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# Change4Life Evidence Review

## Rapid evidence review on the effect of physical activity participation among children aged 5 – 11 years

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# Contents

# Executive summary

In summer 2015, the Change4Life campaign will focus on promoting physical activity to children aged 5 – 11 years. The aim of this rapid evidence review was to identify relevant literature on the physiological, psychological, social, and behavioural outcomes of physical activity participation among children aged 5 – 11 years, and provide an indication of the strength of the evidence for each outcome.

The physiological outcomes with the strongest evidence for a positive association with physical activity among 5 – 11 years olds are: cardio-metabolic health; muscular strength; bone health; and cardiorespiratory fitness. The psychological outcomes with the strongest evidence are: self-esteem; anxiety/stress; academic achievement; cognitive functioning; and attention/concentration. The social outcomes with positive associations with physical activity are confidence and peer acceptance. There was insufficient evidence on any of the behavioural outcomes included in the review.

# Introduction

The importance of physical activity for children and young people's health is well established and there is increasing recognition of the potential of physical activity to impact on a wide variety of health and wellbeing outcomes. Despite concerted efforts to encourage children to be more physically active, worrying gaps still remain; with 79% boys and 84% girls aged 5-15 years in England not meeting the current physical activity recommendations [1].

The World Health Organization advocates that public education, through large scale, evidence based communication campaigns, is a cornerstone of physical activity promotion [2]. Change4Life is the Department of Health's national public health campaign, which began in January 2009. A key focus of the campaign is the promotion of physical activity to both adults and children.

In summer 2015, the Change4Life campaign will focus on promoting physical activity to children aged 5 – 11 years. The aim of this rapid evidence review was to identify relevant literature on the physiological, psychological, social, and behavioural outcomes of physical activity participation among children aged 5 – 11 years, to summarise the evidence, and provide an indication of the strength of the evidence for each outcome. Our review underpins and informs the construction of appropriate messages for parents and children for the Change4Life campaign.

# Methods

We undertook a purposive search to identify relevant literature on the physiological, psychological, social and behavioural outcomes of physical activity participation among children aged 5 – 11 years. The search primarily focused on review level evidence, with the addition of searches of primary research papers in areas lacking a recent review (undertaken in PubMed). We used a set of broad MeSH terms (Medical Subject Headings) to capture the most current studies published post reviews. For example, “confidence” AND “physical activity” AND “children”. Data on each outcome of interest were extracted by a member of the research team and verified by a second member. We also validated all findings with key physical activity reports and texts, eg Start Active, Stay Active: A report on physical activity for health from the four home countries’ Chief Medical Officers [3]. We limited our review to focus on the brief; namely the benefits of physical activity for children aged 5-11 years, however this age range was extended to teenage years where appropriate.

We developed criteria to rate the current state of the evidence for each outcome, based on the number of studies, the types of study design adopted, and the direction and strength of the reported associations. We constructed an overall summary statement on the evidence for each outcome, based on the NICE Public Health Methods Manual [4].

The research team (AC, KM, CF) came to a consensus on each area and coded the strength of the evidence for each outcome as green, amber, or red. Green outcomes reflected a body of research with strong or at least sufficient evidence for a positive association with physical activity. We feel these outcomes should form the basis of any messages used in the Change4Life campaign.

Amber outcomes did not have a strong evidence base; either because the evidence came from a small number of studies, the studies were of poor quality, or the evidence was equivocal ie studies showed mixed/contradictory results. Outcomes coded red, were those where there was not enough evidence to make any statements regarding potential associations with physical activity. We recommend that any variables coded amber or red do not feature in the Change4Life campaign.

We produced a summary table of results and short evidence statements on each outcome.

