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Do youth sports prevent pediatric obesity? A systematic review and commentary

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Abstract

Sport is a promising setting for obesity prevention among youth, but little is known about whether it prevents obesity. We reviewed research comparing sport participants with non-participants on weight status, physical activity and diet. Among nineteen studies we found no clear pattern of association between body weight and sport participation. Among seventeen studies we found that sport participants are more physically active than those who do not participate. Seven studies examined the relationship between sport participation and diet and found that sport participation is associated with more fruit, vegetable and milk consumption, but also more fast food and sugar sweetened beverage consumption and greater overall calorie intake. It is unclear from these results whether sports programs, as currently offered, protect youth from becoming overweight or obese. Additional research may foster understanding about how sport, and youth sport settings, can help promote energy balance and healthy body weight.

Keywords

Overweight; physical activity; diet; youth development; sport; athletics

Introduction

In the United States approximately one in three children are either overweight or obese. Pediatric obesity is clearly a major public health problem in the U.S. and much of the world. Increasing physical activity and promoting a healthier dietary intake are the cornerstones of obesity prevention and treatment.

In the year 2000 the U.S. Secretaries of Health and Human Services and Education issued a joint report recommending sport participation as a strategy to increase energy expenditure, activity, and fitness among youth in order to promote health and prevent increasing levels of overweight among youth (54). The National Council of Youth Sports estimates that more than 44 million youth in the U.S. participate in sport, and more than half of high school students (56%) reported on the Youth Risk Behavioral Surveillance Survey (YRBSS) that they participated on a school or community sport team (12). Youth sport programs are not designed or primarily intended to prevent obesity, but sports is a setting in which many youth are physically active. The physical activity involved in sport participation, combined with the high levels of participation, suggests that youth sport may be a promising setting for obesity prevention. Despite this promise very little research or intervention efforts have focused on sports settings compared with other settings such as schools and after-school programs. The available data indicate that those who participate in youth sport remain susceptible to overweight and obesity. For example, national studies in the U.S. have found that more than 1 in 4 youth sport participants (26% male, 27% female) were overweight (18), and nearly half of youth (48%) who were obese said they participated in sport (7).

In order to better understand the relationship between youth sport participation and obesity prevention, we systematically reviewed the existing research on the association between sport participation and body weight, plus two major determinants of obesity, physical activity and dietary intake. Using the existing studies as a foundation, we highlight areas for future research and practice to help create youth sport settings that are more consistent with obesity prevention goals.

Review Methods

We (TFN and MT) reviewed studies identified through searches of existing literature using the search engines PubMed and Google Scholar through February 2011 and using the terms “sport,” “youth sport,” and “sport participant.” By youth we specifically refer to elementary school through secondary school children who are approximately 6–18 years of age. Our definition of sport includes competitive and physical games or activities that have some degree of organization, and are sponsored by a school or community group. However, most of the research we reviewed lacked precise or detailed measures of sport participation, and this is an important limitation. For the question of weight status, we used key words “weight,” “overweight,” “obese,” and “body mass index.” For the question of on physical activity, key words “physical activity” and “exercise” were used, and for the question of diet, we used key words “nutrition,” “dietary habits,” “diet,” “energy intake,” and “sports drinks.” We included studies that directly compared sport participants with those not participating in sport, as well as studies that employed within-subject designs that directly assessed the effects of sport participation. The primary reason for excluding articles identified in our search from this review was that they did not include a comparison of sport and non-sport conditions. In addition, studies that examined the relationship between sport participation and weight status, and statistically adjusted for physical activity, were excluded. Identified articles were cross-referenced with cited literature using ISI Web of Knowledge to ensure a comprehensive search.

Results

Sport Participation and Weight Status

Our search identified 19 studies that explored the relationship between sport participation and weight status in children and adolescents. As shown in Table 1, most studies used cross-sectional designs with one study employing a longitudinal design.

