A Review of Mediators of Behavior in Interventions to Promote Physical Activity among Children
and Adolescents

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Abstract

Background. The effectiveness of interventions to promote physical activity in youths is still developing. To develop a better understanding “what works”, researchers are now focusing on constructing an evidence base for mediators of behavior change.

Methods. We reviewed studies that examined the direct effect of physical activity interventions on hypothesized mediators and the relationship between mediators and physical activity in young people (aged 5 to 18 years). Studies were identified via electronic database searches and scanning references against predetermined quality criteria.

Results. We found seven studies that evaluated three mediator groups: cognitive, behavioral and interpersonal mediators. Self-efficacy was the most commonly assessed mediator in youth interventions and there was strong support for its role in mediating the relation between theory-based interventions and physical activity. There was some support for the importance of behavioral strategies as mediators of behavior, but no support for the mediating influence of interpersonal factors.

Conclusions. Despite recognition of the importance of mediation studies, few interventions have assessed mediators of physical activity behavior in youth interventions. The small number of studies examining mediators of behavior and the variability in study design and quality prevent us from forming strong conclusions regarding the most effective mediators of behavior.

Key words: Mediation, intervention, physical activity, behavior, psychosocial

variables

Introduction

Due to the benefits of physical activity and concern regarding low levels of activity, numerous interventions targeting activity behavior in youth have been evaluated. However, the majority of these studies have produced modest results (Stone, et al., 1998, Van Sluijs, et al., 2007). It has been suggested the lack of effectiveness of youth interventions is, in part, due to a poor understanding of the mechanisms responsible for behavior change (Baranowski and Jago, 2005). While interventions are generally developed in reference to a theory of health behavior change (e.g. Social Cognitive Theory, Theory of Planned Behavior), few studies have examined possible mediators in effective interventions (Baranowski, et al., 1998). In 2002, Lewis et al. (2002) published an important review of psycho-social mediators of physical activity behavior and found only two studies that examined mediators in youth interventions.

A mediator can be defined as an intervening causal variable necessary to complete the pathway from an intervention to the targeted behavioral outcome (Bauman, et al., 2002). Measurement of these change mechanisms is necessary for the systematic progression of physical activity research (Bauman, et al., 2002) because it allows researchers to determine which components of an intervention contribute to behavior change. Furthermore, mediation analyses allow researchers to develop more parsimonious models by eliminating unrelated mediators from future interventions (MacKinnon and Dwyer, 1993).

Randomized controlled trials are regarded as the ‘gold standard’ for physical activity intervention design and they also provide a valuable opportunity for the identification of mediators of behavior change (Kraemer, et al., 2002). In its simplest form, testing for mediating effects is accomplished by adding a mediating variable (e.g., self-efficacy) to the regression equation of the independent (e.g., intervention condition) and dependent variables (e.g., physical activity). (MacKinnon, et al., 2007). In mediational hypotheses, it is assumed

that the inclusion of a mediating variable will reduce the magnitude of the relationship between the independent and dependent variables (MacKinnon, et al., 2000). However, suppression occurs when the inclusion of an additional variable (e.g. mediator) increases the predictive validity of another variable (e.g. intervention) by its inclusion in an equation (Tzelgov and Henik, 1991). There are three major approaches used to establish statistical mediation, these include the causal steps as proposed by Baron and Kenny (1986), the difference in coefficients and the product of coefficients (MacKinnon, 2000). These methods are described in detail by MacKinnon, Fairchild and Fritz (2007).

Insert figure 1

While studies often cite a theoretical framework for their intervention, they rarely test the efficacy of these models using appropriate strategies (Baranowski, et al., 1998). For example, a study might report the effect of an intervention on hypothesized mediators or psychosocial constructs (e.g. Deforche, et al., 2004, Parcel, et al., 1989, Simon, et al., 2004), without examining potential mediation pathways. This type of analysis does not establish that changes in the theoretical constructs were responsible for changes in the outcome variable. The aim of this paper is to review the evidence of mediators of physical activity behavior change in youth interventions because such an analysis should further our understanding of intervention effectiveness.