# Summary findings

Table 1: Summary of the strength of the association between physical activity and each health outcome

| Physiological | Psychological | Social | Behavioural |
|---|---|---|---|
| Cardio-metabolic health | Self-esteem | Confidence | Physical activity in adolescence/ adulthood |
| Muscular strength | Anxiety/stress | Peer acceptance | Sleep |
| Bone health | Academic achievement | Positive relationships | Risk taking behaviour |
| Cardiorespiratory fitness | Cognitive functioning | Social & communication skills | |
| Motor skills/ development | Attention/ concentration | Self-resilience | |
| Body composition | Self-efficacy | School engagement | |
| | Mood | | |
| | Memory | | |
| | Body image | | |

Green outcomes have consistent evidence

Amber outcomes have inconsistent evidence, or evidence from a small number of studies

Red outcomes have insufficient evidence

# Supporting evidence

## Physiological outcomes

There is a large body of research into the physiological benefits of physical activity participation, much of which has been summarised in high-level review documents including Start Active, Stay Active: A report on physical activity for health from the four home countries' Chief Medical Officers [3] and the U.S physical activity guidelines committee report [5]. In this review we included the six physiological/physical outcomes which have been the focus of much research into the benefits of physical activity among children: cardio-metabolic health; muscular strength; bone health; cardiorespiratory fitness; motor skills/development; and body composition.

## Cardio metabolic health

Children with good cardio-metabolic health have lower-risk of developing a range of risk factors for cardiovascular disease including type 2 diabetes, hypertension, and obesity. There is strong evidence for a positive association between physical activity and cardio-metabolic health among children within the age range of interest, with higher doses of physical activity associated with higher levels of cardiovascular and metabolic health [6]–[8]. Studies typically focus on the relationship between physical activity and risk factors for chronic disease, ie cardiovascular disease and type 2 diabetes, and fasting insulin levels, lipids, and inflammatory markers. Although not the primary focus of the review, research among adolescents shows that the relationship between physical activity and cardio metabolic health is particularly evident among those with an elevated risk status at baseline [9],[10]. Some research suggests that the associations between physical activity and risk factors for cardiovascular disease and type 2 diabetes may differ by gender, although the findings are equivocal [11],[12].

## Muscular strength

There is strong evidence that strength training leads to improvements in muscle strength among children, although the optimal mode, intensity, volume and duration of strength training exercises is yet to be determined [13]. In experimental studies, most training programmes have lasted between 8 and 12 weeks, with 2-3 training sessions per week. These studies consistently report improvements in muscle strength as a result of resistance training, and a reduction in muscle strength when the training is ceased [14]. Furthermore, resistance training has been shown to improve muscle strength in children without causing adverse effects on growth or maturation [14]. While much of the research has been conducted with males only, resistance training has also been shown to improve muscle strength among females [14].

## Bone Health

Bone health refers primarily to the maintenance of bone mineral density and is important for preventing conditions such as osteoporosis in later life. There is sufficient evidence that physical activity is associated with improved bone health in children. Bone-loading physical activity increases both bone mineral content and density. Although the majority of research focuses on girls, several high quality studies have shown the same association among boys [15]–[18]. The exact dose of physical activity to improve bone health among children is yet to be determined.

## Cardiorespiratory fitness

Cardio-respiratory fitness (commonly referred to as aerobic fitness or endurance) relates to the ability to perform sustained bouts of physical activity. There is strong evidence from a large number of high quality studies that physical activity is associated with cardiorespiratory fitness among children. Participation in 'endurance' activities, including brisk walking, running, cycling, stair climbing and sports leads to improved cardiorespiratory fitness (5% to 15% increase in endurance performance) in both boys and girls [5].

## Motor skills/development

'Motor skills' is the term used to describe the ability of the body to perform tasks, such as walking, balancing, catching and throwing. There is some evidence of a relationship between physical activity and motor skill acquisition in children within the age range of interest [19]. Much of the research into physical activity and motor skill development has been conducted in children of pre-school age. However it is suggested that this activity may need to be delivered by physical education specialists to ensure it is developmentally appropriate [20]. In addition, it is likely that sustained participation, as opposed to a single acute episode of physical activity, is required [21]. Some research suggests that children with higher motor proficiently are likely to be more physically active [22], emphasising the importance of developing motor skills to increase participation in physical activity and sports in childhood, although motor skills competency is not a strong predictor of physical activity in adulthood [23].

