Int J Public Health (2015) 60:799–813
DOI 10.1007/s00038-015-0710-y

REVIEW

Socioeconomic position during childhood and physical activity during adulthood: a systematic review

C. E. Juneau · T. Benmarhnia · A. A. Poulin · S. Côté · L. Potvin

Received: 10 March 2015 / Revised: 24 June 2015 / Accepted: 25 June 2015 / Published online: 23 August 2015

Abstract
Objectives A growing body of evidence links socioeconomic position early in life and physical activity during adulthood. This systematic review aimed to summarize this evidence.
Methods Medline and EMBASE were searched for studies that assessed socioeconomic position before age 18 years and physical activity at age ≥18 years. Studies were rated according to three key methodological quality criteria: (1) was childhood socioeconomic position assessed prospectively? (2) Was socioeconomic position during adulthood included in the statistical analysis? (3) Was a validated instrument used to measure of physical activity?
Results Forty-two publications were included. Twenty-six (61.9 %) found a significant association between socioeconomic position early in life and physical activity during adulthood. Twenty-one studies met at least two methodological quality criteria. Among those, the proportion was higher: 15/21 (71.4 %). Associations were of weak to moderate strength, positive for physical activity during leisure time, and negative for transports and work.
Conclusions The bulk of the evidence supports the notion that there is a life course association between socioeconomic position early in life and physical activity during adulthood. Studies using more rigorous methodology supported this conclusion more consistently.

Keywords Public health · Epidemiology · Physical activity · Longitudinal studies · Socioeconomic position · Systematic review

Introduction

In 2009, the World Health Organization ranked physical inactivity as the 4th leading risk factor for global mortality. It was estimated that physical inactivity is responsible for 3.2 million deaths each year, or 6 % of all deaths (World Health Organization 2009). Increasing population levels of physical activity thus hold much promise for public health. This task is challenging, as physical activity is a complex behavior, with many correlates at the individual, environmental, and social levels (Bauman et al. 2012). At the social level, socioeconomic position is a key correlate of physical activity (Trost et al. 2002). Indeed, systematic reviews have found cross-sectional associations between socioeconomic position and physical activity during adolescence (Stalsberg and Pedersen 2010) and during adulthood (Gidlow et al. 2006). That is, low socioeconomic position during adolescence is associated with low levels of physical activity during adolescence (Stalsberg and Pedersen 2010), and low socioeconomic position during adulthood is associated with low levels of physical activity during adulthood (Gidlow et al. 2006).

This raises a question: Is this association is purely cross-sectional, or is there a long-lasting, life course association

This review is part of the special issue "Driving the Best Science to Meet Global Health Challenges" edited on the occasion of the 9th European Congress on Tropical Medicine and International Health 2015.

Electronic supplementary material The online version of this article (doi:10.1007/s00038-015-0710-y) contains supplementary material, which is available to authorized users.

C. E. Juneau (✉) · T. Benmarhnia · A. A. Poulin · S. Côté · L. Potvin
École de Santé Publique, Faculté de Médecine, Université de Montréal, Succursale Centre-ville, C.P. 6128, Montreal, QC H3C 3J7, Canada
e-mail: carl-etienne.juneau@umontreal.ca

between socioeconomic position early in life and physical activity during adulthood? This seems plausible, as socioeconomic position early in life has been associated in systematic reviews with three health outcomes during adulthood closely related to physical activity: cardiovascular disease (Pollitt et al. 2005), obesity (Senese et al. 2009) and physical capability levels (Birnie et al. 2011). Moreover, in a systematic review (Gidlow et al. 2006), physical activity during adulthood was found to be associated with education, an indicator that reflects, at least in part, socioeconomic position during adolescence and early adulthood (Galobardes et al. 2007). We aimed to systematically review and summarize the evidence linking socioeconomic position early in life and physical activity during adulthood. We hypothesized that the bulk of the evidence would support the notion that there is indeed a long-lasting, life course association between socioeconomic position early in life and physical activity during adulthood.

Methods

Search strategy

Medline (1947–2014 October week 4) and EMBASE (1974–2014 week 43) were last searched on October 30, 2014 with no language or date restrictions for studies that assessed socioeconomic position early in life and physical activity during adulthood. Search and screening of title, abstract, and full text for inclusion were carried out by two independent investigators. Discrepancies were solved by mutual agreement. A broad range of keywords related to physical activity, socioeconomic position, and the life course was used (Electronic supplementary material). Reference lists of all included studies were hand searched for additional studies.

Scope of the search and selection criteria

"Early in life" was defined as age lower than 18 years. We chose the term "early in life" to refer to both childhood and adolescence and to avoid any confusion with "childhood socioeconomic position" being interpreted as occurring only during ages 0–12 years (other reviews of childhood socioeconomic position and health outcomes later in life have also included ages 0–17 years; see Pollitt et al. 2005; Senese et al. 2009; Birnie et al. 2011). Adulthood was defined as age $\geq$18 years. Socioeconomic position was defined as a fundamental cause granting access to key resources that can be used to avoid health risks and adopt protective strategies (Link and Phelan 1995). Measures of socioeconomic position included social class, education, income, household amenities, perception of wealth, and area-based measures. Physical activity was defined as bodily movement produced by the contraction of skeletal muscle that increases energy expenditure above the basal level (U.S. Office of the Surgeon General 1996). All types and measures of physical activity were included. Studies were included if (1) they assessed socioeconomic position at least once for childhood or adolescence (age <18 years) and (2) they measured physical activity during adulthood (age $\geq$18 years). Studies that used education as the sole measure of socioeconomic position were excluded because a systematic review already reviewed its association with physical activity (Gidlow et al. 2006). Studies that focused on symptomatic population (e.g., cardiovascular patients) were also excluded. All study designs were considered.

Data extraction

Key methodological characteristics and results of each study were recorded in an Excel database. These included first author, country, date of publication, data source, sample size, age, and measures at each point in time across the life course, and magnitude and direction of the associations. Physical activity outcomes were grouped into two categories. The first category was "all types and measures of physical activity." This category included leisure-time physical activity, physical activity at work, physical activity during transports, physical housework, heavy gardening, free-living 24-h physical activity monitoring by accelerometry, cardiorespiratory fitness tests, musculoskeletal fitness tests, and physical activity diaries. The second category was a subcategory of the first. This category was "leisure-time physical activity only." It included self-reports of physical activity during leisure time, exercise, and sports. Studies that had the outcomes "moderate-to-vigorous" or "vigorous" leisure-time physical activity were also included in this category. We chose to consider leisure-time physical activity as a separate outcome because (1) its scope is easily understood and well defined, (2) it has a long history of research in public health (Paffenbarger et al. 1978), (3) public health recommendations traditionally have focused on leisure-time physical activity (U.S. Office of the Surgeon General 1996), and (4) it was the most commonly reported outcome. Data extraction was carried out by two investigators. After extraction, discrepancies were solved by mutual agreement.