Method

Identification of studies

A comprehensive search of published studies was conducted using the computer databases PubMed, Embase, PsychINFO and SPORTS Discus. Experts in the field were

contacted and the following hand selected scientific journals were searched *Psychology of Sport and Exercise*, *Journal of Sport and Exercise Psychology*, *Preventive Medicine* and *Health Psychology*. The key terms for searches included *mediation*, *mediator*, *intervention*, and *physical activity*. Titles, references, and abstracts of articles identified were checked for relevance by the lead author and references of the full-text articles retrieved were searched. The Quality of Reporting of Meta-analyses statement (QUOROM) (Moher, et al., 1999) was consulted and provided the structure for this review. The flow of studies through the review process is reported in Figure 2.

Insert Figure 2

Criteria for inclusion/exclusion

The criteria for inclusion in this review were as follows: (1) quantitative assessment of physical activity, (2) quantitative assessment of potential mediators, (3) physical activity intervention involving experimental or quasi-experimental design, (4) participants were primary or secondary school age (aged 5 to 18 years), (5) study reported the impact of the intervention on hypothesized mediators and the relationship between the mediator and physical activity after adjusting for the intervention effect, and (6) published in English.

Criteria for assessment of study quality

The present authors assessed the quality of the mediation studies that met the inclusion criteria. A formal quality score for each study was computed (ranging from 0 to 8) by assigning a value of 0 (no) or 1 (yes) to each of the questions listed. (i) Did the study cite a theoretical framework? (ii) Were the study methods/procedures designed to influence mediating variables? (iii) Were pilot studies conducted/reported to test the effect of the intervention on mediators? (iv) Was

an objective measure of physical activity used? (v) Were the psychometric characteristics of the mediator variables reported and were they within accepted ranges (Cronbach alpha and test-retest reliability $> .06$) (Tabachnick and Fidell, 1996)? (vi) Did the study report a power calculation and was the study adequately powered to detect mediation? (vii) Did the study use an experimental design? (viii) Was post-intervention physical activity controlled for baseline physical activity? Studies that scored 0-3 were regarded as low quality studies, studies that scored 4-6 were classified as medium quality and those that scored 7-8 high quality.

In this review, the hypothesized mediators were organized into three groups: cognitive mediators, behavioral mediators and interpersonal mediators. Cognitive mediators included constructs related to participants' thoughts and feelings about physical activity and their ability to overcome barriers to participation. Hypothesized cognitive mediators included self-efficacy, outcome expectancy, enjoyment (including enjoyment of physical education), perceived barriers, perceived benefits and attitudes. Behavioral mediators were classified as strategies used by participants to increase their physical activity adherence. Behavioral mediators assessed were goal setting, commitment to planning, stimulus control and counter conditioning. Interpersonal mediators included constructs related to social support for physical activity and included peer and parent social support, exposure to models, and interpersonal norms.

Results

Overview of study quality

We found seven studies examining potential mediators of physical activity behavior change in youth, spanning three types of mediating variables - cognitive, interpersonal and

behavioral. All of the studies were conducted in secondary schools. Studies were from four countries, Belgium, Iran, the United States of America (USA) and United Kingdom (UK). The sample sizes of the interventions ranged from 78 to 2840 participants. The shortest assessment period was three months and the longest was 2 years. Four studies (Dzewaltowski, et al., 2008, Haerens, et al., 2007, Lubans and Sylva, 2007, Taymoori and Lubans, 2008) used the product of coefficients (POC) (MacKinnon, et al., 1998) to identify potential mediators of behavior and three studies used the joint significance test to identify potential mediators of behavior (Dishman, et al., 2005, Dishman, et al., 2004, Dunton, et al., 2007).