## Body composition

The term body composition is used to describe the percentages of fat, bone, muscle and water in the body. There is a large body of evidence into the relationship between physical activity and body composition, and in particular BMI and percentage body fat. However, due to natural changes in body composition which occur with chronological

age and associated changes in growth and maturation, these studies can be difficult to interpret [24]. In addition, the pattern and direction of these natural changes differs between boys and girls. Overall it appears that programmes aimed at increasing physical activity among normal weight children typically have little effect on adiposity [5]. Among children who are overweight/ obese, physical activity is associated with reductions in overall adiposity and visceral adiposity [25]–[28]. However, there is some contradictory evidence on this relationship, and the evidence regarding the pattern of association in terms of dose-response is inconsistent [5].

## Psychological Outcomes

In addition to the physiological benefits, there are a wide range of psychological outcomes associated with participation in physical activity. Upon reviewing the evidence on the psychological benefits of physical activity, we found the greatest volume of research related to nine principal outcomes: self-esteem; anxiety/stress; academic achievement; cognitive functioning; attention/concentration; self-efficacy; mood; memory; and body image.

### Self-esteem

There is strong evidence that participation in physical activity and sport is associated with self-esteem. One systematic review of randomised controlled trials (RCTs) [29] found several trials which indicated that exercise has positive short term effects on self-esteem in children. A review of reviews [30] looking at physical activity and mental health in children reported on three reviews which all showed a positive association between participation and self-esteem. Furthermore, one longitudinal study [31] investigated participation in organised sports and found that participation was significantly associated with social skills and self-esteem. A recent RCT [32] reported significant positive association following a 10 week community based physical activity intervention; furthermore these gains were retained after 6 months follow-up.

### Anxiety/stress

There is sufficient evidence to support the association of physical activity and anxiety in this age range. Four systematic reviews have reported a small negative association between physical activity and anxiety [30]. In addition, one longitudinal study involving 200 children investigated the effects of participation in extra-curricular sport on the development of social anxiety symptoms and found a negative association between those participating in team sports and social anxiety [35].

## Academic achievement

There is sufficient evidence that physical activity is associated with academic achievement. Of the studies reviewed, academic achievement frequently included indicators of cognitive skills, academic performance, academic concepts, cognitive ability and executive function [36],[37]. There is also emerging evidence for an association with cognitive flexibility and brain function and performance [38]. Over and above any other psychological outcome included in this review, we found a large body of good quality evidence supporting this association. This ranged from support for single bouts of exercise on academic performance [39] as well as acute physical exercise on executive function [40] to a positive long term association with moderate to vigorous physical activity on academic attainment [41].

## Cognitive functioning

There is strong evidence that physical activity is associated with cognitive development. Seven reviews have consistently reported a positive association between physical activity and cognitive functioning [30]. Among them was a large meta-analysis of 44 studies which found a significant and positive relationship between physical activity and cognitive functioning. Middle school aged students showed the biggest effect size followed by young elementary students [42].

## Attention/concentration

There is sufficient evidence that children's attention and concentration are associated with physical activity. Two studies reported a positive association between physical activity and concentration and attention, as well as on-task behaviour [43]. This provides further support to an earlier review [44] which found a significant association between physical activity and concentration and classroom behaviour from cross sectional observations.

## Self-efficacy

There is some evidence to support the association between physical activity and self-efficacy in this age range, although the evidence comes from only a small number of studies. Results from a recent review show that, among the age group of interest, there is moderately strong evidence to suggest that participation in physical activity programs/ interventions is associated with improved self-efficacy [33]. This adds strength to an earlier review which reported that self-efficacy had 'indeterminate' relations with children's physical activity [34].

### Mood

There is equivocal evidence that participation in physical activity is associated with mood. One longitudinal study [46] of over 6,000 primary and secondary school children reported mixed associations between physical activity and mood, and associations varied by gender and school level.

### Memory

There is insufficient evidence that participation in physical activity is associated with memory. Only one study was found [45], which consisted of a nine month RCT. Although this study found that physical activity and cardiorespiratory fitness are associated with improvements in the cognitive control of working memory in preadolescent children (aged 7 – 9 years), further research is needed in this area.

### Body image

There is insufficient evidence that participation in physical activity is associated with body image in this age group. Only one longitudinal study was found [47] of 821 elementary school children (aged 7 – 9 years). Among both boys and girls, weak evidence was found for the relationship between physical activity and body dissatisfaction and these relationships were no longer significant after adjusting for percent body fat.