Data analysis

Our original aim was to carry out a meta-analysis. However, after a preliminary review, we judged that meta-analysis would not be appropriate, because studies were highly heterogeneous (Lau et al. 1998; Egger et al. 2002;

Higgins and Green 2011). Important methodological differences were noted among studies. Notably, (1) the age for which childhood socioeconomic position was measured ranged 0–17 years; (2) childhood socioeconomic position was assessed using 12 different indicators; (3) physical activity was measured using 42 different instruments; (4) 16 different statistical techniques were used; (5) 47 different confounding variables were used. Therefore, we choose not to aggregate study results into a single estimate. Instead, we reported proportions of studies that found a significant association. We reported proportions for men and women combined, and stratified by sex. When available, we reported magnitude and direction of significant associations. For direction of associations, in some cases, the outcome was reverse coded (e.g., physical "inactivity"). For example, Regidor et al. (2004) found that low father social class during childhood was significantly associated with more physical inactivity over age 60 years in women. This was considered a positive association nonetheless, as the underlying interpretation is that women whose father had high social class were more active.

Quality assessment

Based on a preliminary review of study methodology, methodological quality assessment focused on three key study characteristics: (1) Was childhood socioeconomic position assessed during childhood in a prospective study design? Assessing childhood socioeconomic position during childhood is likely to provide more valid estimates. Indeed, retrospective recall of social class during childhood is less valid: published estimates of agreement with historical records range from 53.7 % (Batty et al. 2005) to 80 % (Berney and Blane 1997); (2) Was socioeconomic position during adulthood assessed and included in the multivariate model of physical activity during adulthood, either as an independent, interacting, mediating, or confounding variable? The association of socioeconomic position during adulthood with physical activity during adulthood is well established (Gidlow et al. 2006). Therefore, any association between socioeconomic position early in life and physical activity during adulthood not accounting for socioeconomic position during adulthood may be an artifact of the tracking of socioeconomic position early in life into adulthood (Corcoran 1995). Thus, not including socioeconomic position during adulthood in the model is likely to overestimate the real association between socioeconomic position early in life and physical activity during adulthood. (3) Was physical activity measured using validated methods? In this sample of studies, this included questionnaires with documented validity or reliability, accelerometers (a computerized, portable, objective measure of physical activity), or physical fitness tests (also an objective measure). Studies that referred to any documentation on the reliability or validity of the measurement tool were classified as "yes", regardless of how valid the instrument was. This criterion should therefore not be interpreted as meaning that the instrument used had high validity, although overall, it is likely that studies that used validated methods measured physical activity more accurately than those that did not.

Results

Result of the search

A total of 10,619 papers were found; 653 were retained based on title only. Of those, 135 were retained based on abstract and 48 were retained based on full text. Their reference lists were reviewed and contained two papers which had not already been found (Kimm et al. 2002; Popham and Mitchell 2006). When two papers used data from the same cohort, the older was excluded. Eight studies were thus excluded (Kuh and Cooper 1992; Yang et al. 1996; Brunner et al. 1999; Lawlor et al. 2004, 2005; Wray et al. 2005; Schooling et al. 2008; Walters et al. 2009). This review therefore includes 42 studies. Table 1 presents key characteristics of methodology, a summary of results, and direction of associations. Additional details of methodology and results are show in the Electronic supplementary material.

Measurement of socioeconomic position

All 42 studies assessed socioeconomic position. Eight studies assessed socioeconomic position only once, before age 18 years. The remainder (34 studies) assessed socioeconomic position at least twice: once before age 18 years and once for adulthood. Assessment early in life took place at ages 0 (birth) to 17 years. Eleven different indicators were used: the father's social class, the father's education, the mother's education, the mother's social class, the highest of either parents' social class, the highest of either parents' education, the presence (or absence) of certain household amenities, income, whether the family was perceived as wealthy, family access to a car, neighborhood socioeconomic level, and attendance to a fee paying school. Measurement during adulthood took place for ages 18–79 years. Fourteen different indicators were used: the subject's own education, social class, employment status, income, area-based measures of socioeconomic level, house ownership, car ownership, the household's highest social class, the partner's social class, wealth, job insecurity, skin color, pension arrangements, and perceived family economy.

Table 1 Key characteristics of methodology, summary of results, and direction of associations in the 42 studies included in this systematic review of socioeconomic position before age 18 years and physical activity at age ≥18 years

First authors (year of publication) country	Measurement SEP early in life	Adulthood SEP included analysis?	Validated measure of PA?	Quality score	Result summary	Direction of association
Mann et al. (2013) UK	Prospective	Yes	Yes	3	No associations between the father's social class at birth and sport, occupational, commuting, and household physical activity	Men and women combined LTPA: no association Transport: no association Work: no association Household: no association
Osler et al. (2001) Denmark	Prospective	Yes	Yes	3	No associations between the father's education at age 3–17 years and leisure-time physical activity age 19–31 years	Men LTPA: no association Women LTPA: no association
Poulton et al. (2002) New Zealand	Prospective	Yes	Yes	3	Low parental social class from birth to age 15 years significantly associated with lower cardiorespiratory fitness at age 26 years for men and women. Downward social mobility between 0–15 years and 26 years significantly associated with lower cardiorespiratory fitness at age 26 years for men and women	Men and women combined CRP: positive association
Barnekow-Bergkvist et al. (1998) Sweden	Prospective	Yes	Fitness: yes Transport: no LTPA: no	2 or 3	Father in manual work significantly associated with stronger two-hand lift and weaker standing balance at age 33 years for men only. Working mother (for men) and father in manual work (for women) significantly associated with more sport activities at age 33–36 years	Men LTPA: negative association CRF: no association MSF: positive association Women LTPA: negative association CRF: no association MSF: no association
Silverwood et al. (2012) UK	Prospective	Yes	Cycling: no	2 or 3	Upward social mobility significantly associated with more sedentary behavior during the working day and less walking for men only	Men
			LTPA: yes		Upward social mobility significantly associated with more leisure-time physical activity for men and women	LTPA: positive association
					Downward social mobility significantly associated with less sedentary behavior, more walking, and less leisure-time physical activity for men and women	Transport: negative association
					Upward educational mobility significantly associated with more sedentary behavior during the working day, less walking, and more leisure-time physical activity for men and women	Work: negative association
					Downward educational mobility less sedentary behavior during the working day (for men and women), more walking (for men only), but less leisure-time physical activity (for women only)	Women LTPA: positive association
					Low father education at age 6 years significantly associated with less sedentary behavior during the working day, more walking, less leisure-time physical activity (for men and women) and more cycling (women only)	Transport: negative association
					Low father's social class at age 4 years significantly associated with less sedentary behavior during the working the day for men only, more walking, and less leisure-time physical activity at age 36 years for men and women	Work: negative association