Study criteria and results are presented in Table 1. One study was classified as low quality (Dunton, et al., 2007) and the remaining studies were classified as medium quality (range 4 to 6). The Social Cognitive Theory (SCT) (Bandura, 1986) was used as the theoretical framework for five of the seven studies (Dishman, et al., 2005, Dishman, et al., 2004, Dunton, et al., 2007, Dzewaltowski, et al., 2008, Lubans and Sylva, 2007). One intervention (Taymoori and Lubans, 2008) was based on the Health Promotion Model (HPM) (Pender, et al., 2002) and also included processes of change from the Transtheoretical Model (TTM) (Prochaska, et al., 1997) and one study used data from a school-based intervention grounded in the Theory of Planned Behavior (TPB) and the TTM (Haerens, et al., 2007). All of the studies described intervention components designed specifically to manipulate hypothesized mediators. No study reported the results from a pilot project and all of the studies used questionnaires to assess physical activity. Two studies used confirmatory factor analysis to confirm that all scales were unidimensional (Dishman, et al., 2005, Dishman, et al., 2004). Two studies reported all their scales to have acceptable psychometric properties (Lubans and Sylva, 2007, Taymoori and Lubans, 2008), based on Cronbach alpha ($\alpha > .6$) and test-retest reliability. One study (Haerens, et al., 2007),

included scales that did not have acceptable reliability ($\alpha < .60$), another study reported acceptable internal consistency but did not report test-retest reliability coefficients (Dunton, et al., 2007). Although Dzewaltowski and colleagues provided a reference for a scale validation study, they did not report the psychometric properties used in their study. Four studies included power calculations and were adequately powered for their respective analyses. Six studies used experimental designs, with randomization occurring at the school level (Dishman, et al., 2005, Dishman, et al., 2004, Dzewaltowski, et al., 2008, Haerens, et al., 2007, Taymoori and Lubans, 2008) in all but one intervention (Lubans and Sylva, 2007). One study used a quasi-experimental design (Dunton, et al., 2007). In all of the studies the physical activity at posttest was controlled for baseline physical activity.

Overview of study findings

The LEAP (Dishman, et al., 2005, Dishman, et al., 2004) program was successful in increasing physical activity in the intervention group and a number of mediators of behavior were identified. In the Project FAB (Dunton, et al., 2007) intervention for adolescent girls, none of the psychosocial variables assessed satisfied the criteria for mediation. Taymoori and Lubans (2008) examined potential mediators in two individually-tailored interventions designed for sedentary adolescent girls in Iranian secondary schools. Both interventions had positive effects on physical activity behavior and theoretical constructs from the HPM. In the Lifetime Activity Program (LAP)(Lubans and Sylva, 2007) for senior school students, increases in physical activity among adolescent girls in the intervention were related to changes in the theoretical constructs. Haerens and colleagues (2007) examined potential mediators in a large multi-component intervention for adolescents. The intervention resulted in

significant increases in physical activity. They found that self-efficacy for physical activity at school partially mediated the effects of the intervention. The Healthy Youth Places (HYP) study (Dzewaltowski, et al., 2008) intervention was designed to increase students' proxy efficacy or confidence in their skills and abilities to get others to support their physical activity behaviors.

Summary of cognitive mediators

Self-efficacy was the most commonly assessed cognitive mediator and was included in all of the intervention studies. Self-efficacy was found to mediate changes in physical activity in the LEAP study (Dishman, et al., 2004), the Iranian girls intervention (Taymoori and Lubans, 2008), and the Belgian intervention (Haerens, et al., 2007). The LAP intervention (Lubans and Sylva, 2007) had a significant effect on self-efficacy and the changes in self-efficacy were related to changes in physical activity. In the HYP intervention (Dzewaltowski, et al., 2008), proxy efficacy to influence school physical activity environments mediated the program effects on physical activity at the one year posttest.

Outcome expectancy and perceived benefits were assessed in five studies. Although changes in outcome expectancy/perceived benefits were related to changes in physical activity in the LEAP (Dishman, et al., 2004) and in the Belgian study (Haerens, et al., 2007), it was only in the Iranian girls study (Taymoori and Lubans, 2008) that it satisfied the criteria for mediation. In the Belgian intervention, changes in attitudes were associated with the intervention condition and with changes in physical activity, but could not satisfy the criteria for full mediation because the effects of the intervention were not reduced after controlling for the effect of the mediator. In contrast to expectations, changes in attitude were found to have significant suppression effects on physical activity.

