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Review

Evaluation of physical activity interventions in youth via the Reach, Efficacy/Effectiveness, Adoption, Implementation, and Maintenance (RE-AIM) framework: A systematic review of randomised and non-randomised trials

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ABSTRACT

Context. An identified limitation of existing reviews of physical activity interventions in school-aged youth is the lack of reporting on issues related to the translatability of the research into health promotion practice.

Objective. This review used the Reach, Efficacy/Effectiveness, Adoption, Implementation and Maintenance framework to determine the extent to which intervention studies promoting physical activity in youth report on factors that inform generalizability across settings and populations.

Methods and results. A systematic search for controlled interventions conducted within the last ten years identified 50 studies that met the selection criteria. Based on Reach, Efficacy/Effectiveness, Adoption, Implementation and Maintenance criteria, most of these studies focused on statistically significant findings and internal validity rather than on issues of external validity. Due to this lack of information, it is difficult to determine whether or not reportedly successful interventions are feasible and sustainable in an uncontrolled, real-world setting.

Conclusions. Areas requiring further research include costs associated with recruitment and implementation, adoption rate, and representativeness of participants and settings. This review adds data to support recommendations that interventions promoting physical activity in youth should include assessment of adoption and implementation issues.

Contents

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Introduction

The literature estimates that physical inactivity contributes to 6–10% of the major non-communicable diseases worldwide (i.e., coronary heart disease, type II diabetes, breast and colon cancers) (Lee et al., 2012). In comparison, regular physical activity (PA) confers benefits that extend well beyond physical health and include a better quality of life, reduced stress, improved sleep, and stronger relationships and social connectedness (Das and Horton, 2012). Therefore, PA can be considered a major contributor to overall physical and mental well-being.

The World Health Organization (WHO) guidelines recommend that for optimal health, children and youth (aged 5 to 17 years) should engage in at least 60 min of moderate- to vigorous-intensity physical activity (MVPA) daily (WHO, 2010). However, a synthesis of self-reported global data from WHO Member States estimate that four of every five youth (aged 13–15 years) do not meet the present guidelines (Hallal et al., 2012). Collectively, the established health benefits of regular MVPA and the reported suboptimal activity levels of youth indicate a need for increased participation in PA among this population.

Addressing this need involves a systematic review of the relevant research in order to identify the characteristics of successful interventions designed to promote PA. Several meta-analytic and narrative reviews focus on the efficacy of PA interventions in children and youth, and thereby attempt to provide evidence of a cause and effect relationship between intervention strategies and increased PA levels in participants (Atkin et al., 2011; Cale and Harris, 2006; De Meester et al., 2009; Dudley et al., 2011; Jago and Baranowski, 2004; Lubans et al., 2009b; Metcalf et al., 2012; Salmon et al., 2007; van Sluijs et al., 2007). Although many of these review articles have commented on the potential lack of generalizability of PA interventions in youth (Brown and Summerbell, 2009; Camacho-Miñano et al., 2011; De Meester et al., 2009; Dobbins et al., 2009; Rees et al., 2006; Kriemler et al., 2011; O'Connor et al., 2009; Timperio et al., 2004; van Sluijs et al., 2011), to date, none has specifically addressed the translatability of the research into health promotion practice or its impact on public health. In other words, existing reviews have focused on the internal validity of studies of PA interventions in youth without systematically addressing issues related to external validity.

External validity is defined as the degree to which study findings are generalizable to groups and environments outside the intervention or experimental setting (Gay et al., 2012). To balance the emphasis on internal and external validity, Glasgow et al. (1999) designed an evaluation framework that expands assessments of interventions beyond efficacy. This Reach, Efficacy/Effectiveness, Adoption, Implementation, and Maintenance (RE-AIM) framework has demonstrated utility in evaluating internal and external validity indicators for a number of health behaviour interventions (e.g., nutrition and PA) (Aittasalo et al., 2006; DerAnanian et al., 2012; Dunton et al., 2009; Jenkinson et al., 2012; Nigg et al., 2012), and has been used in reviews of literature to demonstrate the degree to which researchers reported on external validity issues (Akers et al., 2010; Allen et al., 2011; Antikainen and Ellis, 2011; Dzewaltowski et al., 2004; Glasgow et al., 2004; White et al., 2009).