Table 1 continued

First authors (year of publication) country	Measurement SEP early in life	Adulthood SEP included analysis?	Validated measure of PA?	Quality score	Result summary	Direction of association
Aarnio et al. (2002) Finland	Prospective	No	Yes	2	Self-employed father at age 16 years significantly associated with higher odds of persistently inactive status from ages 16 to 18 years for men only. Self-employed mother at age 16 years significantly associated with lower odds of persistent exerciser status from ages 16 to 18 years for men only	Men LTPA: positive association Women LTPA: no association
Beunen et al. (2004) Belgium	Prospective	No	Yes	2	Higher father education at age 18 years significantly associated with higher sport and leisure-time indexes at age 40 years. Higher father's social class at age 18 years significantly associated with higher leisure-time index at age 40 years	Men only LTPA: positive association
Bratteby et al. (2005) Sweden	Prospective	No	Yes	2	High mother education at age 21 years significantly associated with lower total energy expenditure, activity energy expenditure, and physical activity level at age 21 years	Men and women combined Whole-day: negative association
Cleland et al. (2009) Australia	Retrospective	Yes	Yes	2	Highest parent's education at ages 0–12 years significantly associated with decreasing fitness and persistently unfit status from ages 9–15 to 26–36 years. High mother education and medium father education at ages 0–12 years significantly associated with persistently fit status from ages 9–15 to 26–36 years. Persistently high socioeconomic position and upward social mobility from ages 0–12 to 26–36 years significantly associated with less decreasing and more increasing activity and fitness at age 26–36 years	Men LTPA: positive association Women LTPA: no association Men and women combined CRF: positive association
Hart et al. (2008) UK	Prospective	Yes	No	2	No associations between the father's social class at age 10–39 years and usual daily activities at age 30–59 years for men and women	Men Whole-day: no association Women Whole-day: no association
Huurre et al. (2003) Finland	Prospective	Yes	No	2	Manual father social class at age 16 years significantly associated with less leisure-time physical activity at age 22 years for men only	Men LTPA: positive association Women LTPA: no association
Juneau et al. (2014) UK	Prospective	Yes	No	2	Social class at ages 0, 5, 10, 30, and 34 years were associated with physical activity at age 34 years, although the magnitude and the direction of the associations for social class at each age varied by physical activity outcome and by sex	Men LTPA: positive association Transport: no association Work: negative association Women LTPA: positive association Transport: negative association Work: negative association
Kimm et al. (2002) USA	Prospective	No	Yes	2	Black skin color at age 8–9 years associated with a 100 % decline in leisure-time physical activity levels by age 16–17 years (remaining so at 18–19 years). Low parental education at age 8–9 years significantly associated with low leisure-time physical activity at age 18–19 years in white and black girls	Women only LTPA: positive association

Table 1 continued

First authors (year of publication) country	Measurement SEP early in life	Adulthood SEP included analysis?	Validated measure of PA?	Quality score	Result summary	Direction of association
Kvaavik et al. (2012) Norway	Prospective	Yes	No	2	No associations between the father's education or the mother's education at age 11–15 years and leisure-time physical activity at ages 13–17, 23–27, 31–35, and 38-42 years	Men and women combined LTPA: no association
Osler et al. (2007) Denmark	Retrospective	Yes	Yes	2	No association between social class during childhood and walking, running, and biking at age 46–69 years	Men Composite: no association Women Composite: no association
Osler et al. (2008) Denmark	Prospective	Yes	No	2	No associations between the father's social class at birth and walking, running, and biking at age 51 years for men	Men only Composite: no associations
Sagatun et al. (2008) Norway	Prospective	No	Yes	2	High father income at age 17–18 years significantly associated with more leisure-time physical activity at age 18–19 years in ethnic Norwegian and ethnic minority women. Low mother education at age 17–18 years significantly associated with less leisure-time physical activity at age 18–19 years in ethnic Norwegian women only	Men LTPA: no association Women LTPA: positive association
Salonen et al. (2011) Finland	Prospective	No	Yes	2	High father social class at birth significantly associated with higher frequency of leisure-time physical activity at age 57–70 for men only	Men LTPA: positive association Women LTPA: no association
Svedenkrans et al. (2013) Sweden	Prospective	No	Yes	2	Highest parent's education, social class, and income at age 7–17 years significantly associated with higher cardiorespiratory fitness at age 18–26 years	Men only CRF: positive association
Taverno Ross et al. (2014) USA	Prospective	No	Yes	2	Foreign-born at age 14.9 ± 1.6 years significantly associated with less moderate-to-vigorous leisure-time physical activity at age 25.3 ± 1.6 years for men only	Men LTPA: positive association Women LTPA: no association
Telama et al. (2009) Finland	Prospective	No	Yes	2	Low father education at age 12–18 years significantly associated with less leisure-time physical activity across the life course up to age 40–46 years for men and women	Men LTPA: positive association Women LTPA: positive association
Azevedo et al. (2008) Brazil	Prospective	Not specified (unclear, classified as no)	Yes	1	Family income at birth, persistently low income, and downward income mobility from birth to age 22–23 years significantly associated with leisure-time sedentary lifestyle at age 22–23 years for men and women	Men LTPA: positive association Women LTPA: positive association
Bell and Lee (2006) Australia	Retrospective	No	Yes	1	No significant associations between the highest parent's social class during childhood and physical activity at age 22–27 years. Women only	Women only Composite: no association

Table 1 continued

First authors (year of publication) country	Measurement SEP early in life	Adulthood SEP included analysis?	Validated measure of PA?	Quality score	Result summary	Direction of association
Blane et al. (1996) UK	Retrospective	Yes	No	1	No significant associations between the father's social class during childhood and recreational exercise at age 35–64 years	Men only LTPA: no association
Elwell-Sutton et al. (2011) China	Retrospective	No	Yes	1	No significant associations between parental possessions during childhood and leisure-time physical activity over age 50 years	Men and women combined LTPA: no association
Heraclides et al. (2008) UK	Retrospective	No	Yes	1	No associations between the father's social class during childhood and walking, cycling, sports, gardening activities, housework, and house maintenance physical activity at age 45–68 years for men and women	Men Composite: no association Women Composite: no association
Hillsdon et al. (2008) UK	Retrospective	Yes	No	1	Low childhood socioeconomic position significantly associated with lower walking, cycling, heavy gardening, and physical exercise at age 60–79 years for women	Women only Composite: positive association
Leino et al. (1999) Finland	Retrospective	Yes	No	1	No associations between the highest parent's education during childhood and exercise at age 21–30 years	Men LTPA: no association Women LTPA: no association
Lynch et al. (1997) Finland	Retrospective	No	Yes	1	Poor or middle score on index of socioeconomic conditions at age 10 years significantly associated with less leisure-time physical activity at age 42–60 years (men only)	Men only LTPA: positive association
Oygard and Anderssen (1998) Norway	Prospective	No	No	1	No associations between the father's education at age 11–14 years and leisure-time physical activity at age 23–26 years for men and women	Men LTPA: no association Women LTPA: no association
Popham and Mitchell (2006) UK	Retrospective	Yes	No	1	Having attended a fee paying school during childhood significantly associated with more leisure-time physical activity at age 18–64 years for women only	Men LTPA: no association Women LTPA: positive association
Pudrovska and Anishkin (2013) USA	Retrospective	Yes	No	1	High family socioeconomic status at age 17–18 years significantly associated with more leisure-time physical activity at age 64–65 years for men and women	Men LTPA: positive association Women LTPA: positive association
Regidor et al. (2004) Spain	Retrospective	Yes	No	1	Low father social class during childhood significantly associated with more physical inactivity over age 60 years for women only	Men LTPA: no association Women LTPA: positive association