Changes in perceived barriers were not related to changes in physical activity in the Iranian intervention. Although changes in perceived barriers were related to the intervention condition in the Project FAB study, they were not in the hypothesized direction and were not related to changes in physical activity. Changes in perceived barriers were related to the intervention and changes in physical activity in the Belgian study, but could not satisfy the criteria for mediation because the effects of the intervention were not attenuated after controlling for the effect of the mediator. While changes in the enjoyment of physical education were not related to changes in physical activity in the LEAP study, changes in enjoyment of physical activity were. Increased enjoyment in physical activity partially mediated the effects of the LEAP intervention.

Summary of behavioral mediators

Only two studies assessed potential behavioral mediators (Dishman, et al., 2004, Taymoori and Lubans, 2008). In the LEAP study, the intervention was found to have a significant effect on goal setting, but these changes were not related to changes in physical activity. In the Iranian girls' intervention, commitment to planning satisfied all of the mediation criteria in both interventions. In the same intervention the two behavioral processes from the TTM could not satisfy any of the mediation criteria.

Summary of interpersonal mediators

Five studies evaluated the impact of interpersonal factors on physical activity changes (Dunton, et al., 2007, Dzewaltowski, et al., 2008, Haerens, et al., 2007, Lubans and Sylva, 2007, Taymoori and Lubans, 2008). None of the interpersonal variables could satisfy

the criteria for mediation in any of the studies. In the Iranian intervention, changes in exposure to models were related to changes in physical activity, but the changes were not related to treatment condition.

Discussion

Mediation analyses from intervention studies provide researchers, health promoters and educators with evidence about ‘what works’ for changing physical activity behaviors. The aim of our review was to identify mediators of physical activity behavior in youth. Only seven studies satisfied the criteria for inclusion in this review and due to the diversity of interventions, methods, and findings, conclusions are difficult to draw. The majority of studies involved adolescent girls and because determinants of physical activity change over time and are different for boys and girls (Sallis, et al., 2000), the majority of these results are only generalizable to this group.

Self-efficacy was the most commonly assessed mediator and received the strongest support for mediating the relationship between theory-based interventions and physical activity in youth. Although a comprehensive review of physical activity correlates among youth found that the evidence for self-efficacy was indeterminate (Sallis, et al., 2000), a more recent review of correlates among adolescent girls found that self-efficacy was an important correlate (Biddle, et al., 2005). Evidence from this review suggests that interventions to increase physical activity among youth should target self-efficacy using appropriate strategies.

While changes in self-efficacy partially mediated the effects of the Belgian intervention (Haerens, et al., 2007) on total and school related physical activity, significant suppression effects for attitudes, self-efficacy, perceived benefits and barriers on physical activity changes

were found. As mentioned previously, suppression occurs when the inclusion of an additional variable increases the predictive validity of a variable in the same equation. This explains why no mediation effects were found even though there were significant relationships between the intervention and mediators and between mediators and physical activity, after adjusting for the intervention.

Two studies included hypothesized behavioral mediators and only one study (Taymoori and Lubans, 2008) found that increases in the use of behavioral strategies mediated changes in physical activity behavior. This is a surprising finding considering the strong support for the mediating role of behavioral processes in physical activity interventions identified in the review by Lewis and colleagues (Lewis, et al., 2002). Although these findings were based on studies with adults, by late adolescence individuals start to develop adult-like cognitions and strategies. The examination of behavioral mediators requires further attention in this age group. There was limited support for the efficacy of interpersonal variables as mediators of behavior change. None of the studies that assessed interpersonal factors established mediation.

The overall quality of the studies was moderate. Studies were limited by the use of measures with unacceptable psychometric properties, the failure to report a power calculation, and the use of self-report measures of physical activity. Four studies used the product of coefficients test to assess potential mediators of behavior. The product of coefficients test can be used to establish mediation effects in small samples (Cerin, et al., 2006, MacKinnon, et al., 2002, MacKinnon, et al., 1995), even in the absence of a significant effect between intervention and outcome. Three studies used the joint significance test to identify potential mediators of behavior (Dishman, et al., 2005, Dishman, et al., 2004, Dunton, et al., 2007). The joint significance test involves two steps. First, the relationship between a mediator and an outcome variable after adjusting for the effect of an intervention is examined. Then the relationship between the

intervention and the mediator is assessed. The joint significance test refers to statistical significance of both alpha and beta coefficients from the regression models described above. Researchers aiming to identify potential mediators of behavior change should choose a method of mediation analysis that is appropriate for their sample size.