As conceptualized by Glasgow et al. (1999, 2004), reach is a measure of participation characterized by the number, proportion and representativeness of individuals willing to participate in the intervention, and efficacy/effectiveness assesses the impact of an intervention on important outcomes (both positive and negative). The term efficacy applies to trials that test the impact of an intervention under optimum conditions, while the term effectiveness applies to trials that are conducted in real-world settings by individuals who are not part of the research staff (Flay, 1986; Glasgow et al., 2003). Adoption reflects the number, proportion and representativeness of settings and intervention agents who are willing to initiate the intervention, and implementation is concerned with the extent to which the intervention was delivered as intended in the real world. Finally, maintenance assesses the degree to which a programme is sustained over time (Glasgow et al., 1999, 2004).

The RE-AIM framework has been used to guide PA interventions in youth, and to evaluate reviews of PA interventions in adults; however, there has yet to be a review of PA interventions in youth conducted using the RE-AIM framework. Therefore, the purpose of this article is to present the findings of a RE-AIM review in order to evaluate the internal and external validity of randomised and non-randomised interventions designed to increase PA behaviour in youth. Specifically, the findings include an assessment of PA intervention generalizability to field settings, and consideration of variables that may moderate intervention efficacy/effectiveness, such as resource availability, implementation fidelity and possible incorporation into the daily routine (Glasgow et al., 2003, 2004).

Method

Database search and study inclusion

Five electronic databases (Pubmed, Nursing and Allied Health Literature, SPORTDiscus, PsycINFO, and Educational Resources Information Center) were searched for articles written in English and published in peer-reviewed journals from January 2003 to January 2013. For each database, the following search terms were used: (physical activity OR fitness OR exercise OR physical education OR sport OR running) AND (random OR controlled OR trial OR clinical OR intervention) AND (programmes OR strategy OR initiative OR promotion OR curriculum) AND (effectiveness OR sustainability OR feasibility OR implementation) AND (child OR adolescent OR youth OR juvenile OR boy OR girl OR teen). After removal of duplicate citations and screening of abstracts, 669 full-text articles were assessed independently by two reviewers against the following inclusion criteria: studies had to be experimental or quasi-experimental with the key criterion being a control condition; participants had to be 12 to 17 years old and not selected on the basis of having a specific disease or health problem, including obesity; and, the measured outcomes had to include a measure of PA levels and/or psychosocial outcomes. All intervention settings were eligible for inclusion (e.g., school-based, community, family, and primary care clinic), as were all types of interventions (e.g., health programmes, policies, and curriculum) and all types of assessment (objective and subjective). The final review included 66 articles representing 50 interventions (see Fig. 1).

RE-AIM coding protocol and scoring

Two members of the research team independently coded all eligible articles based on the presence or absence of indicators for each RE-AIM component. Binary coding was used to report whether individual indicators were (1) or were not (0) reported within each component. Initial percent agreement was 88.2%, and all discrepancies were resolved by discussion. Following resolution, which was reached by direct reference to the research article, frequency counts and percentages were recorded for each RE-AIM indicator, and means were calculated for each RE-AIM component using Microsoft Excel 2007.