Table 1 continued

First authors (year of publication) country	Measurement SEP early in life	Adulthood SEP included analysis?	Validated measure of PA?	Quality score	Result summary	Direction of association
Salonna et al. (2008) Slovakia	Prospective	No	No	1	Low highest parent's education and low highest parent's social class at age 14–15 years significantly associated with less sport at age 18–19 years for women only	Men LTPA: no association Women LTPA: positive association
Tammelin et al. (2003) Finland	Prospective	No	No	1	No associations between for father social class at age 14 years and leisure-time physical activity at age 31 years for men and women	Men LTPA: no association Women LTPA: no association
Van de Mheen et al. (1998) Netherlands	Retrospective	Yes	No	1	Low father social class at age 12 years significantly associated with lower odds of frequent physical activity at age 25–74 years for women only No associations for "no physical activity" for men and women	Men LTPA: no association Women LTPA: positive association
Bowen (2010) USA	Retrospective	No	No	0	Low mother education, low father education, and manual father social class during childhood significantly associated with less physical activity over age 50 years	Men and women combined Composite: positive association
Heslop et al. (2001) UK	Retrospective	No	No	0	No associations between the father's social class during childhood and recreational exercise at age 35–64 years	Women only LTPA: no association
Suppli et al. (2013) Denmark	Retrospective	No	No	0	Low vigorous physical activity at age 15 years significantly associated with low vigorous physical activity at age 27 years only in participants with low socioeconomic position during childhood	Men and women combined LTPA: positive association
Kamphuis et al. (2013) Netherlands	Retrospective	No	No	0	No associations between the father's social class at age 12 years and leisure-time physical activity, sports, and transport-related physical activity at age 40–75 years for men	Men only Composite: no association
Kittleson et al. (2006) USA	Retrospective	No	No	0	No associations between the father's social class during childhood and physical training at age 26 years	Men only LTPA: no association
Ramsay et al. (2007) UK	Retrospective	No	No	0	Low father social class during childhood significantly associated with inactive lifestyle at age 52–73 years	Men only LTPA: positive association

The literature search was done without country or year restriction; *SEP* socioeconomic position, *PA* physical activity, *LTPA* leisure-time physical activity, *OR* odds ratio, *RR* relative risk, *CRF* cardiorespiratory fitness, *MSF* musculoskeletal fitness)

Measurement of physical activity

All 42 studies measured physical activity; 31 studies had only one outcome for physical activity; 11 had multiple. Physical activity was measured using 42 different instruments. Self-reported leisure-time physical activity (including exercise and sport participation) was the most common outcome (31 studies). Other outcomes included physical activity during transports, physical activity at work, cardiorespiratory fitness, musculoskeletal fitness, walking, cycling, heavy gardening, housework, accelerometry, activity diary, and ad hoc, composite measures based on physical activity in more than one domain of life.

Statistical analysis

Overall, 16 different statistical techniques were used. Logistic regression was the most commonly used technique (it was used in 13 studies). Other techniques included logistic random effects regression, ordinal logistic regression, stratified logistic regression, binomial regression, Poisson regression, multiple regression, generalized estimating equation models, stepwise multiple regression, ANOVA, ANCOVA, *t* test, χ^2 test, log multinomial regression, structural equation modeling, and latent class analysis. Likewise, there was much discrepancy in confounding variables. Age and sex were the most common confounders, but overall, 47 different variables were used as confounders.

Association with outcome "all types and measures of physical activity"

A significant association was found between socioeconomic position early in life and at least one measure of physical activity during adulthood in 26 of the 42 studies (61.9 %) (Table 2). This was true in 16 of the 31 studies that reported results for men (51.6 %), in 13 of the 27 studies that reported results for women (48.2 %), and in 5 of the 8 studies that reported results adjusted for sex (62.5 %).

Association with outcome "leisure-time physical activity"

A total of 31 studies reported results for leisure-time physical activity as a separate outcome. A significant association was found in 21 of these 31 studies (67.7 %) (Table 2). This held true for men in 14 out of 25 studies (56 %), for women in 12 out of 22 studies (54.6 %), and for sex-adjusted analyses in 1 out of 4 studies (25 %).

Magnitude and direction of associations

Most associations were weak to moderate. The strongest association reported was OR (95 % CI) = 2.45 (1.25–4.80) (Aarnio et al. 2002). The weakest significant association was OR (95 % CI) = 0.94 (0.90–0.99) (Hillsdon et al. 2008). Magnitude of associations should be interpreted with caution as methodology varied widely across studies (differences in measurement, statistical technique, and confounders may explain differences in magnitudes of associations). Direction of associations by sex are shown in Table 3 for outcomes reported in at least two studies (for clarity, outcomes reported in only one study and studies that used an ad hoc, composite measure based on physical activity in more than one domain are excluded from Table 3, as these cannot be readily compared). For leisure-time physical activity, for men, 13/25 studies (52 %) found a positive association (i.e., high socioeconomic position early in life, high physical activity during adulthood), 11/25 studies (44 %) found no association, and 1/25 study (4 %) found a negative association. For women, 11/22 studies (50 %) found a positive association, 10/22 studies (45.5 %) found no association, and 1/22 study (4.5 %) found a negative association. In sex-adjusted analyses, 1/4 study (25 %) found a positive association and 3/4 studies (75 %) found no association. Other outcomes were less studied. Only four studies measured cardiorespiratory fitness (Barnekow-Bergkvist et al. 1998; Poulton et al. 2002; Cleland et al. 2009; Svedenkrans et al. 2013). Poulton et al. (2002) and Cleland et al. (2009) adjusted for sex and found a positive association. Svedenkrans et al. (2013) studied men only. They found a positive association as well. Barnekow-Bergkvist et al. (1998) stratified results by sex and found no association. Therefore, overall, a positive association was found for cardiorespiratory fitness in 3/4 studies (75 %), whereas no association was found in 1/4 study (25 %). Only three studies reported results for physical activity at work as a separate outcome (Silverwood et al. 2012; Mann et al. 2013; Juneau et al. 2014). All three were carried out in recent years in the UK. Of those, one study found no association, and two studies found a negative association. The same three studies also reported results for physical activity during transports as a separate outcome. Similarly, one study found no association, and two studies found a negative association (although for women only in Juneau et al. 2014; no association was found for men in that study).

Methodological quality assessment

Of the 42 studies, 23 (54.8 %) measured childhood socioeconomic position during childhood in a prospective

Table 2 Summary of associations between socioeconomic position before age 18 years and physical activity during adulthood in the 42 studies included in this systematic review (the literature search was done without country or year restriction)

	Significant association	No association	Total	% significant
All studies				
All types and measures of physical activity	26	16	42	61.9
Leisure-time physical activity only	21	10	31	67.7
More rigorous methodology				
All types and measures of physical activity	15	6	21	71.4
Leisure-time physical activity only	12	3	15	80.0

Table 3 Direction of associations between socioeconomic position before age 18 years and physical activity during adulthood for outcomes reported in at least two studies, by sex (the literature search was done without country or year restriction)

	Positive association	No association	Negative association	Total	% positive
Men					
Cardiorespiratory fitness[a]	3	1		4	75.0
Leisure-time physical activity	13	11	1	25	52.0
Physical activity at work		1	2	3	0
Physical activity during transports		2	1	3	0
Women					
Cardiorespiratory fitness[a]	2	1		3	66.7
Leisure-time physical activity	11	10	1	22	50.0
Physical activity at work		1	2	3	0
Physical activity during transports		1	2	3	0

[a] Results for cardiorespiratory fitness were pooled for men and women in 3 of the 4 studies

study design. Nineteen (45.2 %) included socioeconomic position during adulthood in their statistical analysis. Twenty-one (50 %) measured physical activity using validated methods. Overall, five studies (11.9 %) met all three quality criteria; 16 studies (38.1 %) met two; 15 studies (35.7 %) met one; and six studies (14.3 %) met zero (Table 1).