## Social Outcomes

Social outcomes are closely related to psychological outcomes and in the papers included in this review were often described in generic terms or mixed with psychological variables. We summarised clusters of outcomes under generic titles but acknowledge there are considerable differences in the use and consistency of terms between primary studies. For example the ‘positive relationships’ outcome included studies that examined children’s relationships with a range of adults (teachers, coaches, neighbours) and peers.

We report results for six principle outcomes which were found to feature commonly in the literature: confidence; peer acceptance; positive relationships; social and communication skills; self-resilience; and school engagement. The majority of studies within this section were cross-sectional so any inference of direct causation between physical activity and the outcome is unproven.

## Confidence

There is sufficient evidence that participation in physical activity is associated with confidence. This evidence comes from longitudinal research and RCTs, as well as cross-sectional studies. A recent RCT reported improvements in confidence following a 10-week community based physical activity intervention among girls aged 10 – 16 years [32]. In addition, longitudinal research shows that team or individual sport participation is associated with positive youth development among the age group of interest, in comparison to participation in development programs, performing arts, arts and crafts, school clubs, volunteering, religious groups, and paid work [48]. Evidence from cross-sectional studies also supports the association between physical activity and positive development among children, even after controlling for total time spent in the activities and the duration of sport participation [49],[50].

## Peer acceptance

There is sufficient evidence that peer acceptance and friendship is associated with physical activity and sport. One cross-sectional study of UK children aged 7 – 9 years reported that peer acceptance was an important moderator of participation in physical activity when combined with age related maturity [51]. Participation in sports supported and reinforced friendships. A recent review of cross-sectional, longitudinal and experimental evidence reported that there is a relationship between peer and/or friend variables and adolescents' physical activity [52]. Clearly the importance of peer support may increase with age but the principle of the promotion of peer support for physical activity and the encouragement of peer acceptance, approval, and friendship in sports to increase motivation and participation in physical activity is unlikely to do harm.

## Positive relationships

There is some, but little, evidence that participation in physical activity is associated with positive relationships. One longitudinal study reported some improvements in co-operation, and one cross-sectional study reported that children participating in both sports and clubs had higher social skill scores compared with children who did not participate in any outside-school activity [31],[53].

## Social and communication skills (negotiation, co-operation, sharing, problem solving)

There is equivocal evidence that children's social and communication skills are associated with their physical activity behaviour, and results are inconsistent by gender and age [31],[49],[50],[53]–[56]. Social and communication skills are also mediated by parental support for physical activity and social status [57].

### Self-resilience

There is some evidence that self–resilience is associated with participation in physical activity but the evidence is of poor quality and from adolescent samples as opposed to the age group of interest [58]–[60]. Among adolescents, participation in both “formal” and “informal” sports has been shown to be related to enhanced emotional and behavioural wellbeing, and those participating in formal sports also reported significantly lower levels of emotional and social problems compared to those participating in fewer formal sports [61]. In addition, one pre-post study reported increases in resilience scores for Canadian Aboriginal adolescents following participation in an outdoor education intervention [62].

### School engagement

There is insufficient evidence and it is of poor quality that school engagement is associated with physical activity in or out of school. One recent pilot intervention study reported that physically active academic lessons may positively influence time-on-task in children, which can contribute to academic success in the long term [63]. In addition, one cross-sectional study reported that high overall sports participation was associated with a reduced risk of truancy [64]. However more research is needed in this area.

## Behavioral Outcomes

The impact of physical activity participation on other behaviours is a relatively under-explored area of research. Of particular interest is whether the establishment of regular physical activity patterns in childhood leads to sustained participation throughout adolescents and adulthood. We reviewed the evidence for this ‘tracking’ of physical activity behaviour. We also searched for evidence of a relationship between physical activity and other behaviours, such as sleep and risk taking behaviour such as smoking, drug-taking, and alcohol use.

### Physical activity into adolescence/ adulthood

There is some evidence from longitudinal studies that physically active children continue to be active throughout adolescence and adulthood, although this evidence comes from a small number of studies. A study tracked 6,458 10 years olds over a 32 year period and reported that those with frequent sports participation at age 10 were significantly more likely to participate in sport and/or physical activity at age 42, although the same relationship was not observed for active play [65]. Another study tracked 2,309 individuals over a 21 year period, and suggested that some evidence of tracking may exist, although the association was weak to moderate, and more evident among males

than females [66]. Although these studies suggest that some tracking of behaviour may exist, the evidence is by no means conclusive and comes from only two longitudinal studies.

