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A systematic review of mediators of physical activity, nutrition, and screen time in adolescents: Implications for future research and clinical practice

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Abstract

Background: Adolescents are not meeting current recommendations for daily physical activity, nutrition, and screentime which has been associated with overweight and obesity. Understanding the mediators that facilitate teens in improving their healthy lifestyle behaviors may be helpful in halting this crisis.

Purpose: The purpose of this systematic review was to assess published findings regarding mediators of adolescent energy balance behaviors.

Method: We followed the Institute of Medicine guidelines for completing a systematic review.

Discussion: Fourteen analyses from 12 studies were included with mediating variables tested for nutrition, physical activity, and screen time. Mediators were identified for all three behaviors and were primarily on the individual level of the social ecological model.

Conclusions: Combining findings from this and other reviews of mediators can help guide researchers in choosing mediating factors for specific target behaviors.

Keywords

Systematic review; Mediators; Adolescent; Nutrition; Physical activity; Screen time

Introduction

Adolescents are not meeting current recommendations for daily physical activity, nutrition, and screen time (Lowry, Michael, Demissie, Kann, & Galuska, 2015). Failure to meet these recommendations is associated with overweight and obesity (Sahoo et al., 2015). Adolescent overweight is defined as a body mass index (BMI) between the 85th and 95th percentiles of the Centers for Disease Control and Prevention sex-specific BMI-for-age growth charts from 2000 (Kuczmarski et al., 2002; Ogden & Flegal, 2010), whereas obesity is a BMI at or above the 95th percentile. Today, 14% of adolescents are overweight, and 20.5% are obese (Ogden, Carroll, Kit, & Flegal, 2014). Adolescent overweight and obesity is a risk factor for

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adult overweight and obesity, which is a public health epidemic in our society (Simmonds, Llewellyn, Owen, & Woolacott, 2016). Understanding the variables or mediators that facilitate teens in improving their healthy lifestyle behaviors may be helpful in halting this crisis.

Mediating variables can be behavioral, biological, psychological, or social constructs (MacKinnon, Fairchild, & Fritz, 2007). Mediation analysis is one method to explain the process by which a variable affects another. Mediating variables are part of many theories and aim to explain behavior. Mediating variables are those factors that exist between an independent variable/intervention and a dependent variable/outcome. An example of a mediator is depicted in Figure 1. In this figure, the mediating variable explains the relationship between the independent and dependent variables; that is, a healthy lifestyle intervention first influences cognitive beliefs about the ability to engage in healthy lifestyle behaviors, which in turn, influence the amount of daily physical activity. Mediation analysis assesses the impact (influence) of identified factors in the change of variables (e.g., screen time, physical activity, nutrition) over time. Several methods of mediation analysis have been identified, and each assesses the relationships of the variables (van Stralen et al., 2011; Figure 2).

Before 2011, three systematic reviews targeting mediators of healthy lifestyle behaviors that included adolescents have been published. Lubans, Foster, & Biddle (2008) reviewed physical activity mediators in adolescents and children with seven studies targeting secondary school-age students. Mediators assessed included self-efficacy, outcome expectancy, perceived benefits, attitudes, perceived barriers, enjoyment, goal setting, two behavioral processes from the transtheoretical model, and interpersonal factors. Strong support was found for self-efficacy mediating physical activity and some support for behavioral strategies. Cerin, Barnett, & Baranowski (2009) evaluated mediators of dietary change in youth. Seven studies were included with a mean age of 8.7 to 15.8 years. Mediators included variables from the health belief model, habit strength theory, social cognitive theory, theory of planned behavior, and transtheoretical model. Although self-efficacy and outcome expectations were most consistently associated with dietary behavior, only outcome expectancies were identified as mediators in multiple interventions. The most recent systematic review was published by van Stralen et al. (2011) and focused on mediators of energy balance in school-based interventions. Twenty-four studies were included with participants between 4 and 18 years. Evidence was found for self-efficacy and intentions as mediators of physical activity, and indications were found for attitude, knowledge, and habit strength as mediators of dietary behavior interventions.

This systematic review aims to generate findings from studies published after or not included in prior reviews for mediators of healthy lifestyle behaviors (e.g., screen time, physical activity, and nutrition) in adolescents. The literature base for mediation analyses is growing and allows targeting a smaller segment of the population for review. Exclusively evaluating adolescent literature will enhance the knowledge available for building interventions for this age group that has been less represented in the literature than other populations. The PICO (i.e., Patient population, Intervention or area of Interest, Comparison intervention or group if relevant, Outcome(s) question that was used to guide this search)

was as follows: In adolescents (P), what factors mediate the effects of behavioral interventions (I) on physical activity, nutrition, and screen-time behaviors (O)?

Methods

We followed the Institute of Medicine (IOM) guidelines for completing a systematic review (IOM, 2011). Before performing this systematic review, a protocol was created. The first and second authors met with a librarian with expertise in performing systematic reviews to assist the researchers in identifying the most effective search strategy. The search strategy was created to identify intervention studies in adolescents which used mediation analysis for outcomes of physical activity, nutrition, and screen time. Search terms included the following: Adolescent OR teenage OR teen, healthy lifestyle, physical activity OR exercise, nutrition OR diet OR healthy eating, screen time OR television OR computers OR video games or smartphone (mobile phone), screen time, mediators OR mediation analysis, and intervention study. Electronic databases were searched by the first and second authors and included PubMed, CINAHL, PsycINFO, SPORTDiscus, Web of Science, and The Cochrane Library (Figure 3; flow diagram). Titles of all articles identified in the search were screened for applicability. Abstracts were reviewed for all chosen titles. If the study appeared to meet inclusion criteria, the full article was reviewed and again assessed for inclusion criteria. All discrepancies in this process were reviewed by the two researchers, and a consensus was met regarding eligibility of study. References of all included studies were reviewed for inclusion. Fourteen separate analyses were identified from 12 published studies (e.g., two studies published separate mediation analyses for different outcome variables). Citations of identified studies for this systematic review were queried in Google Scholar to search for additional studies.