Evidence from studies using more rigorous methodology

Overall, 21 studies met at least two of the three methodological quality criteria. This was considered a subset of studies using more rigorous methodology. In this subset, 15 studies (71.4 %) reported a significant association between socioeconomic position early in life and the outcome "all types and measures of physical activity" during adulthood. This was true for men in 12/16 studies (75 %), for women in 6/14 studies (42.9 %), and for sex-adjusted analyses in 3/5 studies (60 %). For the outcome "leisure-time physical activity only," a significant association was found in 12/15 studies (80 %). This was true for men in 10/12 studies (83.3 %), for women in 6/12 studies (50 %), and for sex-adjusted analyses in 0/2 studies (0 %).

Discussion

This systematic review aimed to summarize the evidence linking socioeconomic position early in life and physical activity during adulthood. We hypothesized that the bulk of the evidence would support the notion that there is indeed a long-lasting, life course association between socioeconomic position early in life and physical activity during adulthood. Overall, the results of this systematic review provided support for our hypothesis.

Using a broad set of keywords, we found 10,619 published studies. We retained studies of all designs that assessed socioeconomic position at least once early in life (age $<$18 years) and that measured physical activity during adulthood (age $\geq$18 years). A total of 42 studies were retained. Socioeconomic position before age 18 years and physical activity during adulthood were associated in 26 of the 42 studies (61.9 %). This proportion increased to 21/31 (67.7 %) when we focused on leisure-time physical activity only as the outcome. This proportion further increased in studies that met at least two of our three methodological quality criteria (prospective measurement of childhood socioeconomic position, statistical inclusion of socioeconomic position during adulthood, and use of a validated instrument to measure

physical activity). In this subset of studies using more rigorous methodology, a significant association between socioeconomic position early in life and physical activity during adulthood was found in 15/21 studies (71.4 %) for all types and measures of physical activity and in 12/15 studies (80 %) for leisure-time physical activity only as the outcome. Associations were in the expected direction for leisure-time physical activity (i.e., high socioeconomic position early in life, high leisure-time physical activity during adulthood). Only one study found a negative association between these two variables (Barnekow-Bergkvist et al. 1998). Other outcomes were less studied. The evidence pointed to a positive association for cardiorespiratory fitness (3/4 studies) and to a negative association for physical activity during transports (2/3 studies) and at work (2/3 studies). Overall, these results suggest that (1) there is indeed a long-lasting, life course association between socioeconomic position early in life and physical activity during adulthood; (2) studies using more rigorous methodology supported this conclusion more consistently; (3) associations for leisure-time physical activity were found more consistently than for physical activity in other domains of life; and (4) direction of associations appeared to be positive for leisure-time physical activity and cardiorespiratory fitness and negative for physical activity during transports and at work.

Our results are in line with those of other systematic reviews that found associations between socioeconomic position early in life and health outcomes during adulthood (Senese et al. 2009; Pollitt et al. 2005; Birnie et al. 2011). Senese et al. (2009) systematically reviewed the literature on socioeconomic position during childhood and obesity during adulthood. They reported that 70 % of studies of females found decreasing obesity during adulthood with increasing socioeconomic position during childhood (this association was found for males in only 27 % of studies, however). Similarly, in their systematic review for cardiovascular diseases, Pollitt et al. (2005) found that "studies reviewed provided moderate support for the role of low early-life socioeconomic status and elevated levels of cardiovascular disease risk factors and cardiovascular disease morbidity and mortality." Lastly, in a meta-analysis, Birnie et al. (2011) found evidence that lower childhood socioeconomic position was associated with modest reductions in physical capability levels in adulthood. Taken as a whole, this body of literature seems to suggest that socioeconomic position early in life is consistently associated with health outcomes during adulthood.

We were hesitant to report the strength of the associations in the studies we systematically reviewed, for a number of reasons related to methodology. Methodology varied widely across studies: (1) most studies stratified results by sex, but some adjusted for sex, and one reported both stratified and adjusted results; (2) most studies assessed socioeconomic position twice, but some assessed it just once (early in life), and a few assessed it three times or more across the life course; (3) socioeconomic position before age 18 years was assessed using 11 different indicators; (4) there was no consistent age for assessment of socioeconomic position before age 18 years (assessment took place for ages 0–17 years) or during adulthood (assessment took place for ages 18–79 years); (5) socioeconomic position during adulthood was assessed using 14 different indicators; (6) physical activity was measured using 42 different instruments; (7) 16 different statistical techniques were used; and (8) 47 different confounding variables were used. No two studies used the same design: even in studies that used the same statistical technique, confounders, measurement of socioeconomic position, or measurement of physical activity were different. As strength of association is dependent on measurement and handling of data, study results should be compared with caution. For example, the strongest association reported was OR (95 % CI) = 2.45 (1.25–4.80) (Aarnio et al. 2002). In this study, there was thus an increased risk of "persistently inactive" status (a dichotomous variable defined as exercise 1–2 times a month or less for 3 years consecutively, at ages 16, 17, and 18 years). It was found in young men whose father was self-employed vs. upper level employee (reference category). Logistic regression was used, and the model was adjusted for smoking, alcohol use, breakfast eating, school type, school grade, and own perception of current health. Compare this with the weakest significant association reported, OR (95 % CI) = 0.94 (0.90–0.99) (Hillsdon et al. 2008). In that study, there was thus a lower risk of being more physically active (defined as an ordinal variable with four categories of increasing weekly hours spent in the following activities: brisk walking, cycling, heavy gardening, and leisure-time physical exercise such as tennis). It was found in women aged 60–79 years. Risk of being more physically active decreased as values on a composite indicator of childhood socioeconomic position increased (this indicator comprised, for childhood: father manual social class, no bathroom at home, no hot water at home, no car access, and shared bedroom). Ordinal logistic regression was used, and the model was adjusted for age, smoking, BMI, cardiovascular disease, respiratory disease, and adult socioeconomic position (including adult social class, housing tenure, car ownership, pension arrangements, and area-level deprivation). How can we explain the differences in results between these two studies? It could be the sample (young men vs. older women) or the country (Finland vs. UK), but it could also be the measure of socioeconomic position (self-employed father vs. composite indicator), the measure of physical activity (persistently inactive vs. a combination of walking, cycling, gardening, and leisure-time exercise), or the

choice of confounders. Until there is more standardization in life course studies of socioeconomic position and physical activity, we believe that only a general, cautious interpretation of this body of literature is in order. We further believe that strengths of associations should not be compared directly and that meta-analysis would not be appropriate.