### Sleep

The evidence on the relationship between physical activity and sleep comes from cross-sectional studies and the findings are equivocal. While one recent study reported that moderate to vigorous physical activity may be associated with better quality sleep in some children [67], other studies show that higher levels of physical activity are associated with less sleep, lower sleep efficiency and increased sleep fragmentation [68],[69].

### Risk taking behaviour (smoking, drug taking, alcohol abuse)

No evidence was found on the association between physical activity and risk-taking behaviour in the age group of interest.

## Conclusions

From this rapid review of the evidence on the outcomes of physical activity participation among children aged 5 – 11 years, the strongest evidence exists for a positive association between physical activity and cardio-metabolic health, muscular strength, bone health, cardiorespiratory fitness, self-esteem, anxiety/stress, academic achievement, cognitive functioning, attention/concentration, confidence, and peer friendship. Therefore these outcomes should underpin the messages used in the new Change4Life campaign.

## References

[1] Health and Social Care Information Centre. Health Survey for England, 2012. Leeds, UK; 2013.

[2] World Health Organization (Who). Global action plan for the prevention and control of noncommunicable diseases 2013-2020. 2013;102.

[3] Department of Health. Start active, stay active. Strategy. London; 2011.

[4] NICE. Methods for the development of NICE public health guidance ( third edition ). 2012;(September):284.

[5] Physical Activity Guidelines Advisory Committee. Physical activity guidelines advisory committee report 2008. Washington, DC; 2008.

[6] Krekoukia M, Nassis GP, Psarra G, Skenderi K, Chrousos GP, Sidossis LS. Elevated total and central adiposity and low physical activity are associated with insulin resistance in children. Metabolism. 2007 Feb;56(2):206–13.

[7] Ondrak KS, McMurray RG, Bangdiwala SI, Harrell JS. Influence of aerobic power and percent body fat on cardiovascular disease risk in youth. J Adolesc Health. 2007 Aug;41(2):146–52.

[8] Raitakari O, Taimela S, Porkka K, Telama R, Valimaki I, Akerblom H, et al. Associations between physical activity and risk factors for coronary heart disease: The Cardiovascular Risk in Young Finns Study. Med &amp Sci Sport &amp Exerc. 1997 Aug;29(8):1055–61.

[9] Kang HS, Gutin B, Barbeau P, Owens S, Lemmon CR, Allison J, et al. Physical training improves insulin resistance syndrome markers in obese adolescents. Med Sci Sports Exerc. 2002;34(12):1920–7.

[10] Ewart CK, Young DR, Hagberg JM. Effects of school-based aerobic exercise on blood pressure in adolescent girls at risk for hypertension. Am J Public Health. 1998;88(6):949–51.

[11] Brage S, Wedderkopp N, Ekelund U, Franks PW, Wareham NJ, Andersen LB, et al. Features of the Metabolic Syndrome Are Associated With Objectively Measured Physical Activity and Fitness in Danish Children: The European Youth Heart Study (EYHS). Diabetes Care. 2004 Aug 26;27(9):2141–8.

[12] Imperatore G, Cheng YJ, Williams DE, Fulton J, Gregg EW. Physical activity, cardiovascular fitness, and insulin sensitivity among U.S. adolescents: the National Health and Nutrition Examination Survey, 1999-2002. Diabetes Care. 2006 Jul;29(7):1567–72.

[13] Blimkie CJR, Bar-Or O. Trainability of muscle strength, power and endurance during childhood. In: Bar-Or O, editor. The child and adolescent athlete. Oxford, UK: Blackwell Science; 1996. p. 113–29.

[14] Malina RM. Weight training in youth-growth, maturation, and safety: an evidence-based review. Clin J Sport Med. 2006 Nov;16(6):478–87.