Twelve studies found that sport participants had lower weight status than non-sport participants in at least one of the comparisons they examined (3, 4, 7, 8, 14, 15, 18, 21, 28, 32, 34, 44). Several of these studies conducted multiple comparisons and found differences only among specific sub-groups of the overall population. Seven studies found no association between sport participation and weight status (6, 30, 41, 50, 51, 58, 63). Overall, most of the comparisons indicated no difference between sport participants and non-participants. We examined whether patterns in the statistically significant findings existed by sex, age, sample size, or study outcome measure across all of these studies and no clear pattern emerged. In particular we suspected that studies with a larger sample size would be more likely to show differences between sport participants and non-participants. Among the 10 studies that had more than 1,000 study subjects 24 comparisons were examined and only nine of these showed significantly lower weight status among sport participants. Only one of these studies examined the type of sport youth were involved in and found that participants in some sports were more likely and in others were less likely to be overweight than non-participants (50). Sports with a higher level of obesity included rugby, swimming, judo and tennis and sports with lower levels of obesity included gymnastics, handball, horse riding and dance, although the sample within each of these sports was relatively small. Another study found lower body mass index among sport participants among females, but not males, participating in weight-related sports (e.g., gymnastics), while no differences existed between power-team (e.g., football, soccer, hockey) sport participants and non-participants (14). One longitudinal study observed that males who participated in sport at age 11–12 were less likely to be overweight at age 14, but no association between sport participation and weight status was observed among females or among males 14–17 years of age (28).

Two small intervention studies are also relevant to the question of sport participation and body weight. One study randomly assigned overweight and previously inactive youth to an after-school soccer program or a group that received health education and found significant increases in objectively measured physical activity, and small, but statistically significant decreases in body mass index at 3 and 6 months in the soccer group compared to the health education group (60). A second, small quasi-experimental study found no differences in BMI between obese youth participating in a sport camp and support program, and a control group (36).

The lack of a clear difference in weight status between participants and non-participants observed in some of the studies reviewed may be attributed to the type of sport studied and the specific body type suited for that sport. The wide variation in the prevalence of obesity between sports should be better understood in further research. Large body size is advantageous in some sports (e.g., American football). A study of high school football players found that 45% of offensive lineman were obese (95th percentile of BMI) (29).

Most current and former adult professional football players meet standard criteria for obesity (53). Elite youth athletes in sports such as soccer and ice hockey tend to have advanced skeletal maturity, which is a risk factor for subsequent obesity (40). Unlike findings among adults, in children, there is a positive association between BMI and height (47). Children who are overweight tend to be tall, undergo less growth in height during adolescence, and have higher BMI as young adults (47). These forces may encourage selection of large children (who are at higher risk for future obesity) in competitive youth sport, particularly at early ages.

Several limitations exist with the studies on sport participation and weight status, including small sample size, employing body mass index (BMI) as an outcome measure, and the use of cross-sectional designs. Small sample sizes may leave studies underpowered to observe differences, even if they do exist, between sport participants and non-participants. BMI is a reasonable measure of adiposity in children and adolescents (16), but it may not be a good indicator among sport participants, especially those who tend to be more muscular (37). Differential body composition may bias comparisons of sport participants and non-participants toward findings of no difference when using BMI, but the extent to which this issue is an important factor among youth is not known. Cross-sectional designs do not account for possible selection bias. For example, physically fit, normal-weight youth may be more likely to join and continue participating in sport, which may account for observed differences in weight status.

Given the limited available research, there is not sufficient evidence to conclude that sport participation protects against the development of obesity. Additional research is needed to understand weight status and weight gain among sport participants and to determine if, and under what conditions, sport can effectively prevent unhealthy weight gain.

Sport Participation and Physical Activity

Table 2 presents a summary of studies, comparing physical activity levels of sport participants and non-participants. Both cross-sectional and longitudinal studies consistently show that youth who participate in sport are more likely to be physically active than non-participants (2, 17, 24, 26, 27, 38–41, 43–45, 48, 51, 55, 58, 59). Longitudinal studies suggest that activity levels decline for many sport participants after they discontinue participation (2, 17, 27, 40, 48, 52, 55). These studies also suggest that the strength of the relationship between sport participation in adolescence and physical activity in adulthood is modest, and does not occur in all subgroups.

Important information about the association of sport participation and physical activity levels can be garnered from two smaller studies evaluating a slightly different research question, namely, the direct contribution of sport to daily physical activity. One study examined self-reported activity to track energy expenditure during a three day period and found that males expended 20%, and females 16%, of their total daily energy in sport (30). A similar study of youth participating in a sports program objectively assessed activity using accelerometers on days when they did and did not participate in sport and found that sport contributed an additional 30 minutes of moderate and vigorous activity per day (59). Finally, a recent study that objectively assessed physical activity of youth sport participants in

soccer, baseball and softball found that fewer than 1 in 4 met recommended levels of activity during their sport team practice (30). This study found that sport participants, on average, were inactive for 30 minutes of their team practices.