Inclusion criteria were as follows: studies of participants with a mean study age of 12 years or older with ages ranging between 11 and 18 years; written in the English language; used mediation analysis; intervention study; and included nutrition, physical activity, or screen time as an outcome. Exclusion criteria included previously reviewed in a systematic review and mediation analysis of cross-sectional data. The gray literature was not searched because the topics covered were not relevant to this analysis such as surgical or pharmacologic interventions.

Quantitative and qualitative data were extracted from each study by two independent researchers using a standard data extraction form created for this study. All team members extracted data from one article to assess inter-rater reliability. All discrepancies were reviewed and resolved through discussion with research team members. Critical appraisal of the studies was performed using Cochrane Collaboration's tool for assessing risk of bias (Higgins et al., 2011) and selected items from a rapid critical appraisal tool (Melnik & Fineout-Overholt, 2015).

Findings

Fourteen analyses representing 12 studies were identified for this review searched from no beginning time limit to November 2016 (Table 1). Figure 3 represents the selection process of studies. Studies were primarily excluded for cross-sectional mediation analysis, published

in a prior review on mediators of energy balance behaviors, and age (e.g., older or younger than target population). Studies were performed in Australia ($n = 5$), North America ($n = 5$), and Europe ($n = 3$; Table 1). All studies were either randomized controlled trials ($n = 10$) or quasi-experimental studies with a randomizing component ($n = 3$). Sample sizes ranged from 241 to 1,136 participants. Study settings included secondary and high schools ($n = 10$), an after-school care program ($n = 1$), and primary care ($n = 1$). Intervention length ranged from one session to 21 months (two school years). Intervention target(s) were multicomponent ($n = 6$) focusing on more than one energy balance behavior (e.g., nutrition, physical activity, sedentary time, and/or screen time), nutrition ($n = 5$), and physical activity ($n = 1$). Nine studies had significant effects for the primary outcomes in the studies with three studies having null findings.

Outcomes assessed included nutrition ($n = 8$), physical activity ($n = 7$), and screen time ($n = 2$). Theoretical underpinnings included social cognitive theory ($n = 8$), social determination theory ($n = 4$), transtheoretical model ($n = 4$), theory of planned behavior ($n = 3$), attitudes, social influence, and self-efficacy model ($n = 1$), behavioral determinants model ($n = 1$), and behavior-image model based on self-regulation theory ($n = 1$). Six studies included more than one theory.

Bias was evaluated using the Cochrane Collaboration's tool for assessing risk of bias in randomized trials (Higgins et al., 2011; Table 2). All studies had a random component with randomization occurring at the school level ($n = 10$) or after-school care site ($n = 1$), within the school ($n = 1$), and by individual in primary care ($n = 1$). Of the 12 studies, only five discussed the randomization method used. Allocation concealment was clearly presented in four studies with all being low risk of bias. Blinding of participants and personnel was clearly presented in four studies with two being high risk of bias and two low risk of bias. Blinding of outcome assessment was clearly presented in two studies with two being low risk of bias and one being high risk of bias. Attrition bias was low in eight studies and unclear in four studies. Reporting bias appeared low in all studies. Only two studies reported fidelity of the intervention. A common bias in most studies was use of self-report measures.

Additional components for study quality also were evaluated (Table 3). Baseline differences were not found ($n = 6$), not reported ($n = 5$), and identified in outcome variables ($n = 1$) in the studies. Six studies did not have adequate time for the control group, five studies had an adequate control group, and one study description was unclear. Most studies reported adequate reliability of measures (Cronbach $\alpha > 0.7$), and one study reported validity of measures. Reports of how missing data were assessed or handled were described ($n = 8$) and not discussed ($n = 4$). Intention-to-treat analysis was completed ($n = 6$), not discussed ($n = 5$), and not done ($n = 1$). Eleven studies reported attrition with five studies $< 20\%$, four studies $> 20\%$, and two studies had one group $> 20\%$ and one group $< 20\%$.

Mediation analysis techniques included product of coefficients ($n = 6$), bootstrapping ($n = 4$), Sobel test ($n = 1$), structural equation modeling ($n = 1$), method of Cheong, MacKinnon, and Khoo (2003; ($n = 1$), and not reported ($n = 1$). Findings from analyses were primarily reported in a table format for the action theory test, conceptual theory test, and mediated effect test (Tables 4–6). Single mediation and multiple mediation analyses were performed.