To improve standardization in future research, we suggest a number of guidelines. Future research should measure physical activity using validated methods. Of the 42 studies, we included in this systematic review, only 21 (50 %) did so. Validated questionnaires were often used. These are a step in the right direction, but validated questionnaires are still prone to significant measurement error. Indeed, systematic reviews have concluded that self-reports of physical activity are inaccurate (Prince et al. 2008), even when validated questionnaires are used (Lee et al. 2011). Therefore, the results obtained in the 21 studies included in this systematic review (50 % of our sample) that did not use validated methods to measure physical activity should be interpreted with caution. In addition, even when validated questionnaires were used, internal validity could have been improved by using objectives measures such as accelerometers. Accelerometers can be used in subsamples when budgets are limited. They are generally regarded as providing more valid estimates than questionnaires (Prince et al. 2008). However, they do readily not distinguish between domains of physical activity. Therefore, depending on the study objective, questionnaires may still be useful to assess separately physical activity during leisure-time, during transports, at work, and at home. Whenever possible, we recommend a combination of methods to measure physical activity in future research: objectives measures to obtain more valid estimates and questionnaires to assess physical activity in each domain of life separately. Some authors have done this (Silverwood et al. 2012; Mann et al. 2013; Juneau et al. 2014), but other have collapsed multiple domains of physical activity into one single composite measure (Bell and Lee 2006; Bowen 2010; Hart et al. 2008; Heraclides et al. 2008; Hillsdon et al. 2008; Kamphuis et al. 2013; Osler et al. 2007, 2008). For example, Hart et al. (2008) combined data on "usual daily activity" (i.e., work) and "physical activity during non-working time" (i.e., leisure time) into a single measure. These outcomes are generally associated with socioeconomic position in different directions (i.e., higher socioeconomic position, more physical activity during leisure time and less physical activity at work). Thus, perhaps not surprisingly, Hart et al. (2008) found no association between their composite measure of physical activity and socioeconomic position during childhood. A final reason to use validated questionnaires or accelerometers is to enable comparisons between studies. In our sample, studies that did not use validated questionnaires used their own ad hoc measure of physical activity. This made comparisons across studies difficult.

In addition, future research on life course socioeconomic position should assess childhood socioeconomic position during childhood in a prospective study design. While commonly done in life course research, assessing childhood socioeconomic position retrospectively during adulthood may involve substantial measurement error and recall bias. Indeed, published estimates of agreement between retrospective recall and historical records range from 53.7 % (Batty et al. 2005) to 80 % (Berney and Blane 1997). Berney and Blane (1997) collected information from 57 UK subjects aged 64–83 years and compared it with archive material of the same subjects' social circumstances recorded 50 years previously. Their sample comprised subjects from two historical cohorts. In the first cohort, 80 % of subjects recalled their father's occupation correctly. In the second cohort, 66 % of subjects did so. Batty et al. (2005) analyzed data from a cohort of 12,150 children who took part in a school-based survey in 1962. In this survey, information was collected about the father's occupation at birth (reported by the mother at birth) and the father's occupation during childhood (reported in 1962 at age 6–12 years by children). Between 2000 and 2003, a questionnaire was mailed to traced cohort members. A total of 7183 (63.7 %) persons responded to the mid-life questionnaire. Subjects recalled their father's occupation at birth correctly in 53.7 % of cases, and that of their father during their childhood (at age 6–12 years) in 61.4 % of cases. Of the 42 studies included in our systematic review, only 23 (54.8 %) assessed childhood socioeconomic position prospectively during childhood. The remainder measured it during adulthood using retrospective recall. The evidence we have briefly reviewed here suggests that these studies' results should be interpreted with caution.

Moreover, in future research, we recommend that investigators include socioeconomic position during adulthood in their statistical analysis. This variable should be included as an independent, interacting, mediating, or confounding variable, based on the conceptual model that guides the study, as the association of socioeconomic position during adulthood with physical activity during adulthood is well established (Gidlow et al. 2006). As socioeconomic position tracks across the life course (Corcoran 1995), any association between socioeconomic position early in life and physical activity during adulthood unadjusted for socioeconomic position during adulthood is likely to be overestimated. In addition, whenever possible, socioeconomic position and physical activity should be assessed at multiple points in time across the life course, as both may fluctuate. Finally, future research, if possible, should try to determine whether the association between

socioeconomic position early in life and physical activity during adulthood is graded, to strengthen causal inference.

How can we explain the association between socioeconomic position early in life and physical activity, especially leisure-time physical activity, during adulthood? While a comprehensive answer is beyond the scope of this review, the literature on fundamental movement skills may shed some light on this question. Fundamental movement skills are basic motor skills. They include skills like running and hopping (locomotor skills), catching and throwing (object control), and balancing and twisting (stability) (Lubans et al. 2010). They are "considered to be the building blocks that lead to specialized movement sequences required for adequate participation in many organized and non-organized physical activities for children, adolescents and adults" (Stodden et al. 2008). Stodden et al. (2008) proposed that "fundamental movement skills competency interacts with perceptions of motor competence and health-related fitness to predict physical activity and subsequent obesity from childhood to adulthood." Thus, according to this literature, early childhood and adolescence may both be sensible periods for physical activity later in life (because fundamental movement skills are learned during early childhood and because they are refined into specialized movement sequences during adolescence). Systematic review evidence that low socioeconomic position during adolescence is associated with low physical activity during adolescence (Stalsberg and Pedersen 2010) supports this hypothesis. Systematic review evidence that school-based interventions focusing on physical activity, fitness, or fundamental movement skills increase physical activity later in life further support this hypothesis (Lai et al. 2014). More research is needed to test this hypothesis, and the potential role of fundamental movement skills as a mediator between low socioeconomic position early in life and low physical activity during adulthood.

A limitation of this systematic review is that nearly all studies were carried out in high-income countries (including 17 in Scandinavian countries and 10 in the UK). Therefore, their conclusions should not be overly generalized to others settings, especially to lower income countries.

In conclusion, the bulk of the evidence we have reviewed in this systematic review supported the hypothesis that there is a long-lasting, life course association between socioeconomic position early in life and physical activity during adulthood. This hypothesis was supported more consistently for leisure-time physical activity and in studies using more rigorous methodology. To strengthen methodology in future research, we recommend that researchers (1) measure physical activity using accelerometers in subsamples, (2) report results for each domain of physical activity separately, (3) assess childhood socioeconomic position prospectively during childhood, and (4) include socioeconomic position during adulthood in their statistical analysis.

Acknowledgments This work was supported by the Canadian Institutes for Health Research (#204633), the University of Montreal, the University of Montreal Public Health Research Institute, the Quebec Inter-University Centre for Social Statistics, and the *Centre Léa-Roback de recherche sur les inégalités sociales de santé de Montréal*. None of the funding bodies had any input in the design, conduct, or reporting of this study.

Conflict of interest We declare no conflict of interest.

