	N=243; 12.2 years; 60% girls; 85% Australian born	Physical activity Sedentary behaviour	5-8 months	Accelerometer: mean time (min) spent in MVPA, LPA, and SB, meeting PA recommendations Self-report behavioural questionnaires: PA,	- All students showed a decline in daily MVPA (mean ±SD)(−4 min ± 13), LPA (−23 min ± 33), cycle/scoot to/from school (-0.7 ± 4.1 times/week), and an increase in daily after-school being very active (10 min ± 66) All $P<0.05$ - No changes in PA behaviour were found for mean daily weekend being very active and walk to/from school (0-10 times/week)	Accelerometer 80% Questionnaire 60%

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					active transport, screen-behaviour	- Increases in daily SB (mean ±SD)(16 min ± 76), weekday leisure screen time (17 min ± 126) and weekday homework screen time (25 min ± 67), all *P*<0.05 - No changes in sedentary/screen behaviour were found for weekend leisure screen time (min/day) [Exact McNemar or Bowker paired test of proportions or paired t-test of means]	
Okazaki et al. (64)	Japan	N=55; 9.9±0.3 years; 56% girls	Physical activity Sedentary behaviour	5 years	Accelerometer: mean minutes of SB, LPA, MVPA per day	- Increase SB (min/day (SE)) by 3.3 (1.48), P=0.025 - Decrease MVPA (min/day (SE)) by 2.3 (0.71), P=0.002 - Decrease LPA (min/day (SE)) by 1.0 (1.16), P=0.370 [Linear mixed models]	80%
Ridgers et al. (56)	Australia / CLAN and HEAPS studies	N=773; 10-12 years old	Physical activity Sedentary behaviour	3 years	Accelerometer: mean minutes of SB, LPA, MPA, VPA per valid day	- During recess (boys): %SB B: 25.2, 95% CI: 19.8 to 30.6, %LPA B: -11.2, 95% CI: -15.0 to -7.4, %MPA B: -8.5, 95% CI: -10.5 to -6.5, %VPA B: -4.2, 95% CI: -5.1 to -3.3, All P<0.001 - During recess (girls): No significant changes for %LPA, %SB B: 22.6, 95% CI: 17.1 to 28.1, %MPA B: -10.6, 95% CI: -12.7 to -8.6, %VPA B: -8.0 95% CI: -9.0 to -7.0, All P<0.001 - During lunchtime (boys): %SB B: 23.1, 95% CI: 19.1 to 27.1, %LPA B: -9.2, 95% CI: -11.7 to -6.8, %MPA B: -8.5, 95% CI: -9.6 to -7.4, %VPA B: -4.5, 95% CI: -5.4 to -3.6, All P<0.001 - During lunchtime (girls): No significant changes for %LPA, %SB B: 17.6, 95% CI: 13.5 to 21.7, %MPA B: -9.7, 95% CI: -10.9 to -8.4, %VPA B: -6.4, 95% CI: -7.4 to -5.4, All P<0.001 [Multilevel analysis]	80%
Rutten et al. (58)	Belgium / no study name	N=472; 11.0±0.4 years; 55% girls	Physical activity Sedentary behaviour	2 years	PA: pedometer for 7 days, mean daily steps + self-reported with the PAQ-C questionnaire. SB: self-reported	- No change was found in mean steps per day (for all categories) - TPA (1-5) in boys with NW changed from (mean ±SD) 3.1±0.6 to 2.8±0.51, p=0.000. for boys OW and girls OW and NW no changes were found	40%