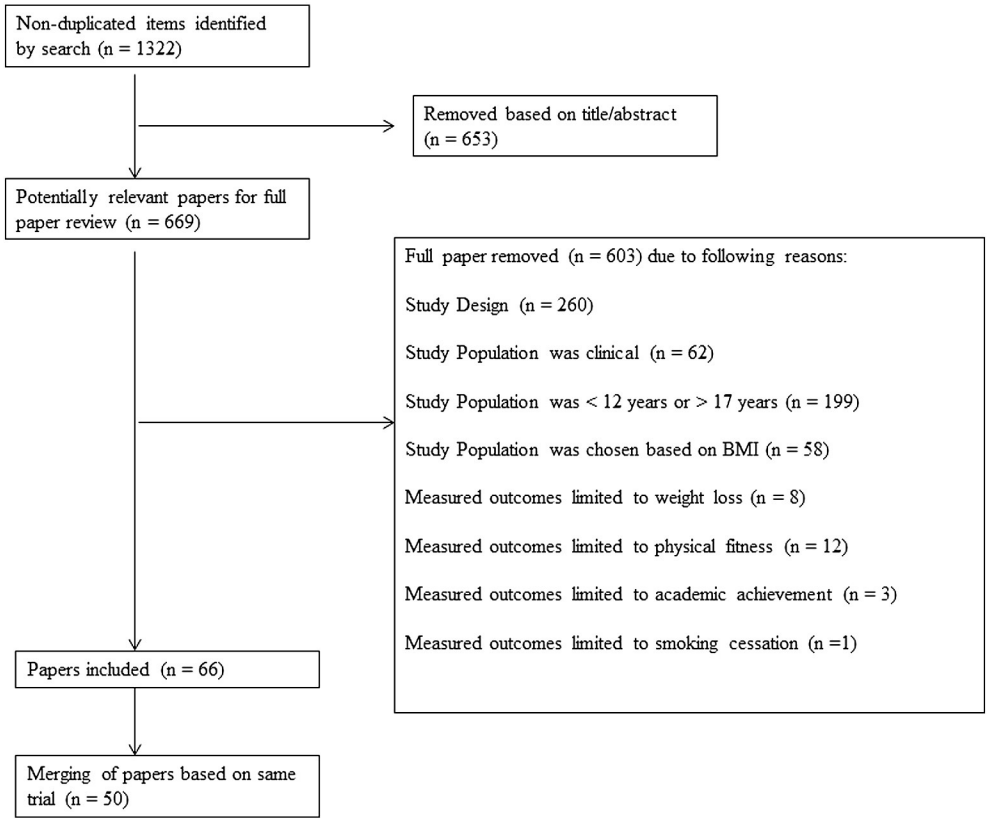

Fig. 1. Selection of physical activity interventions for RE-AIM review.

Results

Intervention characteristics

Table 1 summarizes the reviewed interventions, and organizes them by design. For the purposes of this review, intervention effects on measured outcomes were recorded as positive when the individual study authors reported a statistically significant change between intervention and control/comparison groups. This liberal summation resulted in considerable variation in both the magnitude and nature of the positive PA effects, which included increases in self-reported leisure time physical activity (LTPA) and/or total PA (min/week or min/day), increases in active transportation (min/day), decreases in self-reported sedentary behaviours (30-min blocks/day), observed proportion of lesson time spent in MVPA (%), number of self-reported exercise sessions (for at least 30 or 60 min/week), accelerometer-measured activity (minutes of sedentary, light and moderate to vigorous PA per day and cpm), pedometer-measured (steps/day), and likelihood of meeting specified PA guidelines in a given period of time (e.g., in the past seven days).

Assessing RE-AIM characteristics

Table 2 provides a summary of the overall percentage of studies reporting on each of the RE-AIM dimensions.

Reach

The median number of participants across all 50 studies was 268 (ranged from 33 to 25,000). Four of the studies (Dudley et al., 2010; Peralta et al., 2009; Sirriyeh et al., 2010; Slootmaker et al., 2010) were reportedly insufficiently powered to detect statistically significant differences between the groups. The reported participant characteristics ranged from minimal (age, ranging from 12 to 17 years, and gender) to comprehensive (ethnicity, income, education, and health). Many of the interventions (54%) targeted specific sub-populations as specified in Table 1. Most of the studies were conducted in North America (50%), Western Europe (40%) or Australia (6.0%), with one being conducted in each of South Africa and Iran.