References

Aarnio M, Winter T, Kujala U, Kaprio J (2002) Associations of health related behaviour, social relationships, and health status with persistent physical activity and inactivity: a study of Finnish adolescent twins. Br J Sports Med 36(5):360–364

Azevedo MR, Horta BL, Gigante DP, Victora CG, Barros FC (2008) Factors associated to leisure-time sedentary lifestyle in adults of 1982 birth cohort, Pelotas, Southern Brazil. Rev Saude Publica 42(Suppl 2):70–77

Barnekow-Bergkvist M, Hedberg G, Janlert U, Jansson E (1998) Prediction of physical fitness and physical activity level in adulthood by physical performance and physical activity in adolescence—an 18-year follow-up study. Scand J Med Sci Sports 8(5 Pt 1):299–308

Batty GD, Lawlor DA, Macintyre S, Clark H, Leon DA (2005) Accuracy of adults' recall of childhood social class: findings from the Aberdeen children of the 1950s study. J Epidemiol Community Health 59(10):898–903

Bauman AE, Reis RS, Sallis JF, Wells JC, Loos RJF, Martin BW, for the Lancet Physical Activity Series Working Group (2012) Correlates of physical activity: why are some people physically active and others not? Lancet 380(9838):258–271

Bell S, Lee C (2006) Does timing and sequencing of transitions to adulthood make a difference? Stress, smoking, and physical activity among young Australian women. Int J Behav Med 13(3):265–274

Berney LR, Blane DB (1997) Collecting retrospective data: accuracy of recall after 50 years judged against historical records. Soc Sci Med 45(10):1519–1525

Beunen GP, Lefevre J, Philippaerts RM, Delvaux K, Thomis M, Claessens AL, Vanreusel B, Lysens R, Vanden Eynde B, Renson R (2004) Adolescent correlates of adult physical activity: a 26-year follow-up. Med Sci Sports Exerc 36(11):1930–1936

Birnie K, Cooper R, Martin RM et al (2011) Childhood socioeconomic position and objectively measured physical capability levels in adulthood: a systematic review and meta-analysis. PLoS ONE 6(1):e15564

Blane D, Hart CL, Smith GD, Gillis CR, Hole DJ, Hawthorne VM (1996) Association of cardiovascular disease risk factors with socioeconomic position during childhood and during adulthood. BMJ 313(7070):1434–1438

Bowen ME (2010) Coronary heart disease from a life-course approach: findings from the health and retirement study, 1998–2004. J Aging Health 22(2):219–241

Bratteby LE, Sandhagen B, Samuelson G (2005) Physical activity, energy expenditure and their correlates in two cohorts of Swedish subjects between adolescence and early adulthood. Eur J Clin Nutr 59(11):1324–1334

Brunner E, Shipley MJ, Blane D, Smith GD, Marmot MG (1999) When does cardiovascular risk start? Past and present socioeconomic circumstances and risk factors in adulthood. J Epidemiol Community Health 53(12):757–764

Cleland VJ, Ball K, Magnussen C, Dwyer T, Venn A (2009) Socioeconomic position and the tracking of physical activity and cardiorespiratory fitness from childhood to adulthood. Am J Epidemiol 170(9):1069–1077

Corcoran M (1995) Rags to rags: poverty and social mobility in the United States. Annu Rev Sociol 21:237–267

Egger M, Ebrahim S, Smith GD (2002) Where now for meta-analysis? Int J Epidemiol 31(1):1–5

Elwell-Sutton TM, Jiang CQ, Zhang WS, Cheng KK, Lam TH, Leung GM, Schooling CM (2011) Socioeconomic influences at different life stages on health in Guangzhou, China. Soc Sci Med 72(11):1884–1892

Galobardes B, Lynch J, Smith GD (2007) Measuring socioeconomic position in health research. Br Med Bull 81–82:21–37

Gidlow C, Johnston LH, Crone D, Ellis N, James D (2006) A systematic review of the association between socio-economic position and physical activity. Health Educ J 65:338–367

Hart C, McConnachie A, Upton M, Watt G (2008) Risk factors in the Midspan family study by social class in childhood and adulthood. Int J Epidemiol 37(3):604–614

Heraclides A, Witte D, Brunner EJ (2008) The association between father's social class and adult obesity is not explained by educational attainment and an unhealthy lifestyle in adulthood. Eur J Epidemiol 23(8):573–579

Heslop P, Smith GD, Macleod J, Hart C (2001) The socioeconomic position of employed women, risk factors and mortality. Soc Sci Med 53(4):477–485

Higgins JPT, Green S (eds) (2011) Cochrane handbook for systematic reviews of interventions. The Cochrane Collaboration. www.cochrane-handbook.org. Accessed 17 June 2015

Hillsdon M, Lawlor DA, Ebrahim S, Morris JN (2008) Physical activity in older women: associations with area deprivation and with socioeconomic position over the life course: observations in the British Women's Heart and Health Study. J Epidemiol Community Health 62(4):344–350

Huurre T, Aro H, Rahkonen O (2003) Well-being and health behaviour by parental socioeconomic status: a follow-up study of adolescents aged 16 until age 32 years. Soc Psychiatry Psychiatr Epidemiol 38(5):249–255

Juneau CE, Sullivan A, Dodgeon B, Côté S, Ploubidis GB, Potvin L (2014) Social class across the life course and physical activity at age 34 years in the 1970 British birth cohort. Ann Epidemiol 24(9):641–647

Kamphuis CB, Turrell G, Giskes K, Mackenbach JP, van Lenthe FJ (2013) Life course socioeconomic conditions, adulthood risk factors and cardiovascular mortality among men and women: a 17-year follow up of the GLOBE study. Int J Cardiol 168(3):2207–2213

Kimm SY, Glynn NW, Kriska AM, Barton BA, Kronsberg SS, Daniels SR, Crawford PB, Sabry ZI, Liu K (2002) Decline in physical activity in black girls and white girls during adolescence. N Engl J Med 347(10):709–715

Kittleson MM, Meoni LA, Wang NY, Chu AY, Ford DE, Klag MJ (2006) Association of childhood socioeconomic status with subsequent coronary heart disease in physicians. Arch Int Med 166(21):2356–2361

Kuh DJ, Cooper C (1992) Physical activity at 36 years: patterns and childhood predictors in a longitudinal study. J Epidemiol Community Health 46(2):114–119

Kvaavik E, Glymour M, Klepp KI, Tell GS, Batty GD (2012) Parental education as a predictor of offspring behavioural and physiological cardiovascular disease risk factors. Eur J Public Health 22(4):544–550

Lai SK, Costigan SA, Morgan PJ, Lubans DR, Stodden DF, Salmon J, Barnett LM (2014) Do school-based interventions focusing on physical activity, fitness, or fundamental movement skill competency produce a sustained impact in these outcomes in children and adolescents? A systematic review of follow-up studies. Sports Med 44(1):67–79

Lau J, Ioannidis JP, Schmid CH (1998) Summing up evidence: one answer is not always enough. Lancet 351:123–127

Lawlor DA, Smith GD, Ebrahim S (2004) Association between childhood socioeconomic status and coronary heart disease risk among postmenopausal women: findings from the British Women's Heart and Health Study. Am J Public Health 94(8):1386–1392

Lawlor DA, Ebrahim S, Davey Smith G (2005) Adverse socioeconomic position across the lifecourse increases coronary heart disease risk cumulatively: findings from the British women's heart and health study. J Epidemiol Community Health 59(9):785–789

Lee PH, Macfarlane DJ, Lam TH, Stewart SM (2011) Validity of the International Physical Activity Questionnaire Short Form (IPAQ-SF): a systematic review. Int J Behav Nutr Phys Act 21(8):115

Leino M, Raitakari OT, Porkka KV, Taimela S, Viikari JS (1999) Associations of education with cardiovascular risk factors in young adults: the Cardiovascular Risk in Young Finns Study. Int J Epidemiol 28(4):667–675

Link BG, Phelan J (1995) Social conditions as fundamental causes of disease. J Health Soc Behav. Spec No: 80–94

Lubans DR, Morgan PJ, Cliff DP, Barnett LM, Okely AD (2010) Fundamental movement skills in children and adolescents: review of associated health benefits. Sports Med 40(12):1019–1035