Together these studies suggest that participating in sport can help youth engage in more physical activity. However, there are important limitations to this literature. For example, the majority of studies used cross-sectional designs, thus making it unclear whether sport is causing the participants to be more active or whether more active children join sport programs. Many existing studies on sport and physical activity used self-reported measures rather than objective measurement of physical activity. Only one study identified in our search explored the factors that determine the amount of activity that occurs during youth sport, finding that activity varied by participant sex and type of sport (30). Instruction and motor skill development are important parts of many sport practices and these may account for the sedentary time observed during sport in these studies. It is not clear from these studies how much of the sedentary time in sport was spent in these sport-related activities, nor is it clear the extent to which physical activity can be optimized in these settings without sacrificing instruction and skill development. These are topics for future research. Other relevant factors may be associated with physical activity during sport include the amount of playing time, intensity level, skill-level of players, coach expertise, practice organization and effectiveness, availability of appropriate equipment and facilities, and team/league policies (30). Each of these areas presents an opportunity for further research and may be amenable to interventions to influence physical activity and energy expenditure in youth sport.

Sport Participation and Dietary Intake

The majority of studies on diet among sport participants have focused on elite competitors or the female athlete triad (disordered eating, menstrual dysfunction, and low bone density), which may occur among athletes in sports that emphasize leanness (e.g., endurance sports, gymnastics) (35). We identified seven studies that compared sport participants and non-participants with respect to their dietary intake. These studies are summarized in Table 3.

The most comprehensive study to date comparing dietary intake of sport participants with non-participants found that youth involved in sport had better overall nutrient intake than youth not involved in sport (14). Other studies found that sport participants are more likely to report consuming fruits, vegetables and milk than non-participants (10, 24, 48); however, sport participants appear to consume more overall calories than non-participants (12, 14). One small study of male tennis players in Brazil found that nearly half the sample (45%) consumed more calories per day than they expended (25). Findings such as this may account for the lack of a clear effect of sport participation for preventing obesity.

Higher energy intake may be important for sport participants if energy expenditure is high but may lead to weight gain if energy intake exceeds expenditure. The available research suggests that excess calories consumed by youth sport participants may come from two sources: 1) fast food and 2) sugar-sweetened beverages such as soft drinks, fruit juices and sports drinks (e.g., Gatorade and PowerAde). A study of middle and high school youth found a positive association between sports team participation and frequency of fast food consumption among males (19). A subsequent longitudinal analysis of these data found that

among males, sport team participation during middle school predicted greater fast food consumption into the high school years (5). Frequent fast food consumption is associated with greater intake of total calories, total fat, saturated fat, carbohydrates, sodium, added sugar, and sugar-sweetened beverages, and lower intake of milk, fruits and vegetables, higher weight, and weight gain (23). In other research sport participants were more likely than non-participants to consume sports drinks and fruit juice and equally likely to consume soft drinks (12). Consumption of sugar-sweetened beverages is associated with excess calorie intake, increased risk of overweight and obesity, weight gain, metabolic risk factors, and risk for type 2 diabetes (49). Sugar-sweetened beverage consumption among youth has risen over the past several decades, particularly among youth aged 6–11, and is associated with rapid increases in childhood obesity (56).

Our review of the studies that directly compare dietary habits of sport participants with non-participants found that the existing literature has several limitations. Most employed cross-sectional designs. It is possible that youth who are more inclined to participate in sport are also more likely to have a particular diet. The studies, in general, had limited assessment of dietary variables. Finally, all studies used self-reporting measures of diet. Additional research in this area could help identify possible areas for future intervention to improve eating behavior of sport participants.

Commentary

Energy Balance in Youth Sport

Whether or not youth sport participation can effectively prevent overweight and obesity depends upon energy balance, a function of calorie consumption and physical activity. Although growing bodies require slightly more energy intake than expenditure, energy surplus and weight gain can occur when caloric intake exceeds expenditure. The best available estimates indicate that childhood obesity is driven by a surplus of approximately 110–165 kcal/day for children ages 2–7 years and 678–1017 kcal/day for adolescents aged 12–17 (57).