When participation rate was reported, it was between 37.5% and 97.8% (median of 76%), with only two of the interventions being unable to attract more than 50% of the target population (Lubans and Morgan, 2008a; Sirriyeh et al., 2010). The four studies that reported on the representativeness of the recruited participants compared to the non-participants found no differences (Haerens et al., 2007; Patrick et al., 2006), or that non-participants were more likely to live in a low socioeconomic environment (Dzewaltowski et al., 2009), older, less likely to participate in sports clubs, and/or spent more time in sedentary activities (Simon et al., 2008).

Efficacy/effectiveness

Efficacy/effectiveness was the most consistently reported RE-AIM component across all studies. All articles included in this review included PA measures (34%), psychosocial measures (2.0%), or both PA and psychosocial measures (64%) as primary outcomes. Of the 24 studies that specified an intervention focus, 17 mentioned that the trial was examining the effectiveness and 7 indicated that the trial was examining the efficacy of the intervention. The remaining 26 studies were each coded as either an efficacy trial, if it was implemented by the research staff and provided resources for a defined length of time, or as an effectiveness trial, if it was implemented by regular staff and relied on existing resources and/or procedures (Glasgow et al., 2003). This increased the total number of effectiveness and efficacy trials to 28 and 22, respectively.

Of the 49 studies that measured PA outcomes, 27 reported that the intervention resulted in statistically significant positive changes in PA levels (see Table 1 for criteria used when coding significant outcomes). The majority of the studies assessed PA solely by observation or self-report questionnaires (79.6%), followed by those using

Table 1
Intervention characteristics of studies reviewed.