Seventeen mediators were assessed for nutrition outcomes and include self-efficacy, intention, outcome expectations, attitude, perceived social norms, behavioral beliefs, facilitating factors, pros, cons, forward stage movement, autonomous motivation, perceived barriers, planning, perceived behavioral control, parental support, parental encouragement, and home environment. McCabe, Plotnikoff, Dewar, Collins, and Lubans (2015) tested and reported mediators for four separate outcome variables (i.e., self-efficacy for healthy eating: fruit, vegetables, fat intake, and sugar-sweetened beverages). Gray, Contento, Koch, and Noia (2016) tested a structural equation model with indirect and proximal mediators. All mediators in the model were reported as significant with two variables labeled as the proximal mediators that directly impacted the outcome variable. Significant mediators for nutrition included self-efficacy ($n = 3$), planning ($n = 1$), increase in pros ($n = 1$), forward stage movement ($n = 1$), and goal intention and decreased perceived barriers with outcome expectations, self-efficacy, and autonomous motivation indirectly mediating ($n = 1$), and perceived parental support ($n = 1$).

Twelve mediators were assessed for physical activity and included self-efficacy, perceived environmental barriers, behavioral strategies, outcome expectancies, outcome expectations, resistance training skills competency, attitudes, goal intention, autonomous motivation, pros, cons, and social support (e.g., from peer, parent, sports peer). Gray et al. (2016) tested a structural equation model with indirect and proximal mediators. All mediators in the model were reported as significant with two variables labeled as the proximal mediators that directly impacted the outcome variable. Significant mediators for physical activity included (a) perceived environmental barrier of neighborhood safety and sports facility availability ($n = 1$) and (b) goal intention and decreased perceived barriers with outcome expectations, self-efficacy, and autonomous motivation indirectly mediating ($n = 1$). Behavioral strategies met criteria for mediation with the action theory test, conceptual theory test, and mediated effect test being significant, but the between-group difference for the variable was not significant ($n = 1$).

Four mediators of screen time were assessed and included autonomous motivation, controlled motivation, amotivation, and screen time rules. Only autonomous motivation to decrease screen time was found to be significant ($n = 2$).

Level of social ecological model was identified for significant mediators in (a) nutrition at the individual level and interpersonal level, (b) physical activity at the individual level, and (c) screen time at the individual level.

Discussion and Recommendations

The purpose of this systematic review was to assess published findings regarding mediators of adolescent energy balance behaviors. Fourteen analyses from 12 studies were included with mediating variables tested for nutrition ($n = 6$), physical activity ($n = 5$), screen time ($n = 2$), and both physical activity and nutrition ($n = 1$).

Nutrition behavior varied among the studies and included fruit and vegetable intake ($n = 2$), decreasing fast food intake ($n = 1$), high-fat low replacing foods with fat ($n = 1$), healthy

eating ($n = 1$), eating low-fat snacks at home ($n = 1$), and sugar-sweetened beverage consumption ($n = 1$; Table 4). Significant mediators were identified on two levels of the ecological model and included self-efficacy ($n = 3$), increases in pros ($n = 1$), forward stage movement ($n = 1$), planning ($n = 1$), perceived parental support ($n = 1$), and goal intention and decreased perceived barriers with outcome expectations, self-efficacy, and autonomous motivation indirectly mediating ($n = 1$). Two prior reviews evaluated mediation of nutrition behaviors in children and adolescents (Cerin et al., 2009; van Stralen et al., 2011) and identified significant mediators of group norms, knowledge, habit, outcome expectancies/attitude, and project appreciation. Unlike prior reviews in which no support was found for social support, one study in this review found significant mediating variables for the social ecological level of interpersonal.

Significant mediators for physical activity included goal intention and decreased perceived barriers with outcome expectations, self-efficacy, and autonomous motivation indirectly mediating ($n = 1$) and perceived environmental barrier ($n = 1$). Prior studies of mediators of physical activity in children and adolescents (Lubans et al., 2008; van Stralen et al., 2011) identified self-efficacy, outcome expectancy, perceived benefits, enjoyment planning, intention, self-regulation, intrinsic motivation, autonomy support, and proxy efficacy as significant mediators. Unlike prior reviews, although self-efficacy was evaluated in five studies, it was not found to mediate physical activity in a single-mediator model. Self-efficacy was assessed in multiple-mediator model and indirectly mediated the effects.

Autonomous motivation was the only significant mediator found for screen time in the two identified studies. One prior review (van Stralen et al., 2011) included sedentary behaviors as an outcome with no significant mediators identified from three studies.

Most adolescent interventions are multicomponent and do not use different mediating strategies for the different outcome behaviors (e.g., physical activity, screen time, nutrition). Overlap in mediators has been identified for self-efficacy (physical activity and nutrition), planning (physical activity and nutrition), autonomous motivation/intrinsic motivation (screen time and physical activity), outcome expectancy (nutrition and physical activity), and reduced barriers (nutrition and physical activity). It may be beneficial to target specific change mechanisms for each outcome behavior in an intervention to enhance the effects.

Challenges exist in performing a systematic review related to the lack of similarity in methods used for analysis, mediators assessed, tools used to assess mediators, and mediation criteria followed for significance of mediators. Differences in each of these factors limit the comparability of study outcomes and weakens the strength of the evidence.

Standardization and confidence in reporting findings should be based on published standards and national guidelines (e.g., IOM, PRISMA, AMSTAR, CONSORT, and Cochrane). This provides an excellent standardized template for comparing for risk bias and individual study quality among studies. Bias is a major concern in conducting and articulating the research, and using Cochrane's collaboration for assessing risk bias provides consistent structure and emphasis on the various biases often not reported in the articles (e.g., of the 12 studies, only five discussed randomization methods). A summation score for risk of bias and the quality

of each study was not completed because of the variability of the importance of each category in each study (Higgins & Green, 2011). Most studies did not report all information needed to determine risk of bias and quality, which hinders confidence in interpreting findings and once again highlights the importance of reporting findings based on published standards.