Little formal research has assessed energy balance in sport. Studies among elite athletes show that overall energy intake increases as activity levels and expenditure increase (42). While sport participants are more active than their peers who do not participate in sport, the benefits in terms of energy expenditure may be small, since most of the time that youth spend in sport is either sedentary or in light-intensity activity (30,59). A study of youth participating in a school-based activity intervention found that youth may overcompensate for increased physical activity by eating more and gaining weight (46). If this commonly occurs in sport, it may account for why youth in sport are not less likely to be overweight or obese. The benefits of sport participation for obesity prevention are dependent on the actual amount of energy expended in sport and must be considered in the context of dietary habits of sport participants.

Youth may be unprepared to start playing sport

One challenge to making sport an effective setting for obesity prevention is that some youth may be unprepared for involvement in sport because they are already overweight. Youth

who master fundamental skills of movement such as running, catching, throwing and balancing are more likely to continue being physical active and less likely to be overweight (32), while overweight youth may have poor fitness levels and underdeveloped motor skills that leave them at a disadvantage when beginning sport. This situation is compounded by the lack of formal physical education and other opportunities to engage in physical activity during the school day in many public schools in the United States (11). Youth who are in this circumstance may need remedial efforts to improve their fitness and motor skill development before they are able to begin competing in sport at the same level with their peers. These factors are likely to influence whether youth are involved with sport at all and also whether they are likely to prematurely drop out of sport. Little research has examined the contribution of these factors to pediatric obesity at a population-level.

Foods and Beverages in Youth Sport

Candy, confectionary, sugar-sweetened beverages, (including sport drinks) and ice cream are commonly sold at youth sport events or brought to the event by contestants and parents (12). Youth sport marketing is a key part of food and beverage marketing strategies, and voluntary industry guidelines may actually encourage food and beverage companies to associate those products with health and fitness activities such as youth sport (61). Sports drinks such as Gatorade and Powerade are commonly marketed to, and used by, youth sport participants. Among some sport teams and leagues, the practice of providing snacks and beverages is institutionalized, wherein volunteer parent coordinators develop and assign a snack schedule. The snacks and beverages provided are often packaged convenience food (e.g., sport drinks, soda pop, candy bars, cookies, chips, “fruit” snacks) and in combination could total 300 to 500 calories or more. A recently published report from the Committee on Nutrition and the Council on Sports Medicine and Fitness recommended that children avoid sports and energy drinks during meals, snacks and as a replacement for low-fat milk or water because they increase the risk for overweight or obesity in children and adolescents (13).

In addition to direct access to excess calories available in sport settings, participants are subject to time pressures associated with attending sport practices and events. Time pressures may lead to more consumption of fast food and other processed food, which tend to be convenient but less healthy options (19). Regular family meals are associated with healthful dietary behaviors, but may be sacrificed due to sport participation (9). Parents of youth sport participants report that sport-related time pressures influence meal planning and preparation, interfering with family meals (20).

Weight Status, Physical Activity and Diet – when youth drop out of sport

Participation in youth sport has a modest, positive association with adult physical activity and exercise habits, even for those who are no longer involved in sport (49, 55). However, sport dropout is common during adolescence into young adulthood and associated with declines in physical activity (49, 55). A few studies have examined the impact of dropping out of sport on future dietary intake, and weight status. One study of adult women found no relationship between history of sport participation as a youth and either total daily caloric intake or proportion of calories from fat (3). A study from Finland found that adults who

participated in youth sport were less likely to meet the criteria for metabolic syndrome than those who never participated in sport, but the group that dropped out of sport was at higher risk than those who had sustained participation (62).

Dropout from youth sport occurs for a variety of reasons, including personal factors such as lack of enjoyment or motivation, time constraints, pressure to perform, and low achievement orientation, and organizational factors such as coaching issues, lack of playing time, and lack of opportunities to participate. (23, 45). These specific reasons youth drop out of sport may differ by age, competition level, sport, and gender and additional research is needed in this area (23). Regardless of the reason for dropping out of sport, decreasing energy expenditure without replacement with other forms of physical activity and/or decreasing caloric intake can promote energy surplus and weight gain. Childhood eating patterns help establish adult dietary habits, and these findings highlight the importance of promoting good nutrition in conjunction with youth sports. Whether youth sport participation predicts future dietary intake is understudied and warrants further research.