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					questionnaire.	- School related PA (1-5) in boys NW changed from 3.9±0.7 to 2.2±0.7, P=0.000. For boys OW and girls OW and NW no changes were found - Leisure time PA (1-5) in boys NW changed from 2.6±0.7 to 2.5±0.7 P=0.002, girls NW changed from 2.5±0.6 to 2.3±0.6 P=0.018. For boys OW and girls OW no changes were found - Screen based SB (hrs/wk) in boys NW changed from 21.6±14.6 to 23.8±13,0, P=0.000. For boys OW and girls OW and NW no changes were found - Homework (hrs/wk) boys OW changed from 8.2±5.4 to 7.6±4.2, P=0.033. for boys NW and girls OW and NW no changes were found [ANOVA]	
Rutten et al. (57)	Belgium / no study name	N=472; 11.0±0.4 years; 55% girls	Physical activity Sedentary behaviour	2 years	PA: pedometer for 7 days and PAQ-C questionnaire (MVPA). Screen based SB: questionnaire	The steps per day (mean ±SD) increased from 15052±4264 to 15589±5110. MVPA decreased from 3.0±0.6 to 2.6±0.5. screen-based SB increased from 19.7±12.9 to 22.6±13.5. [No statistical analysis]	40%
Sedentary behaviour							
Atkin et al. (60)	UK / SPEEDY study	T0 N=1512; 10.3±0.3 years; 55% girls T4 N=319; 14.3±0.3 years; 52% girls	Sedentary behaviour	4 years	Accelerometer: hrs/wk sedentary time Questionnaire: self-reported screen time hrs/wk	Sedentary time (mean ±SD) increased from 34.9±5.3 to 40.3±5.3 (hrs/wk). Self-reported screen time (median IQR) increased from 6.9 (2.9-14.8) to 15.1 (8.5-26.0)(hrs/wk) [No statistical analyses]	Accelerometer 60% Questionnaire 40%
Dietary behaviour							
Lytle et al. (16)	USA / CATCH study	N=291; 45% girls; 92.8% Caucasian	Dietary behaviour	3 years	Weekday 24 hour recalls	Prevalence: - Consumption of breakfast decreased from 94.4% to 85.2%. Consumption of lunch decreased from 100% to 98.3%. Fruit and vegetable consumption decreased from 55.9% (fruit) and 49.5 (vegetables) to 37.1% (fruit) and 41.6% (vegetables). Drinking milk decreased from 97.9% to 90.1%. Drinking fruit juice decreased from 47.4% to 32.0%. Drinking soft drink increased from 30.8% to 57.1%. eating high-fat salty snacks decreased from 59.9% to 46.7%. All P<0.05. no diff in consumption of dinner, snacks, fruit-flavoured beverages, high-fat sweet snacks, and fast	60%

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						food. Mean daily frequency (mean number of eating occasions): - Drinking milk decreased from 2.2 to 1.9. Drinking fruit juice decreased from 0.6 to 0.4. drinking soft drinks increased from 0.4 to 0.8. eating high-fat salty snacks decreased from 0.8 to 0.6. All P<0.05. No diff in consumption of fruit-flavoured drink, snacks, and high-fat sweet snacks. [ANOVA]	
Marks et al. (61)	Australia / no study name	N=243; 12.2 years; 60% girls; 85% Australian born	Dietary behaviour	5-8 months	Eat Well Be Active questionnaire: school day about quantity and total intake of various food and drink items.	- The daily intake of non-core food items (−1.2; 95% CI, −1.7 to −0.7; P<.001) and SSB (−0.3; 95% CI, −0.5 to −0.1; P<.001) decreased. - The intake of school-day fruit (−0.2; 95% CI, −0.4 to −0.1; P=.003) and school-day vegetables (−0.2; 95% CI, −0.3 to −0.1; P<.001) decreased. - No diff in daily frequency of fruit consumption. [Exact McNemar or Bowker paired test of proportions or paired t-test of means]	60%
Oza-Frank et al. (62)	USA / ECLS-K study	N=7,445; 50% girls 58.4% white	Dietary behaviour	3 years	Food consumption questionnaire: containing 19 questions about food and beverages	Green salad consumption (P<.01) from 2.2 to 2.6 servings per week. Potatoes intake from 2.1 to 2.2 servings per week. Carrots intake (P<.01) from 2.8 to 1.9 servings per week. Other vegetables (P<.05) from 5.2 to 4.9 servings per week. Fruit (P<.05) from 7.7 to 7.2 servings per week. Fast food (P<.01) from 3.2 to 2.4 servings per week. Total servings of caloric beverages from 21.6 to 19.7 (P<.01). Drinking milk from 10.3 to 8.5 servings per week (P<.05). Servings of 100% fruit juice from 5.1 to 5.6 servings per week (P<.01). [T-tests]	20%[a]
Ross et al. (63)	USA / TRACK study	N=260; 10.5±0.6 years; 59% girls; 33% white, 43% black, 9% Hispanic, and 15% other race/ethnicity	Dietary behaviour	2 years	Total diet quality: 24 hour recall (Block Food Screener)	Total diet quality declined -0.4 points per year (P<0.001) [Growth curve analysis]	60%
Winpenny et al.	UK / SPEEDY	N=351; 10.2±0.3 years;	Dietary behaviour	4 years	Food diaries: mean	Mean change total daily intake of energy KJ b	60%