Study	Int. setting	Int. length (wks)[a]	Int. focus~	PA measure	Targeted sub-population	Sig. outcomes[b]	
						PA	PS
Cluster randomised controlled trials (54% of studies)							
Bayne-Smith et al. (2004)	I	12	Effect[1]	S-R	♀s	No	NM
Chatzisarantis and Hagger (2009)	I	5	Effect[1]	S-R	No	Yes	Yes
De Bourdeaudhuij et al. (2010)	I + IV	4	Effect[2]	S-R	No	Yes	NR
Dzewaltowski et al. (2009)	III	64	Effect[1]	S-R	No	Yes	Yes
Fairclough and Stratton (2005, 2006)	I	5	Effect[2]	PEO	♀s	Yes	No
Haerens et al. (2006a,b, 2007)	III	64	Effect[1]	S-R	Vocational schools	Yes°[1]	NM
Haerens et al. (2009)	I + IV	12	Effic[2]	S-R	No	No	NM
Hill et al. (2007)	I	<1	Effect[1]	S-R	No	Yes	Yes
Jago et al. (2006)	V	9	Effic[2]	Acc	♂s	Yes	No
Jemmott et al. (2011)	II	1	Effic[2]	S-R	No	Yes	Yes
Jones et al. (2008)	I	72	Effect[2]	S-R	♀s	Yes	NR
Lindgren et al. (2011)	II	24	Effect[2]	N/A	♀s at risk◇	NM	Yes
Lubans et al. (2009a)	II	10	Effic[2]	Ped	Low SES	Yes	NM
Mauriello et al. (2010)	I + IV	8	Effect[1]	S-R	No	Yes	Yes
McKenzie et al. (2004); Sallis et al. (2003)	III	64	Effect[2]	PE O	No	Yes	No
Murphy et al. (2006)	I	24	Effect[2]	S-R	♀s at risk◇	No	No
Neumark-Sztainer et al. (2003a,b)	I	16	Effic[2]	S-R	♀s at risk◇	No	Yes
Neumark-Sztainer et al. (2010)	I	32	Effic[2]	S-R	♀s at risk◇	Yes	Yes
Pate et al. (2005); Dishman et al. (2004); Ward et al., 2006	III	32	Effect[2]	S-R	♀s	Yes	Yes
Prins et al. (2012)	I + IV	<1	Effect[1]	S-R	No	No°[3]	NM
Prochaska and Sallis (2004)	IV	< 1	Effic[1]	Acc	No	Yes	NM
Schofield et al. (2005)	II	12	Effic[1]	S-R, Ped	♀s at risk◇	No for both	NM
Simon et al. (2004, 2006, 2008)	III	128	Effect[2]	S-R	No	Yes°[3]	Yes
Singh et al. (2006, 2009)	III	32	Effect[1]	S-R	Low SES	No	NR
Taymoori and Lubans (2008)	III	24	Effic[2]	S-R	♀s at risk◇	Yes	Yes
Tsorbatzoudis (2005)	I	12	Effect[1]	S-R	No	Yes	Yes
Webber et al. (2008)	III	96	Effic[2]	PEO, Acc	♀s	Yes for both	NM
Randomised controlled trials (30% of studies)							
Black et al. (2010)	V + VI	44	Effic[2]	Acc	Ethnic minority	No	NM
Bronikowski and Bronikowska (2011)	I	60	Effect[1]	S-R	No	Yes	NM
Dudley et al. (2010)	I	11	Effic[1]	Acc	♀s at risk◇	No[c]	No[c]
Lubans and Sylva (2006)	I	10	Effic[2]	S-R	No	Yes	Yes
Marks et al. (2006)	IV	2	Effect[1]	S-R	♀s	No	Yes
Ortega-Sanchez et al. (2004)	VII	48	Effect[2]	S-R	No	Yes	NM
Patrick et al. (2006)	VII + IV	48	Effic[2]	S-R	No	Yes°[2]	NM
Peralta et al. (2009)	I + II	24	Effic[1]	Acc	♂s at risk◇	No[c]	NM
Ransdell et al. (2003a,b)	VI	12	Effect[1]	S-R	♀s at risk◇	No	No
Robbins et al. (2006)	IV	9	Effect[2]	S-R	♀s at risk◇	No	Yes
Sirriyeh et al. (2010)	I + IV	2	Effic[1]	S-R	No	No[c]	NM
Slootmaker et al. (2005, 2010)	IV	12	Effect[1]	S-R	No	No[c]	No[c]
Werch et al. (2003)	II	12	Effic[1]	S-R	No	No	NM
Werch et al. (2005)	II	32	Effic[1]	S-R	No	Yes	NM
Young et al. (2006)	I + VI	32	Effect[1]	S-R	♀s	No	NM
Non-randomised trials with a comparison group (16% of studies)							
Armour and Duncombe (2012)	II	32	Effect[1]	PEO	Disengaged with school	No	No
Bush et al. (2010)	II	16	Effic[2]	S-R	Low SES	No	No
Frenn et al. (2005); Frenn and Malin (2003)	I + IV	4	Effect[1]	S-R	Low SES	No	No
Jamner et al. (2004)	I	16	Effic[2]	S-R	♀s at risk◇	Yes	No
Lubans and Morgan (2008a,b)	II	8	Effic[2]	Ped	No	Yes	No
Murray and Tenenbaum (2010)	I + IV	5	Effect[1]	S-R	No	No	Yes
Schneider et al. (2007, 2008) Graham et al. (2008)	I	32	Effic[2]	S-R	♀s at risk◇	Yes	No
Zizzi et al. (2006)	I	3	Effect[2]	Ped	No	No	No

Int.: intervention, PA: physical activity, PS: psychosocial, PE: physical education, Sig: statistically significant, NM: not measured, NR: not reported, PEO: physical education observation, S-R: self-report, Acc: accelerometer, Ped: pedometer.
~Effect = effectiveness; Effic = efficacy ([1]specified in study; [2]coded by researcher).
I: school-based (curricular), II: school-based (extra-curricular), III: school-based (multi-level), IV: computer-tailored advice/internet/SMS text, V: community-based, VI: family-based, VII: primary-care-based.
SES: socioeconomic status.
◇for being overweight.
°a sub-sample was also measured with accelerometers ([1]yes for sub-sample; [2]yes for sub-sample, boys only; [3]sub-sample data not reported).
[a] 32 weeks = 1 school year; 64 weeks = 2 school years; 96 weeks = 3 school years; 128 weeks = 4 school years.
[b] Yes = primary PA and/or PS measure reported a statistically significant difference compared to a control or comparison condition.
[c] Not adequately powered to detect statistically significant differences.

objective measures such as accelerometers and pedometers (16.3%), and those using a combination of observation or self-report and objective measures (4.1%). Of the interventions that relied solely on observation or self-report questionnaires, 56.4% reported significant differences in PA levels between experimental and control groups, compared with 50% of those that used objective measures (alone or in combination with self-report or observation). Four of the self-report studies measured a sub-sample of the participants with accelerometers. For two of these studies, the objective data was unreported, and for the other two, it supported a significant finding.