Fidelity to the intervention is of upmost importance in outcome research. Several studies cited that specific intervention components were not fully implemented to the entire intervention sample (Table 2). Lack of fidelity may erroneously show lack of impact of an intervention component on an outcome, whereas if the intervention was fully implemented, significant changes may have been noted. Caution should be exercised before discarding a mediator that has been tested because of previously insignificant findings. This seemed especially apparent in the home portion of interventions. Better methods should be sought to implement a home component although this barrier will continue to challenge researchers.

Similar to studies in prior reviews, most mediators tested were at the individual level of the social ecological model and focused on cognitive beliefs. Evidence exists for including these mediators in interventions with adolescents to impact targeted healthy lifestyle behaviors. For example, the National Cancer Institute (NCI) has evaluated and presented research-tested intervention programs (RTIPs; <https://rtips.cancer.gov/rtips/programSearch.do>). Several studies included by NCI as RTIPs conducted in the last 5 years have used individual-level cognitive approaches, such as awareness building, behavior modification, self-efficacy, and motivation and include COPE (Creating Opportunities for Personal Empowerment) Healthy Lifestyles TEEN (Thinking, Emotions, Exercise, Nutrition) Program (Melnik et al., 2007), increasing park-based physical activity through community engagement (Cohen et al., 2013), and Youth Fit 4 Life (Annesi & Vaughn, 2015). Furthermore, expanding the types of mediators tested and on additional levels of the ecological model will likely be fruitful in identifying additional mediational processes that may strengthen the effects of an intervention.

A continued call for mediation analysis in theory-based intervention studies is needed. Understanding the process through which treatments work to influence outcomes is important to both strengthen interventions and extend the science (Melnik & Morrison-Beedy, 2012). Researchers are currently developing a formal methodology for linking behavior change techniques (BCTs) to mechanisms of action. with the intention to develop an ontology of behavior change that specifies the relations between BCTs, theoretical mechanisms, modes of delivery, population, setting and type of behavior (<http://www.ucl.ac.uk/behaviour-change-techniques/About>). Mediation analysis provides a rigorous test of these relationships.

This systematic review provides level 1 evidence extending the science to better identify intervention factors that influence healthy behaviors in adolescents. Based on the studies reviewed, there are clear recommendations for further intervention studies. Suggestions for clinical practice include encouraging researchers to develop study designs that are focused on early prevention, detection, and interventions that lead to more favorable outcomes. Targeting individual levels of the ecological model was favorable and included cognitions,

behavioral skills, and social support. Develop study designs that understand the influence of the mediators impacted by specific developmental age vs. the broad categorization as found in some previous reviews with children and adolescent age groups combined. Targeting specific change mechanisms for each outcome behavior in an intervention also may prove beneficial. The gaps in the literature from the systematic review demonstrated a need to target all levels of the ecological model and mental health/cognitive beliefs. Thus, translation of research to effectiveness trials and conducting theory-based interventions that use mediation analysis to further understand paths of behavior change at all ecological model levels should be encouraged.

Limitations exist for this review and are similar to prior published reviews. Reporting of at least one key quality indicator was lacking in most studies. Unclear bias was identified for numerous aspects of the studies. Dietary intervention focus was different in all but two studies (e.g., fruit and vegetable intake) with the mediating mechanisms possibly being different for the subcategories.

Conclusions

Evidence was found for self-efficacy as a mediator in three nutrition interventions. Additional significant dietary mediators identified included increases in pros and forward stage movement, planning, perceived parental support, and goal intention and decreased perceived barriers with outcome expectations, self-efficacy, and autonomous motivation indirectly mediating the outcome. Significant mediation was found for physical activity for perceived environmental barriers and goal intention and decreased perceived barriers with outcome expectations, self-efficacy, and autonomous motivation indirectly mediating the outcome. Autonomous motivation was identified to mediate screen time in two studies. Combining findings from this and other reviews of mediators can help guide researchers in choosing mediating factors for specific target behaviors. Continued development and refinement of sensitive, reliable, and valid measures is vital to further this work.

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Figure 1 –.
Creating Opportunities for Personal Empowerment (COPE) intervention (Melnyk et al., 2007).

Figure 2 —.
Mediation model.

Figure 3 –.
 Flow diagram of search.