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(15)	study	56% girls			daily consumption of macronutrients (% en) and food groups.	(SE): 247 KJ (64) (P<.001), %En protein: 0.04 (0.20), %En carbohydrates: 0.43 (0.35), En% sugar: -2.64 (0.44) (P<.001), %En fat: -0.56 (0.33), %En sat. fat: -0.54 (0.18) (P<.01), NSPs g/MJ: 0.07 (0.03) (P<.05), confectionary g/MJ: - 0.63 (SE: 0.25) (P<.05), Savoury snacks: 0.26 (0.14), SSBs g/MJ: 4.66 (1.87) (P<.05), fruits g/MJ: -3.13 (1.14) (P<.01), vegetables g/MJ: 1.55 (0.48) (P<.01), fries g/MJ: 1.31 (0.39) (P<.01). [Multilevel mixed effects logistic and linear regression]	
Physical activity, sedentary behaviour, and dietary behaviour							
Dowda et al. (36)	USA / TRACK study	N=658; 11.0±0.5 years; 55% girls; 40% white, 33% black, 9% Hispanic, and 18% other race/ethnicity	Physical activity, sedentary behaviour, and diet quality	2 years	Accelerometer: MVPA (min/hr) and SB (min/hr) 24-h recalls (self-report) (one week): diet quality (41 specific food items, plus frequency and amount of intake) (higher score (max=50) indicates better quality)	- MVPA (mean ±SD) declined (boys): from 3.7±2.1 (5^{th} grade) to 3.4±1.8 (6^{th} grade) min/h (not significant) - sedentary behaviour increased significantly: from 31.0±4.2 (5^{th} grade) to 34.1±4.1 (6^{th} grade) min/hr over time. - Diet quality decreased significantly From 29.8±5.5 (5^{th} grade) to 28.5±6.0 (6^{th} grade) - MVPA significantly declined (girls): from 2.2±1.2 (5^{th} grade) to 1.9±1.0 (6^{th} grade) min/h - Sedentary behaviour increased significantly: from 32.8±4.4 (5^{th} grade) to 37.0±4.5 (6^{th} grade) min/hr over time. - Diet quality decreased significantly from 30.3±5.4 (5^{th} grade) to 29.5±5.6 (6^{th} grade) [Chi-square and t-tests]	40%

a = studies with a poor quality rating are not mentioned in the evidence synthesis, LPA = Light intensity Physical Activity, MPA = Moderate Physical Activity, MVPA = Moderate-to-vigorous Physical Activity, NW = normal weight, OW = overweight, PA = Physical Activity, PAQ-C = Physical Activity Questionnaire for Older Children, SB = Sedentary Behaviour, SSB = Sugar Sweetened Beverages, TPA = Total Physical Activity, UK = United Kingdom, USA = United States of America, VPA = Vigorous Physical Activity * = Studies that produced multiple papers are listed together.

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Table 3. Summary of evidence on changes in energy balance-related behaviours across the school transition.

Physical activity		**Sedentary behaviour**		**Dietary behaviour**	
TPA	- ±[a] ±[bc] ±[d]	Sedentary behaviour	+ + + + +	Fruit and vegetable	- - -
LPA	**0 - - ±[b] ±[d]**	Screen time	±[d] ±[bc]	SSBS	- + +
MVPA	**- - - - - + + ±[bd] ±[d]** ±[b]			Unhealthy snacks	- ±[e] ±[e]
Active transport	0 + + ±[e] **±[df]**			Fruit juice	-
Extracurricular PA	-			Milk	-
School related PA	±[bc]			Total energy intake	+
				Dietary fibre	+
				Intake from sugars	-
				Intake of saturated fatty acids	-
				Energy percentage from protein	0
				Energy percentage from carbohydrates	0
				Energy percentage from Fat	0
				Total diet quality	-

Note that only strong and moderate quality studies were included in the evidence synthesis. In bold = study with high quality rating, + = a significant improvement in behaviour, - = significant worsening in behaviour, 0 = no change in behaviour, ± = inconsistent findings within a study, a = different results for different measurement method, b = different results for boys and girls, c = different results for different weight categories, d = different results for different time segments of the day or week, e = different results in subcategories of energy balance-related behaviours, f = different results for different intensity levels of active transport.

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