There are limitations in this review that should be noted. First, our criterion for assessing the psychometric qualities of the scales used was limited. Cronbach's alpha represents one of many indicators of metric properties of a scale. While internal consistency is often reported as a measure of reliability, it provides limited information on measurement quality and is dependent on the number of scale items. Test-retest reliability was also assessed in this study; however, few studies reported reliability coefficients. Furthermore, the quality of the mediators assessed could not be determined in studies that did not report any psychometric properties. Second, we cannot be certain that studies included in the review had conducted pilot studies and did not report them in their mediation analyses.

Future Research

Interventions to promote physical activity have traditionally targeted individuals and focused on increasing knowledge and skills through educational programs (Dishman, 1994, Kremers, et al., 2007, McLeroy, et al., 1988). More recently, the importance of targeting the physical environment has been identified (Fein, et al., 2004, Sallis, et al., 2001). Some school-based interventions that have combined environmental changes with educational programs have demonstrated potential in promoting sustainable behavior change (Haerens, et al., 2006, Sallis, et al., 2003, Simon, et al., 2004). Future studies should explore the impact of environmental interventions by examining individuals' perceptions of their environment to determine if changes to the physical environment are accompanied with changes in perception,

which in turn contribute to increased physical activity. Recent reviews have identified a number of potentially modifiable environmental correlates of physical activity in youth populations (Ferreira, et al., 2007, Salmon and Timperio, 2007). However, the contribution of such variables in explaining the variance of physical activity behavior is much smaller than the contribution of cognitive and interpersonal variables (Giles-Corti and Donovan, 2002) and assessing these constructs must remain a priority. It may be necessary for researchers to evaluate more complicated models which recognize that the small size of the effects of changes in environmental variables on behavior change may be due to these changes being mediated by cognitive variables (e.g. self-efficacy).

None of the studies included in this review included an objective measure of physical activity. The measurement of physical activity among youth using self-report measures is notoriously problematic. While it has been suggested that social desirability may lead young people to overestimate their physical activity (Warnecke, et al., 1997), more recently, researchers have found that children and adolescents underestimate physical activity of moderate intensity (Riddoch, et al., 2004, Telford, et al., 2004). Future studies should assess changes in physical activity using a combination of objective and self report measures. This will provide a more accurate assessment of the amount and context of activity and enable researchers to determine the effect of interventions on specific physical activity behaviors.

Finally, the overall quality and quantity of mediation studies in children and adolescents is lacking. We recommend more studies examining potential mediators of physical activity behavior change in youth populations, especially among boys. To improve the quality of studies and to enable readers to evaluate the quality of existing studies, researchers should use and report their studies using the CONSORT criteria. As the majority of behavior change models have been developed for adult populations, they may not be entirely appropriate for children and adolescents. Future studies may choose to evaluate the efficacy of models

designed specifically for youth (e.g. Youth Physical Activity Promotion Model) using scales that demonstrate strong psychometric properties. Theory driven interventions that allow researchers to investigate the effects of manipulating potential mediating variables provide the greatest opportunity for understanding behavior change and should be focus of future research, rather than those that adopt a chance approach to establishing mediation.

Conclusion

There is considerable work to be done in order to improve our understanding of physical activity behavior change in youth populations. While an increased emphasis on descriptive longitudinal studies may help to identify more highly predictive causal mediators, the global pediatric obesity epidemic and general decline in physical activity levels require immediate interventions. These interventions should be guided by theories of behavior change and involve rigorous mediation analyses to identify important mechanisms for behavior change. This will enable researchers to develop more effective interventions and expand our knowledge of how to change behavior in specific youth populations.

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Table 1: Mediation study quality checklist with quality scores assigned

Table 2: Summary of interventions examining potential mediators of physical activity behavior change in youth

Table 2: Results from mediation analyses in interventions designed to promote physical activity among youth

Figure 1: Overview of Mediation Analysis

Figure 2: Flow of Studies Through the Review Process