Promoting Energy Balance in Youth Sport

Despite the lack of research on obesity prevention in youth sport, opportunities exist for facilitating energy expenditure and limiting energy intake from sources of low nutritional value in these settings. It is important to recognize that youth sport coaches and league administrators are often volunteers with little formal training in physical education, coaching, or nutrition. It is not reasonable to expect them to intervene in an area where they are not trained or experienced. Youth, parents and coaches may have little or no awareness of the large number of calories contained in snacks and beverages commonly offered in youth sport settings, nor the relatively small number of calories children expend during sport. One potential intervention approach is to develop training and education materials for youth coaches in an accessible format. These materials could help coaches become more aware of energy balance in youth sport and emphasize ways to organize and structure practices and events maximize physical activity, limit sedentary time and promote healthy eating during youth sport. Other opportunities exist to reach youth coaches through seminars and clinics. Guidelines for minimum education and qualifications to coach youth sport could be established for promotion of activity and healthy eating in youth sport. In addition, many leagues sell foods and beverages to fund youth sport with high caloric content and low nutritional value, while overlooking their potential deleterious effects on child health. The Institute of Medicine recognized the potential for food and beverage sales in youth sport in contributing to the childhood obesity epidemic and recommended that programs encourage the sale of healthier options in youth sport venues. However, no system or guidelines are currently in place to monitor or enforce these standards. Other simple interventions for youth sport leagues include the development of guidelines for fundraising and for parents who organize post-game snacks to include health-promoting products. Existing research and experience in other settings such as schools and after-school programs can help guide recommendations and interventions. Regulation of advertising and sponsorship in youth sport could be implemented by either governmental or youth sport governing bodies.

Aside from providing guidance, physicians can help through direct patient care. A pre-participation examination is generally required prior to participation in sports at the high school level and occasionally required in youth sport leagues during the early teenage years. The pre-participation physical offers an excellent opportunity for physicians to offer their patients tailored advice about activity, nutrition, and obesity prevention for sport. The American College of Sports Medicine has issued a consensus statement that encourages team physicians to evaluate the weight status, nutritional needs and training habits of adolescent athletes, provide appropriate counseling on nutrition and exercise, as well as monitor athletes' weight status (1). Physicians should aim to identify problems before they manifest as excess weight or related health consequences. They should also anticipate the high dropout rate from sport as youth move into adulthood and consider the likelihood that youth will not be involved in sport in the future in their advice. All sport participants should be advised by their physicians to regularly engage in behaviors to avoid excess weight gain. Physicians can establish better links with athletes, parents and coaches to increase their awareness of issues related to energy balance in youth sport and recommend strategies for maintaining healthy weight.

Conclusions

Sport is beneficial for youth as it provides a setting for engaging in physical activity, interacting with adults and peers, and developing a variety of physical and social skills. Many features of youth sport make it a natural setting for pursuing obesity prevention goals. Currently it is unclear whether youth sport effectively works to prevent the development of pediatric obesity. Youth participating in sport are more physically active than those who do not participate, and sport participation should be encouraged on this basis. However, the existing research suggests that youth in sport are more likely to consume greater amounts of calories and consume some unhealthy foods and beverages. It is unclear whether the higher energy expenditure associated with sport compensates adequately for this additional energy intake.

More research is needed to better understand and identify a possible role for sport participation in obesity prevention. Future research efforts could include the direct comparison of energy expenditure and energy intake among participants, an assessment of how food and drinks consumed in sport settings contributes to total daily caloric intake and whether youth compensate for that consumption through additional activity or reduced caloric intake at other meals. Appropriate measures to assess sport participation are needed to understand the potential sources of variation within sport that may impact weight status, physical activity and diet, including type of sport, playing time, intensity level, skill-level, practice effectiveness, coach expertise, availability of appropriate programs, equipment, and facilities, and availability of food in sport settings. Much of the existing research involves studies with cross-sectional design. More research is needed that incorporate longitudinal assessment of sport participation, weight status, physical activity, and diet with studies specifically designed to study the contribution of sport participation. These study designs will also shed light on the effects of dropping out of sport on physical activity, diet, and weight status. Small intervention studies are also needed to assess the effects of modifications to sport programs on weight status, physical activity, and diet.

There are many opportunities to encourage sport participants to be even more active during their practices and to improve their dietary intakes. Participants, parents, coaches, league administrators, and physicians are important target audiences for awareness and intervention. Additional discussions among key stakeholders are needed and interventions to reduce the exposure to the excessive calories and other unhealthy food and beverage options available in your sport must occur before the promise of obesity prevention in youth sport can be realized.