Lynch JW, Kaplan GA, Salonen JT (1997) Why do poor people behave poorly? Variation in adult health behaviours and psychosocial characteristics by stages of the socioeconomic lifecourse. Soc Sci Med 44(6):809–819

Mann KD, Hayes L, Basterfield L, Parker L, Pearce MS (2013) Differing lifecourse associations with sport-, occupational- and household-based physical activity at age 49–51 years: the Newcastle Thousand Families Study. Int J Public Health 58(1):79–88

Osler M, Clausen JO, Ibsen KK, Jensen GB (2001) Social influences and low leisure-time physical activity in young Danish adults. Eur J Public Health 11(2):130–134

Osler M, McGue M, Christensen K (2007) Socioeconomic position and twins' health: a life-course analysis of 1266 pairs of middle-aged Danish twins. Int J Epidemiol 36(1):77–83

Osler M, Godtfredsen NS, Prescott E (2008) Childhood social circumstances and health behaviour in midlife: the Metropolit 1953 Danish male birth cohort. Int J Epidemiol 37(6):1367–1374

Oygard L, Anderssen N (1998) Social influences and leisure-time physical activity levels in young people: a twelve-year follow-up study. J Health Psychol 3(1):59–69

Paffenbarger RS Jr, Wing AL, Hyde RT (1978) Physical activity as an index of heart attack risk in college alumni. Am J Epidemiol 108(3):161–175

Pollitt RA, Rose KM, Kaufman JS (2005) Evaluating the evidence for models of life course socioeconomic factors and cardiovascular outcomes: a systematic review. BMC Public Health 20(5):7

Popham F, Mitchell R (2006) Leisure time exercise and personal circumstances in the working age population: longitudinal analysis of the British household panel survey. J Epidemiol Community Health 60(3):270–274

Poulton R, Caspi A, Milne BJ, Thomson WM, Taylor A, Sears MR, Moffitt TE (2002) Association between children's experience of socioeconomic disadvantage and adult health: a life-course study. Lancet 360(9346):1640–1645

Prince SA, Adamo KB, Hamel ME, Hardt J, Gorber SC, Tremblay M (2008) A comparison of direct versus self-report measures for assessing physical activity in adults: a systematic review. Int J Behav Nutr Phys Act 6(5):56

Pudrovska T, Anishkin A (2013) Early-life socioeconomic status and physical activity in later life: evidence from structural equation models. J Aging Health 25(3):383–404

Ramsay SE, Whincup PH, Morris RW, Lennon LT, Wannamethee SG (2007) Are childhood socio-economic circumstances related to coronary heart disease risk? Findings from a population-based study of older men. Int J Epidemiol 36(3):560–566

Regidor E, Banegas JR, Gutiérrez-Fisac JL, Domínguez V, Rodríguez-Artalejo F (2004) Socioeconomic position in childhood and cardiovascular risk factors in older Spanish people. Int J Epidemiol 33(4):723–730

Sagatun A, Kolle E, Anderssen SA, Thoresen M, Søgaard AJ (2008) Three-year follow-up of physical activity in Norwegian youth from two ethnic groups: associations with socio-demographic factors. BMC Public Health 22(8):419

Salonen MK, Kajantie E, Osmond C, Forsén T, Ylihärsilä H, Paile-Hyvärinen M, Barker DJ, Eriksson JG (2011) Prenatal and childhood growth and leisure time physical activity in adult life. Eur J Public Health 21(6):719–724

Salonna F, van Dijk JP, Geckova AM, Sleskova M, Groothoff JW, Reijneveld SA (2008) Social inequalities in changes in health-related behaviour among Slovak adolescents aged between 15 and 19: a longitudinal study. BMC Public Health 12(8):57

Schooling CM, Jiang CQ, Lam TH, Zhang WS, Cheng KK, Leung GM (2008) Life-course origins of social inequalities in metabolic risk in the population of a developing country. Am J Epidemiol 167(4):419–428

Senese LC, Almeida N, Fath AK, Smith BT, Loucks EB (2009) Associations between childhood socioeconomic position and adulthood obesity. Epidemiol Rev 31(1):21–51

Silverwood RJ, Pierce M, Nitsch D, Mishra GD, Kuh D (2012) Is intergenerational social mobility related to the type and amount of physical activity in mid-adulthood? Results from the 1946 British birth cohort study. Ann Epidemiol 22(7):487–498

Stalsberg R, Pedersen AV (2010) Effects of socioeconomic status on the physical activity in adolescents: a systematic review of the evidence. Scand J Med Sci Sports 20(3):368–383

Stodden D, Goodway JD, Langendorfer S et al (2008) A developmental perspective on the role of motor skill competence n physical activity: an emergent relationship. Quest 60:290–306

Suppli CH, Due P, Henriksen PW, Rayce SL, Holstein BE, Rasmussen M (2013) Low vigorous physical activity at ages 15, 19 and 27: childhood socio-economic position modifies the tracking pattern. Eur J Public Health 23(1):19–24

Svedenkrans J, Henckel E, Kowalski J, Norman M, Bohlin K (2013) Long-term impact of preterm birth on exercise capacity in healthy young men: a national population-based cohort study. PLoS One 8(12):e80869

Tammelin T, Näyhä S, Laitinen J, Rintamäki H, Järvelin MR (2003) Physical activity and social status in adolescence as predictors of physical inactivity in adulthood. Prev Med 37(4):375–381

Taverno Ross SE, Larson N, Graham DJ, Neumark-Sztainer D (2014) Longitudinal changes in physical activity and sedentary behavior from adolescence to adulthood: comparing U.S.-born and foreign-born populations. J Phys Act Health 11(3):519–527

Telama R, Laakso L, Nupponen H, Rimpelä A, Pere L (2009) Secular trends in youth physical activity and parents' socioeconomic status from 1977 to 2005. Pediatr Exerc Sci 21(4):462–474

Trost SG, Owen N, Bauman AE, Sallis JF, Brown W (2002) Correlates of adults' participation in physical activity: review and update. Med Sci Sports Exerc 34(12):1996–2001

U.S. Office of the Surgeon General, National Center for Chronic Disease Prevention, Health Promotion, President's Council on Physical Fitness, & Sports (1996) Physical activity and health: a report of the surgeon general. Jones & Bartlett Learning, USA

Van de Mheen H, Stronks K, Looman CW, Mackenbach JP (1998) Does childhood socioeconomic status influence adult health through behavioural factors? Int J Epidemiol 27(3):431–437

Walters S, Barr-Anderson DJ, Wall M, Neumark-Sztainer D (2009) Does participation in organized sports predict future physical activity for adolescents from diverse economic backgrounds? J Adolesc Health 44(3):268–274

World Health Organization (2009) Mortality and burden of disease attributable to selected major risks. WHO Press, Geneva

Wray LA, Alwin DF, McCammon RJ (2005) Social status and risky health behaviors: results from the health and retirement study. J Gerontol B Psychol Sci Soc Sci 60(Spec No 2):85–92

Yang XL, Telama R, Laakso L (1996) Parents' physical activity, socioeconomic status and education as predictors of physical activity and sport among children and youths—a 12-year follow-up study. Int Rev Soc Sport 31:273–291