Table 1 –

Study Details

Study/Year Published/ Name	Sample	Design	Focus of Study	Assessments/ Intervention Duration	Measures	Intervention	Primary Study Findings
Babic et al., 2016	New South Wales, Australia Eight schools n = 322	Cluster RCT, wait-list control School-level randomization	Recreational screen time, mental health, objectively measured PA, and BMI	Baseline and 6 months 6-month intervention	Adolescent Sedentary Activity Questionnaire, wrist-worn accelerometers, Strength and Difficulties Questionnaire, Kessler Psychological Distress Scale, Marsh's Physical Self-Description Questionnaire, Flourishing Scale, The Motivation to Limit Screen-Time Questionnaire	Interactive seminar, eHealth messaging (informational and motivational messages twice per week from their preferred social media and messaging systems [i.e., Twitter, Facebook, Kik, email, or text messages]), a behavioral contract, and six parental newsletters	No significant between-group intervention effects for screen time, mental health outcomes, physical activity, or BMI
Switch-Off 4 Healthy Minds (S4HM)	Mean age, 14.4 ± 0.6 years M&F	Two groups					
Beaulieu and Godin, 2012	Canada Two schools n = 241 12–17 years M&F	Quasi-experimental School-level randomization Two groups	Lunch behavior: encourage to eat lunch from home/purchase lunch at school	Baseline and 8-month FU 12-week intervention	Intention, attitude, perceived behavioral control, perceived social norms, behavioral beliefs, control beliefs, facilitating factors, and self-efficacy	(a) classroom (tools, recipes, & pamphlets; audio messages by teachers & school principal; and cooking sessions); (b) at lunch time (improvisation play theater); (c) during free periods (electronic messages, school Web site, and quiz); and (d) to parents (electronic messages, conference, and distribution of tools)	Proportion of EG students eating fast food decreased
Cook et al., 2014	Europe Secondary and high schools n = 1,054 12–17 years M&F	Quasi-experimental, school randomized Six recruitment centers Two groups	PA	Baseline and postintervention 3-month intervention	Demographics, PA questionnaire, psychosocial determinants, and perceived environmental barriers	Internet-based computer-tailored PA intervention. Tailored feedback for PA based on questionnaire completed. Two collective intervention sessions	Increase in MVPA and MPA in leisure time for the intervention group with a decrease in the control group
Helena Activ-O-Meter							
Dewar et al., 2014; McCabe et al., 2015	New South Wales, Australia 12 schools n = 357; * n = 256 PA, * n = 294 diet	Cluster RCT wait-list control School-level randomization	Obesity prevention targeting psychological, behavioral, and environmental influences of dietary behavior;	Baseline and postintervention 12-month intervention	Accelerometers, Adolescent Sedentary Activity Questionnaire, six social cognitive scales for PA; Australian Eating Survey, intention, confidence rating, anticipated outcomes of healthy eating, expectancies scale, home dietary environment scale, and benefits of healthy eating	Enhanced school sport, lunch time PA sessions, interactive seminars, student handbooks, nutrition w/s, pedometers, parent newsletters, & text messages to encourage PA & healthy eating & decrease in sedentary time; handbook provided key health messages for adolescents and included 10 weeks of home challenges designed to promote healthy eating. Three practical nutrition workshops. Participants attended three	Significantly reduced girls' time spent in self-reported sedentary activities; no intervention effects for the key dietary behaviors, i.e., energy intake from fruit, energy from vegetables, proportion of energy from fats, and proportion of energy

Study/Year Published/ Name	Sample	Design	Focus of Study	Assessments/ Intervention Duration	Measures	Intervention	Primary Study Findings
NEAT girls	Mean age (SD), 13.2 (0.5) F	Two groups: control provided with a condensed version after 24-month assessments	PA, reduce sedentary behaviors			interactive seminars. Four parent newsletters and text messaging for social support	
Di Noia and Prochaska, 2010	East Coast of the United States 27 Youth service agencies (after school care)	Quasi-experimental study design Service agency-level randomization	Fruit and vegetable intake	Baseline and 2-week postintervention 4-week intervention	Demographics; pros and cons of consuming five or more daily servings of F&V; self-efficacy for F&V consumption; TTM staging measure; and F&V consumption	Delivered via CD-ROM, four 30-min sessions of interactive intervention content. Three different sets of materials on the health benefits of eating fruits and vegetables for youths divided up precontemplation, contemplation/preparation, or action/maintenance	Youths in the EG increased their fruit and vegetable consumption pretest to post compared with CG
TTM intervention program	n = 549 Mean age (SD), 12.44 (0.98) M&F	Two groups					
Gray, Contento, Koch, & Noia, 2016	New York City, NY, USA 10 middle schools	Cluster RCT School-level randomization	PA and nutrition	Baseline and postintervention 8–10 week intervention	Eat Walk Survey & Tell Me about You Mediator survey: outcome expectations, intentionality, perceived barriers, and self-efficacy for each of the targeted behaviors	24 lessons that used science inquiry-based investigations to enhance motivation for action and social cognitive and self-determination theories to increase personal agency and autonomous motivation to take action	EG significantly decreased consumption of sweetened drinks and packaged snacks, smaller sizes of fast food increased intentional walking for exercise, and decreased leisure screen time
Choice, control, and change curriculum	n = 1,136 Mean age, 12. Range, 11–13 M&F	Wait-list control					
Lubans et al., 2012	New South Wales, Australia 10 middle schools	RCT School-level randomization	Promotion of lifetime/lifestyle activities; encouraged boys to become PA leaders in their schools/at home; nutrition	Baseline and postintervention 6-month intervention	PA self-efficacy, resistance training self-efficacy, PA behavior strategies, peer support for PA; BMI; height, weight, BMI, pedometer, SCT constructs	School sport sessions, PA and nutrition handbooks, interactive seminars, lunch-time activities, leadership sessions, and pedometers for self-monitoring	No change in P/
Physical activity leaders	n = 100 Mean age (SD), 14.3 (0.6) M	PE teachers selected students Two groups					