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TABLE 1

Relationship between sports participation and weight status¹

Study	Design	Study Population	Comparison	Outcome Measure	Direction	
					Males	Females
Katzmarzyk and Malina (1998)	Cross-sectional	Students in grades 6–8 in Michigan (U.S.) (Males= 90; Females= 93)	Sport participants vs. Non-participants	• Mean BMI	S=N	S=N
Garaulet et al. (2000)	Cross-sectional	Students aged 14–18 in Torre Pacheco (SE Spain) (Males= 139; Females= 192)	BMI 23 vs. BMI < 23	• Sport index	S<N	S=N
Dowda et al. (2001)	Cross-sectional	Children and adolescents aged 8–16 in the United States (NHANES III) (Males= 1336; Females= 1455)	Sports team and exercise program participants vs. Non-participants	• % Overweight (BMI 85 th percentile)	S<N	8–13y: S=N 14–16y: S<N
Trost et al. (2001)	Cross-sectional	Students in grade 6 in South Carolina (U.S.) (Males= 89; Females= 98)	BMI 95 th percentile vs. BMI < 95 th percentile	• Sport participation	S=N ^a	
Alfano et al. (2002)	Cross-sectional, retrospective	African American and White females aged 18–39 in Tennessee (U.S.) (Females= 486)	Previous sport participation ^b (number of sports; 0–4+)	• Mean BMI (current)	S<N	
DeFonche et al. (2003)	Cross-sectional	Flemish students aged 12–18 in Belgium (Males= 1646; Females= 1560)	BMI > 90 th percentile vs. BMI 90 th percentile ^c	• Sport index	S<N	S=N
Levin et al. (2003)	Cross-sectional	Students in grades 9–12 in the United States (Males= 6451; Females= 6844)	BMI 85 th percentile vs. BMI 15 th –85 th percentile	• Sports participation	S=N	S<N
Manios et al. (2004)	Cross-sectional	Greek students in grade 6 (Males= 92; Females= 106)	BMI	Organized moderate to vigorous physical activities, usually in sports club settings	S<N ^a	
Beets and Piteetti (2005)	Cross-sectional	Students aged 14–19 in a Midwestern city (U.S) (Males= 120; Females= 67)	School-sponsored sport participants vs. Non-participants	• Mean BMI	S=N	S=N
Croll et al. (2006)	Cross-sectional	Students aged 11–18 in Minnesota (U.S.) (Males= 1350; Females= 1203)	Power team sport participants vs. weight-related sport participants vs. non-sport participants	• Mean BMI	Weight-related S=N Power-team S=N	Weight-related S<N Power-team S=N

Study	Design	Study Population	Comparison	Outcome Measure	Direction			
					Males	Females	Males	Females
Ward et al. (2006)	Cross-sectional	African American and White females in grade 9 in South Carolina (U.S.) (Females= 1015)	BMI 85th percentile vs. BMI < 85th percentile	• Sports team participation			S=N	
Sirard et al. (2008)	Cross-sectional	African American and White females in grade 8 in South Carolina (U.S.) (Females= 1903)	Sport participants vs. Non-participants	• Mean BMI			S<N	
Bel.ue et al. (2009)	Cross-sectional	Adolescents aged 12–17 in the United States (Males= 17,592; Females=17,592)	BMI 95th percentile vs. BMI < 95th percentile	• Sports participation	S<N ^a			
Lajunen et al. (2009)	Longitudinal	Twins aged 11–12 and two follow-up periods (age 14 and age 17) in Finland (N= 5184)	Sport participants vs. Non-participants	• % Overweight ^d at 14 years and 17 years	Age 14 S<N	Age 17 S=N	Age 14 S=N	Age 17 S=N
Phillips and Young (2009)	Cross-sectional	Females in grade 9 in Baltimore City, Maryland (U.S.) (Females= 221)	Sport participants vs. Non-participants	• Mean BMI			S=N	
Zahner et al. (2009)	Cross-sectional	Students in grades 1 and 5 in Switzerland (Males= 211; Females= 227)	Sport club participants vs. Non-sport club participants	• BMI 90th percentile	S=N ^a			
Bengochea et al. (2010)	Cross-sectional	Adolescents aged 12–15 in Canada (Males= 1,626; Females= 1,533)	Organized physical activity participants (sports with a coach) vs. Non-participants	• % Overweight ^d • % Obese ^d	Age 12–13 S=N ^a	Age 14–15 S=N ^a	Age 12–13 S=N ^a	Age 14–15 S=N ^a
Thibault et al. (2010)	Cross-sectional	Students aged 11–18 in France (Males=1,213; Females=1,172)	Sport club participants vs. Non-sport club participants	• BMI 30 kg/m ² • BMI 25 kg/m ²	S=N ^a S=N ^a			
Antonogeorgos et al. (2011)	Cross-sectional	Students aged 10–12 years in Greece (Males=323; Females=377)	Extracurricular sport participants vs. Non-participants	• BMI 85th percentile	S=N		S=N	S<N