[15] Bradney M, Pearce G, Naughton G, Sullivan C, Bass S, Beck T, et al. Moderate exercise during growth in prepubertal boys: Changes in bone mass, size, volumetric density, and bone strength: A controlled prospective study. J Bone Miner Res. 1998;13(12):1814–21.

[16] Macdonald HM, Kontulainen SA, Khan KM, McKay HA. Is a school-based physical activity intervention effective for increasing tibial bone strength in boys and girls? J Bone Miner Res. 2007 Mar;22(3):434–46.

[17] MacKelvie KJ, Petit MA, Khan KM, Beck TJ, McKay HA. Bone mass and structure are enhanced following a 2-year randomized controlled trial of exercise in prepubertal boys. Bone. 2004 Apr;34(4):755–64.

[18] MacKelvie KJ, McKay HA, Petit MA, Moran O, Khan KM. Bone mineral response to a 7-month randomized controlled, school-based jumping intervention in 121 prepubertal boys: Associations with ethnicity and body mass index. J Bone Miner Res. 2002;17(5):834–44.

[19] Laukkanen A, Pesola A, Havu M, Sääkslahti A, Finni T. Relationship between habitual physical activity and gross motor skills is multifaceted in 5- to 8-year-old children. Scand J Med Sci Sports. Blackwell Munksgaard; 2014 Apr;24(2):e102–10.

[20] Morgan PJ, Barnett LM, Cliff DP, Okely AD, Scott HA, Cohen KE, et al. Fundamental movement skill interventions in youth: a systematic review and meta-analysis. Pediatrics. 2013 Nov;132(5):e1361–83.

[21] Fisher A, Reilly J, Kelly L, Montgomery C, Williamson A, Paton J, et al. Fundamental Movement Skills and Habitual Physical Activity in Young Children. Med Sci Sport Exerc. 2005 Apr;37(4):684–8.

[22] Wrotniak BH, Epstein LH, Dorn JM, Jones KE, Kondilis VA. The relationship between motor proficiency and physical activity in children. Pediatrics. 2006 Dec;118(6):e1758–65.

[23] Holfelder B, Schott N. Relationship of fundamental movement skills and physical activity in children and adolescents: A systematic review. Psychol Sport Exerc. Elsevier BV; 2014 Jul;15(4):382–91.

[24] Malina RM, Bouchard C, Bar-Or O. Growth, maturation, and physical activity. Champaign, Illinois: Juman Kinetics; 2004.

[25] Barbeau P, Johnson MH, Howe CA, Allison J, Davis CL, Gutin B, et al. Ten months of exercise improves general and visceral adiposity, bone, and fitness in black girls. Obesity (Silver Spring). 2007 Aug;15(8):2077–85.

[26] Gutin B, Cucuzzo N, Islam S, Smith C, Stachura M. Physical training, lifestyle education, and coronary risk factors in obese girls. Med Sci Sport Exerc. 1996 Jan;28(1):19–23.

[27] Owens S, Gutin B, Allison J, Riggs S, Ferguson M, Litaker M, et al. Effect of physical training on total and visceral fat in obese children. Med Sci Sport Exerc. 1999 Jan;31(1):143–8.

[28] Yin Z, Gutin B, Johnson MH, Hanes J, Moore JB, Cavnar M, et al. An environmental approach to obesity prevention in children: Medical college of georgia fitKid project year 1 results. Obes Res. 2005;13(12):2153–61.

[29] Ekeland E, Heian F, Hagen KB. Can exercise improve self esteem in children and young people? A systematic review of randomised controlled trials. Br J Sports Med. 2005;39(11):792–8; discussion 792–8.

[30] Biddle S, Asare M. Physical activity and mental health in children and adolescents: a review of reviews. Br J Sports Med. 2011;45(11):886–95.

[31] Findlay LC, Coplan RJ. Come out and play: Shyness in childhood and the benefits of organized sports participation. Can J Behav Sci. 2008;40(3):153–61.

[32] Tirlea L, Truby H, Haines TP. Pragmatic, Randomized Controlled Trials of the Girls on the Go! Program to Improve Self-Esteem in Girls. The American Journal of Health Promotion, Inc.; 2015 May 14;

[33] Cataldo R, John J, Chandran L, Pati S, Shroyer a LW. Impact of physical activity intervention programs on self-efficacy in youths: A systematic review. ISRN Obes. 2013;2013:586497.