Study/Year Published/ Name	Sample	Design	Focus of Study	Assessments/ Intervention Duration	Measures	Intervention	Primary Study Findings
Luszczynska et al., 2016	Poland 10 schools n = 506 Mean age (SD), 16.35 (0.79) M&F	RCT School-level randomization Three groups	Replacing high-energy dense foods with low-energy dense foods	Baseline, 2 months, and 14-month FU 8–11 week intervention	Body weight and height, fruit and vegetable intake, energy-dense food intake, cognitive mediators (self-efficacy, planning, intention to eat a healthy diet, dietary planning, action and recovery dietary self-efficacy)	All experimental conditions received a set of handouts for 3 weeks. A face-to-face session shortly after T1 and a booster session delivered at 8–11 weeks after T1	Similar significant increases of FVI were found for planning and self-efficacy interventions. Planning did not influence energy-dense food intake, and self-efficacy resulted in stabilizing intake. There were no effects on bodyweight
Roesch et al., 2009	San Diego, CA, USA n = 819 Mean age (SD), 12.7 (1.2). Range, 11–15 years M&F	RCT Recruited through PCPs office Two groups	PA, sedentary behavior, total fat intake, and servings per day of fruits and vegetables	Baseline and postintervention 12 month intervention	Seven-day PA recall, psychosocial constructs change strategies, pros and cons of change, self-efficacy, family support, and peer support. Accelerometer, decisional balance, self-efficacy, family support, peer support, 24-hr dietary recall; height and weight	EG: computerized kiosk in the PCPs office with 3–5 min counseling session with provider, printed manual, mailed worksheets, and tip sheets that provided further information on change strategies and on activity and food choices, and monthly counselor telephone calls. CG: sun protection intervention with a PCPs office-based computer assessment of sun protection behaviors followed by tailored computer-generated printed recommendations for improvement. Brief counseling telephone calls with a health counselor at 3 and 6 months followed by a mailed feedback report and tip sheet to encourage continued sun protection behavior	Significant between-group differences for (a) girls and boys in the diet and PA intervention Significantly reduced sedentary behaviors, (b) boys reported more active days per week, and (c) percentage of adolescents meeting recommended health guidelines was significantly improved for girls for consumption of saturated fat and for boys' participation in days/week of PA
Smith et al., 2016a, 2016b (PA & screen time) Active teen leaders avoiding screen time	New South Wales, Australia 14 schools n=361 Age, 12.7 ± 0.5 years M	RCT: wait-list controlled cluster RCT School-level randomization Two groups	Improving body composition, muscular fitness, and weight-related behaviors (i.e., screen time, PA, and sugared beverage consumption)	Baseline and postintervention 8-month intervention	Height and body mass, body composition, PA by accelerometer, resistance training skill competency, and muscular fitness	Researcher-led seminars, fitness equipment to schools, a Smartphone application, and Web site, pedometers, parental strategies for reducing screen time (i.e., newsletters), lunch-time PA mentoring sessions, and face-to-face activity sessions run by teachers	No significant intervention effects for body composition, PA, or grip strength. Significant group-by-time effects for screen time, pushups, and SSB consumption
Van Lippevelde et al., 2012	Belgium n = 2,232 10 schools Mean age (SD), 13.06 (0.81) M&F	Cluster RCT School-level randomization Three groups in study (two included in this analysis)	School: (increasing school availability of a healthy food environment) and individual-based component of computer-tailored fat intake	Baseline and postintervention 21-month intervention (2 school years)	Fat intake, home-related factors to eating low fat, Flemish PA Questionnaire (PA self-report), and index of PA. Accelerometers, food frequency for fruit, water, and soft drinks	Environment, individual, and parent; the food intervention focused on three behavioral changes: (a) increasing fruit consumption to at least two pieces a day, (b) reducing soft drink consumption and increasing water consumption to 1.5 L a day, and (3) reducing fat intake	No significant increase or decrease of the intervention effects on PA and eating behaviors was found as a result of the second intervention

Study/Year Published/ Name	Sample	Design	Focus of Study	Assessments/ Intervention Duration	Measures	Intervention	Primary Study Findings
Werch et al., 2011	Southeast USA	RCT	PA, healthy nutrition, sleep, relaxation techniques, and message on how substance use interferes with positive image attainment	Baseline and 3- month FU	Health and fitness survey; substance use; Leisure-time Exercise Questionnaire; F&V intake; sleep; stress; coupling beliefs; self-image; self-efficacy; and peer influenceability	A 9-item life skills screen assessing target health behaviors, a one-on-one consultation, behavioral recommendations for enhancing future fitness, and a personal fitness goal setting and commitment strategy	Significant reductions in alcohol use quantity, increases in eating five or more servings of fruits and vegetables, and practicing relaxation activities
Project active	Two schools n = 479 Mean age (SD), 17.0 (0.82) M & F	Within school design Two groups		One intervention session			

Note. BMI, body mass index; CD-ROM, compact disc; CG, control group; EG, experimental group; F, female; FU, follow-up; F&V, fruit and vegetable; FVI, fruit and vegetable intake; M, male; MPA, moderate physical activity; MVPA, moderate to vigorous physical activity; NEAT, Nutrition and Enjoyable Activity for Teen; PA, physical activity; PACE, Physician-based Assessment and Counseling for Exercise; PCP, primary care provider; PE, physical education; RCT, randomized controlled trial; SCT, social cognitive theory; SD, standard deviation; SSB, sugar-sweetened beverage; TTM, transtheoretical model; ws, workshop.

*
n for mediation analysis.