^a All studies objectively measured height and weight except Bel.ue et al (2009), Levin et al (2003), and Lajunen et al (2009) who used self-report measures

S: Sport participants

N: Non-sport participants

S=N indicates no difference in BMI between sport participants and non-sport participants

S<N indicates sport participants have lower BMI than non-sport participants

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^d Analysis combined for Male and Female

^e Sport participation in junior or senior high school or college

^c BMI percentiles based on age subgroups within study population

^d Overweight defined according to International Obesity Task Force age- and sex-specific Analysis

BMI cut points analogous to BMI cut-off point of 25 kg/m² for adults overweight.

TABLE 2

Relationship between sports participation and physical activity levels

Study	Study Population	Comparison	Outcome Measure(s)	Direction	
				Males	Females
Cross-sectional Study Design					
Pate et al. (1996)	Students in grades 9–12 in the United States (Males= 2304; Females= 1989)	High-active vs. Low-active ^d	School sports team participation	+	+
Katzmarzyk and Malina (1998)	Students in grades 6–8 in Michigan (U.S.) (Males= 90; Females= 93)	Sports participants vs. Non-participants	Mean TDEE Mean MVVE	+	+
Pate et al. (2000)	Students in grades 9–12 in the United States (Males= 7033; Females= 7188)	Sports participants vs. Non-participants	Regular vigorous activity	+	+
Harrison and Narayan (2003)	Students in grade 9 in Minnesota (U.S.) (Males= 23, 208; Females= 24, 226)	Sports participants vs. Non-participants	MPA or VPA guidelines met	+	+
Sirard et al. (2006)	Students in grades 7 and 8 in CO, CA, PA, and OH (U.S.) (Males= 853; Females= 839)	Sports participants vs. Non-participants	VPA MVPA Sedentary behavior	+	= -
Ward et al. (2006)	African American and White females in grade 9 in South Carolina (U.S.) (Females= 1015)	Active vs. Low-active ^b	Sports team participation		+
Wickel and Eisenmann* (2007)	Males aged 6–12 in Michigan (U.S.) (Males= 36)	Sports day vs. Non-sport day	MVPA	+	
Sirard et al. (2008)	African American and White females in grade 8 in South Carolina (U.S.) (Females= 1903)	Sports team participants (one sport and multisport) vs. Non-participants	VPA MVPA Sedentary behavior	+	+
Phillips and Young (2009)	Females in grade 9 in Baltimore City, Maryland (Females= 221)	Sport participants vs. Non-participants	Mean TDEE		+
Silva et al. (2010)	Students aged 12–18 in Portugal (Males=79; Females=129)	Sport participants (school sports, club sports, both) vs. Non-participants	MVPA PA 60 min/day	+	+
Longitudinal Study Design					

Study	Study Population	Comparison	Outcome Measure(s)	Direction	
				Males	Females
Trost et al. (1997)	Students in grade 5 and 12-month follow-up (grade 6) in rural South Carolina (Males= 92; Females= 110)	Community sports participants vs. Non-participants	VPA MVP ^A	=	+
Dovey et al. (1998)	Adolescents aged 15 and one follow-up period (age 18) in New Zealand (Males= 400; Females= 375)	Sport participants vs. Non-participants (age 15)	PA 4 hours/week (age 18)		+
Aarnio et al. (2002)	Twins aged 16 and two follow-up periods (age 17 and 18) in Finland (Males= 1338; Females= 1596)	Sport participants vs. Non-participants	PA 4 times/week	+	+
Pfeiffer et al. (2006)	Adolescent females in grade 8 and two follow-up periods (grade 9 and 12) in South Carolina (U.S.) (Females= 239)	Three-year sport participants vs. Non-participants	VPA MVP ^A ^C	+	+
Kjonniksen et al. (2009)	Students aged 13 and seven follow-up periods (age 14, 15, 16, 18, 19, 21, 23) in Norway (N= 650)	Sports participants vs. Non-participants	PA ^d	+	+
Walters et al. (2009)	Students in high school in Minnesota with a 5-yr follow-up (Males= 733; Females= 906)	Sports participants vs. Non-participants	MVP ^A ^e	+	+
Taliaferro et al. (2010)	Trend study of students in grade 9–12 in the U.S. (Males= 35,301; Females= 36,553)	Sports participants vs. Non-participants	VPA	+	+