[34] Sallis JF, Prochaska JJ, Taylor WC. A review of correlates of physical activity of children and adolescents. Med Sci Sports Exerc. 2000;32(5):963–75.

[35] Schumacher Dimech A, Seiler R. Extra-curricular sport participation: A potential buffer against social anxiety symptoms in primary school children. Psychol Sport Exerc. 2011;12(4):347–54.

[36] Singh A, Uijtdewilligen L, Twisk J, van Mechelen W, Chinapaw M. Physical activity and student performance at school: A systematic review of the literature including a methodological quality assessment. Arch Pediatr Adolesc Med. 2012;166(1):49–55.

[37] Wittberg R a., Northrup KL, Cottrell L a. Children’s aerobic fitness and academic achievement: A longitudinal examination of students during their fifth and seventh grade years. Am J Public Health. 2012;102(12):2303–7.

[38] Hillman CH, Pontifex MB, Castelli DM, Khan N a., Raine LB, Scudder MR, et al. Effects of the FITKids Randomized Controlled Trial on Executive Control and Brain Function. Pediatrics. 2014;134(4):e1063–71.

[39] Haapala E. Physical Activity, Academic Performance and Cognition in Children and Adolescents. A Systematic Review. Balt J Heal Phys Act. 2012;4(1):53–61.

[40] Tremblay MS, Inman JW, Willms DJ. The Relationship Between Physical Activity,Self-Esteem, and Academic Achievement in 12-Year-Old Children. Pediatric Exercise Science. 2000. p. 312–23.

[41] Booth JN, Tomporowski PD, Boyle JM, Ness a. R, Joinson C, Leary SD, et al. Associations between executive attention and objectively measured physical activity in adolescence: Findings from ALSPAC, a UK cohort. Ment Health Phys Act. 2013;6(3):212–9.

[42] Sibley BA, Etnier JL. The Relationship Between Physical Activity and Cognition in Children : A Meta-Analysis. Pediatr Exerc Sci. 2003;15(3):243–56.

[43] Erwin H, Fedewa A, Beighle A, Ahn S. A Quantitative Review of Physical Activity, Health, and Learning Outcomes Associated With Classroom-Based Physical Activity Interventions. J Appl Sch Psychol. 2012;28(1):14–36.

[44] Trudeau F, Shephard RJ. Physical education, school physical activity, school sports and academic performance. Int J Behav Nutr Phys Act. 2008 Jan;5:10.

[45] Kamijo K, Pontifex MB, O'Leary KC, Scudder MR, Wu C-T, Castelli DM, et al. The effects of an afterschool physical activity program on working memory in preadolescent children. Dev Sci. 2011 Sep;14(5):1046–58.

[46] McKercher C, Schmidt MD, Sanderson K, Dwyer T, Venn AJ. Physical activity and depressed mood in primary and secondary school-children. Ment Health Phys Act. Elsevier Ltd; 2012;5(1):50–6.

[47] Olive LS, Byrne DG, Cunningham RB, Telford RD. Effects of physical activity, fitness and fatness on children's body image: The Australian LOOK longitudinal study. Ment Health Phys Act. 2012 Dec;5(2):116–24.

[48] Zarrett N, Fay K, Li Y, Carrano J, Phelps E, Lerner RM. More than child's play: variable- and pattern-centered approaches for examining effects of sports participation on youth development. Dev Psychol. 2009 Mar;45(2):368–82.

[49] Holt NL, Kingsley BC, Tink LN, Scherer J. Benefits and challenges associated with sport participation by children and parents from low-income families. Psychol Sport Exerc. 2011 Sep;12(5):490–9.

[50] Wiersma LD, Fifer AM. “ The schedule has been tough but we think it ’ s worth it ”: The joys , challenges , and recommendations of youth sport parents. J Leis Res. 2008;40(4):505–30.

[51] Pindus DM, Davis RDM, Hillman CH, Bandelow S, Hogervorst E, Biddle SJH, et al. The relationship of moderate-to-vigorous physical activity to cognitive processing in adolescents: findings from the ALSPAC birth cohort. Psychol Res. Springer Verlag; 2014 Oct 29;

[52] Fitzgerald A, Fitzgerald N, Aherne C. Do peers matter? A review of peer and/or friends’ influence on physical activity among American adolescents. J Adolesc. 2012 Aug;35(4):941–58.