Table 2 –

Cohrane Quality Assessment Tool

Last Name of First Author	Selection Bias Random Sequence Generation Was method disclosed? (yes = Y, no = N)	Allocation Concealment	Performance Bias Blinding of Participants and Personnel	Detection Bias Blinding of Outcome Assessment	Attrition Bias Incomplete outcome Data	Reporting Bias Selective Reporting	Other Bias
Babic	Y	+	+	+	+	+	First eight schools to accept invitation and 40 students to return signed consent letters were included; few parents completed evaluation; unclear to what extent parents implemented the strategies; no fidelity checks reported
Beaulieu	N	?	?	?	+	+	Not all participants received same components of intervention (e.g., at least 30% of parents did not get electronic messages, only 11% of teens did cooking session); process evaluation findings not reported, no fidelity checks reported
Cook	N	?	?	?	?	+	Assessment of mediators did not precede outcome, was performed concurrently; no objective measure for PA—only self-report instruments; no fidelity checks reported
Dewar/McCabe	N	?	?	?	?	+	Intervention fidelity 74.0%, IG attended on average <1/2 of the PA sessions (42.5%), & did 9.0% of home PA and nutrition challenges, poor participant compliance with accelerometry. No fidelity checks reported
Di Noia	N	?	?	?	?	+	Self-report, self-selected sample; no fidelity checks reported
Gray	N	?	?	?	+	+	Self-report measures; no fidelity checks reported
Lubans	Y	+	–	–	?	+	No fidelity checks reported; teachers selected students
Luszczynska	Y	+	+	+	+	+	No intention-to-treat analysis
Roesch	N	?	–	?	+	+	No fidelity checks reported
Smith	Y	+	?	?	+	+	Screen time was self-reported, 36% of boys provided complete data for MVPA (no imputation was performed on variable), no fidelity checks reported
Van Lippevelde	N	?	?	?	+	+	Lack of process evaluation data on implementation and levels of parental involvement; self-report measures, no fidelity checks reported
Werch	Y	+	?	?	+	+	No fidelity checks reported

Table 3 –

Quality Assessment Items

Author	Baseline Groups Similar	Adequate CG for Attention	Use of Reliable Measures	Missing Data	Intention-to-Treat Analysis	Attrition <20% (% at Postanalysis)
Babic	No statistical test reported	No—wait-list control	Cronbach α 0.78–0.93. Test—retest correlations, 0.43–0.70. No validity reported	4% missing data	Intention-to-treat similar to case analysis	96
Beaulieu	Differences in percent eating lunch at school	Unsure—activities for CG not mentioned	Cronbach α 0.61–0.94. No validity reported	Last observation carried forward	Intention to treat	EG: 71.6; CG: 67
Cook	Not reported	Yes	Cronbach α 0.57–0.81 No validity reported	Did not discuss	Not discussed	50
Dewar/McCabe	No baseline differences	No—wait-list control	Cronbach α 0.63–0.79. Validity reported	Did not discuss	Intention to treat	EG: 79.2; CG: 85
Di Noia	No differences for outcome variables	No—usual care	Cronbach α 0.85–0.91. No validity reported	Did not discuss	Not discussed	92
Gray	Not reported	No—wait-list control	Cronbach α 0.70–0.88. Test-retest correlations 0.30–0.80. No validity reported	Missing data were treated with multiple imputations	Not discussed	EG: 81; CG: 76
Lubans	No baseline differences	No—wait-list	Cronbach α 0.63–0.88. ICC, 0.81–0.89. No validity reported	Did not discuss	Intention to treat	82
Luszczynska	No baseline differences	Yes	Cronbach α 0.59–0.89 No validity reported	Missing data imputed with an expectation—maximization approach	No intention to treat	72
Roesch	Not reported	Yes	Cronbach α 0.64–0.86 No validity reported	Maximum likelihood missing data procedure	Not discussed	88
Smith	No statistical test reported	No—wait-list	Reliability not reported	Missing data imputed	Intention to treat	80 at post and 73 at 18-mo FU
Van Lippevelde	No baseline differences	Yes	Reliability not reported	Carried the last observation forward	Intention to treat	Not reported
Werch	No baseline differences	yes	Cronbach α 0.63–0.68. Not reported for all measures. No validity reported	6% missing data	Not discussed	94

Note. CG, control group; EG, experimental group; FU, follow-up; ICC, intraclass correlation coefficient.

Table 4 –

Nutrition Mediators Details

Author	Intervention Effect on Outcome Variable	Method	Theory	Author	Action Theory Single/Multiple	Conceptual Theory Single/Multiple	Mediated Effect Single/Multiple
Beaulieu	Eating lunch at school +	Bootstrapping	TPB	Beaulieu	+	+	+
Di Noia	FVI +	Product of coefficients	Sobel test	Di Noia	–	NT	NT
Gray	SSB +	SEM	SCT, SDT	Gray	/+	/+	/+
Luszczynska	FVI +	Bootstrapping	SCT	Luszczynska	/+	/–	/–
McCabe	All dietary measures –	Product of coefficients	SCT	McCabe	–/–	+/+	–
Van Lippevelde	Eating behaviors –	Product of coefficients	TPB and TTM	McCabe	–/–	–/–	–/–
Werch	FVI +	Bootstrapping	BIM	McCabe	–/–	–/–	–/–
				Werch	NR	NR	/+
				Beaulieu	NR	NR	–
				Gray	/+	* /+	/+
				McCabe	–/–	+/–	–
				McCabe	–/–	+/+	–/–
				McCabe	–/–	+/+	–/–
				McCabe	–/–	–/–	–/–
				Beaulieu	NR	NR	–
				Gray	/+	* /+	/+
				McCabe	–/–	+/–	–
				McCabe	–/–	+/+	–/–
				McCabe	–/–	–/–	–/–
				Beaulieu	NR	NR	–
				Gray	/+	/+	/+