* All studies assessed physical activity with self-report methods except Wickel & Eisenmann (2007) and Silva et al (2010) who used accelerometers

⁺ Positive association between sports participation and activity level or energy expenditure

⁻ Negative association between sports participation and sedentary behavior

⁼ No association between sports participation and activity level

MPA = Moderate physical activity

MVPA = Moderate-to-vigorous physical activity

VPA = Vigorous physical activity

TDEE = Total daily energy expenditure ($\text{kcal} \cdot \text{kg}^{-1} \cdot \text{day}^{-1}$)

MVEE = Moderate-to-vigorous energy expenditure ($\text{kcal} \cdot \text{kg}^{-1} \cdot \text{day}^{-1}$)

^a High-active defined as 6 or more days of hard and 6 or more days of light exercise in the past 14 days; low-active defined as fewer than 2 days of light exercise and no days of hard exercise in the past 14 days

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^b Active defined as an average of one or more 30-minute blocks of vigorous PA per day averaged over 3 days of measurement (3DPA); participants not meeting “active” criteria were considered low-active

^c Results significant at 8th and 9th grade, but not 12th grade

^d Frequency of exercise, times per week

^e Results significant at time 1 and time 2

^f No significant change over time

TABLE 3

Relationship between sports participation and dietary habits⁷

Study	Study Population	Comparison	Outcome Measure(s)	Direction*	
				Males	Females
Cavadini et al. (2000)	Students in grades 8, 10, and 11 in Switzerland (N= 658)	Athletic vs. non-athletic participants ^a	• Meal frequency	↔	↔
			• Vegetables	↔	↔
			• Milk	↑ ^b	↔
			• Fruit	↑	↑ ^b
			• Fruit juice	↑ ^b	↑ ^b
			• Sports drink	↑ ^b	↑ ^b
			• Soft drink	↔	↔ ^c
Pate et al. (2000)	Students in grades 9–12 in the United States (Males= 7,033; Females= 7,188)	Sport team participants vs. non-participants	• Fruit or fruit drink	↑	↑
			• Salad or vegetables	↑	↑
			• High-fat foods	↔	↔
French et al. (2001)	Students in grades 7–12 in Minnesota (U.S.) (Males= 2,365; Females= 2,345)	Fast food restaurant use (never vs. 1–2 times/week vs. 3 times/week)	• Participation in team sports (no./past year)	↑	↔
			• Energy intake (kcal/day)	↔	↔
Alfano et al. (2002)	African American and White females aged 18–39 in Tennessee (U.S.) (Females= 486)	Previous sport participation (number of sports; 0–4) ^d	• Total fat (g/1000 kcal)	↔	↔
			• Milk	↑	↑
Harrison and Narayan (2003)	Students in grade 9 in Minnesota (U.S.) (Males= 23,208; Females= 24,226)	Sports participants vs. Non-participants	• Fruit/vegetables	↑	↑
			• Energy intake (kcal)	↑	↔
Croll et al. (2006)	Students aged 11–18 in Minnesota (U.S.) (Males= 1,350; Females= 1,203)	Power team sports vs. weight-related sports vs. non-sport participants	• Nutrient adequacy score	↑	↑
			• Fast food intake (5-yr follow-up)	↑	↔
Bauer et al. (2008)	Students in middle school in Minnesota with a 5-yr follow-up (U.S.)	Sports team participants vs. non-participants	• Fast food intake (5-yr follow-up)	↑	↔

Study	Study Population	Comparison	Outcome Measure(s)	Direction*	Males	Females
	(Males= 335; Females= 409)					

J All studies employed a cross-sectional design except Alfano et al (2002) who asked about past sports participation and Bauer et al (2008) who followed a prospective cohort

* Consumption among sports participants compared to non-participants

^a Daily sports activity vs. no sport activity

^b Results significant for grades 10 and 11 only

^c No difference for grades 10 and 11; among girls in grade 8, non-athletic participants consume more soft drinks than athletic participants

^d Sport participation in junior or senior high school or college