[53] Howie LD, Lukacs SL, Pastor PN, Reuben CA, Mendola P. Participation in activities outside of school hours in relation to problem behavior and social skills in middle childhood. J Sch Health. 2010 Mar;80(3):119–25.

[54] Hansen DM, Larson RW, Dworkin JB. What Adolescents Learn in Organized Youth Activities: A Survey of Self-Reported Developmental Experiences. J Res Adolesc. 2003 Mar;13(1):25–55.

[55] Brettschneider W. Effects of sport club activities on adolescent development in Germany. Eur J Sport Sci. Taylor & Francis Group; 2001 Jun 9;1(2):1–11.

[56] Sebire SJ, Jago R, Fox KR, Page AS, Brockman R, Thompson JL. Associations between children’s social functioning and physical activity participation are not mediated by social acceptance: a cross-sectional study. Int J Behav Nutr Phys Act. 2011 Jan;8:106.

[57] McMinn AM, van Sluijs EMF, Nightingale CM, Griffin SJ, Cook DG, Owen CG, et al. Family and home correlates of children’s physical activity in a multi-ethnic population: the cross-sectional Child Heart and Health Study in England (CHASE). Int J Behav Nutr Phys Act. 2011 Jan;8:11.

[58] Valois RF, Umstattd MR, Zullig KJ, Paxton RJ. Physical activity behaviors and emotional self-efficacy: is there a relationship for adolescents? J Sch Health. 2008 Jun;78(6):321–7.

[59] Bartko WT, Eccles JS. Adolescent Participation in Structured and Unstructured Activities: A Person-Oriented Analysis. J Youth Adolesc. 2003;32(4):233–41.

[60] Steptoe A, Wardle J, Pollard TM, Canaan L, Davies GJ. Stress, social support and health-related behavior: A study of smoking, alcohol consumption and physical exercise. J Psychosom Res. 1996 Aug;41(2):171–80.

[61] Donaldson SJ, Ronan KR. The efects of sports participation on young adolescents' emotional well-being. Adolescence. 2006;41(162):369–89.

[62] Ritchie SD, Wabano M-J, Russell K, Enosse L, Young NL. Promoting resilience and wellbeing through an outdoor intervention designed for Aboriginal adolescents. Rural Remote Health. 2014 Jan;14:2523.

[63] Mullender-Wijnsma MJ, Hartman E, de Greeff JW, Bosker RJ, Doolaard S, Visscher C. Moderate-to-vigorous physically active academic lessons and academic engagement in children with and without a social disadvantage: a within subject experimental design. BMC Public Health. 2015 Apr 19;15(1):404.

[64] Nelson MC, Gordon-Larsen P. Physical activity and sedentary behavior patterns are associated with selected adolescent health risk behaviors. Pediatrics. 2006 Apr;117(4):1281–90.

[65] Smith L, Gardner B, Aggio D, Hamer M. Association between participation in outdoor play and sport at 10years old with physical activity in adulthood. Prev Med (Baltim). 2015 May;74:31–5.

[66] Telama R, Yang X, Leskinen E, Kankaanpää A, Hirvensalo M, Tammelin T, et al. Tracking of physical activity from early childhood through youth into adulthood. Med Sci Sports Exerc. 2014 Jan;46(5):955–62.

[67] Ekstedt M, Nyberg G, Ingre M, Ekblom Ö, Marcus C. Sleep, physical activity and BMI in six to ten-year-old children measured by accelerometry: a cross-sectional study. Int J Behav Nutr Phys Act. 2013;10:82.

[68] Pesonen AK, Sjöstén NM, Matthews K a., Heinonen K, Martikainen S, Kajantie E, et al. Temporal associations between daytime physical activity and sleep in children. PLoS One. 2011;6(8):4–9.

[69] Williams SM, Farmer VL, Taylor BJ, Taylor RW. Do more active children sleep more? A repeated cross-sectional analysis using accelerometry. PLoS One. 2014;9(4):3–10.