Ecological Level & Mediator(s)	Author	Action Theory Single/Multiple	Conceptual Theory Single/Multiple	Mediated Effect Single/Multiple
Affective outcome expectations	Gray	/+	/+	/+
Outcome expectancies for healthy eating (fruit)	McCabe	-/-	-/-	-
Outcome expectancies for healthy eating (veggies)	McCabe	-/-	-/-	-/-
Outcome expectancies for healthy eating (fat intake)	McCabe	-/-	-/-	-/-
Outcome expectancies for healthy eating (SSB)	McCabe	-/-	-/-	-/-
Perceived social norms	Beaulieu	NR	NR	-
Behavioral beliefs	Beaulieu	NR	NR	-
Facilitating factors	Beaulieu	NR	NR	-
Pros	Di Noia	+	+/-	+/-
Cons	Di Noia	-	NT	NT
Forward stage movement	Di Noia	+	+/+	+/+
Autonomous motivation	Gray	/+	/+	/+
Perceived barriers	Gray	/+	/+*	/+
Planning intervention group	Luszczynska	/+	/+	/+
Planning		/+	/+	/+
Self-efficacy		/+	/+	/+
Perceived behavioral control	Beaulieu	NR	NR	-
Interpersonal				
Parental encouragement	Van Lippevelde	-	+	-
Parental support	Van Lippevelde	+	+	+
Setting				
Home environment for healthy eating (fruit)	McCabe	-/-	-/-	+
Home environment for healthy eating (veggies)	McCabe	-/-	-/-	-/-
Home environment for healthy eating (fat intake)	McCabe	-/-	-/-	-/-
Home environment for healthy eating (SSB)	McCabe	-/-	-/-	-/-
Home availability	Van Lippevelde	-	+	-

Note. BIM, body image model based on self-regulation theory; FVI, fruit and vegetable intake; NR, not reported; NT, not tested; SCT, social cognitive theory; SDT, social determination theory; SEM, structural equation modeling; SSB, sugar-sweetened beverage; TPB, theory of planned behavior; TTM, transtheoretical model.

+ = significant; - = nonsignificant.

* Proximal mediator in structural equation modeling model.

Table 5 –

Physical Activity Mediator Details

Author	Intervention Effect on Outcome Variable	Method	Theory	Author	Action Theory Single/Multiple	Conceptual Theory Single/Multiple	Mediated Effect Single/Multiple
Cook	MVPA +	Bootstrapping	TPB, SCT, ASSM, TTM	Cook	–	+	–/–
Dewar	Sedentary time +; PA –	NR	SCT	Dewar	–	NT	NT
Gray	Stair + (boys only)	SEM	SCT, SDT	Gray	/+	/+	/+
Lubans	PA –	Product of coefficients	SCT	Lubans	–	–	–
Roesch	PA –	Cheong et al. (2003)	BDM, SCT, and TTM	Lubans	+	–	–
Smith	PA –	Product of coefficients	SCT, SDT	Roesch	–	+	–
				Smith	+	–	–
				Cook	–	–	–/–
				Dewar	–	NT	NT
				Dewar	–	NT	NT
				Gray	/+	/+	/+
				Gray	/+	/+	/+
				Dewar	–	NT	NT
				Lubans	–	–	–
				Roesch	+	+	+
				Cook	+	+	+/+
				Cook	+	+	+/–
				Cook	+	+	+/–
				Gray	/+	/*	/+
				Dewar	–	NT	NT

Ecological Level & Mediator(s)	Author	Action Theory Single/Multiple	Conceptual Theory Single/Multiple	Mediated Effect Single/Multiple
Goal intention	Gray	/+	*/+	/+
Autonomous motivation	Gray	/+	/+	/+
Pros	Roesch	+	-	-
Cons	Roesch	+	-	-
Interpersonal				
Social support from a sports partner	Cook	-	+	-/suppress
Social support	Dewar	-	NT	NT
Family support	Roesch	-	+	-
Peer support for physical activity	Lubans	-	-	-
Peer support	Roesch	-	+	-

Note. ASSM, Attitudes, Social Influence, and Self-efficacy Model; BDM, behavioral determinants model; MVPA, moderate to vigorous physical activity; NR, not reported; NT, not tested; PA, physical activity; PEB, perceived environmental barrier; SCT, social cognitive theory; SDT, social determination theory; SEM, structural equation modeling; TPB, theory of planned behavior; TTM, transtheoretical model.

+ = significant; - = nonsignificant.

* Proximal mediator in structural equation modeling model.

Table 6 –

Screen-Time Mediator Details

Author	Intervention Effect on Outcome Variable		Method		Theory	
	Screen time –	Screen time +	Product of coefficients	Product of coefficients	SDT	SCT, SDT
Babic						
Smith						
Ecological Level & Mediator(s)						
Individual	Author	Action Theory	Single/Multiple	Conceptual Theory	Single/Multiple	Mediated Effect Single/Multiple
Autonomous motivation	Babic	+		+		+/+
Autonomous motivation	Smith	+/+		+/+		+/+
Controlled motivation	Babic	+		–		–/–
Controlled motivation	Smith	–/–		–/–		–/–
Amotivation	Babic	–		–		–/–
Amotivation	Smith	–/–		+/–		–/–
Setting						
Screen-time rules	Smith	–/–		+/+		–/–

Note. SDT, social determination theory; SCT, social cognitive theory.

+ = significant; – = nonsignificant.