Sub-analyses revealed that the percentages of studies reporting significant findings were comparable for efficacy (59%) and effectiveness

Table 2
Proportion of physical activity interventions reporting RE-AIM indicators and components (n = 50 interventions).

Indicators organized by RE-AIM component	Number reporting	Percent reporting[a]
Reach		
Method to identify target population	48	96
Inclusion criteria	47	94
Exclusion criteria	27	54
Sample size	50	100
Participation rate	30	60
Characteristics of participants	50	100
Characteristics of non-participants	4	8.0
Efficacy		
Measures and results	50	100
Intent-to-treat analysis utilized	15	30
Presence of psychosocial measures	35	70
Participant attrition	46	92
Baseline activity reported	48	96
Theory-based	39	78
Adoption		
Description of intervention location	49	98
Description of staff delivering intervention	46	92
Methods used to identify staff	8	16
Level of expertise of staff	34	68
Inclusion/exclusion criteria for setting and staff	3	6.0
Adoption rate	0	0.0
Characteristics of adoption/non-adoption	0	0.0
Start-up costs	3	6.0
Implementation		
Type, frequency, intensity of intervention	50	100
Extent to which protocol was delivered	27	54
Cost of delivery	4	8.0
Maintenance		
Assessed outcomes ≥ 6 months post-intervention	11	22
Current status of programme/policy	7	14
Cost of maintenance	0	0.0

[a] Based on denominator of 50 interventions.

(53.6%) trials, as well as for studies that targeted PA alone (56.2%) and in combination with other behavioural outcomes (e.g., dietary behaviour) (55.6%). Study design appeared to influence measured outcomes, with 73.1% of the cluster randomised controlled trials (RCT) reporting significant findings, compared to 33.3% and 37.5% for RCT and non-randomised trials, respectively. Summarizing the results based on intervention type indicates that school-based interventions were the most effective, with 23 of the 33 interventions reporting significant outcomes. Of these, the school-based interventions that included environment and policy strategies and/or community and family linkages (multi-level) were the most successful, with 87.5% of the studies showing promising results. The curriculum-based and extra-curricular interventions were relatively successful, with 62.5% and 55.6% of the studies, respectively, reporting significant results. For the interventions that were performed in a community-, family-, and/or primary-care-based setting (n = 5), only 40% reported statistically significant differences in PA outcomes between intervention and control groups. There were no settings that did not result in significant results; however, the interventions that included a computer-tailored advice component and/or an internet-based delivery mode (n = 12) reported mixed results. When the computer/internet-delivered advice was administered during class time (n = 7), the PA outcomes were only significant in 28.6% of the studies, compared to 40% of those administered outside of the classroom (n = 5).

Psychosocial measures were included in 33 of the studies, 17 of which reported statistically significant differences in measured outcomes, including self-efficacy (Lindgren et al., 2011; Lubans and Sylva, 2006; Murray and Tenenbaum, 2010; Pate et al., 2005; Simon et al., 2008; Taymoori and Lubans, 2008), autonomous motivation (Chatzisarantis and Hagger, 2009), intentions (Chatzisarantis and Hagger, 2009; Hill et al., 2007; Jemmott et al., 2011; Marks et al., 2006; Simon et al., 2008; Tsorbatzoudis, 2005), self-esteem (Neumark-Sztainer et al., 2010), behavioural control (Hill et al., 2007; Tsorbatzoudis, 2005), attitudes (Hill et al., 2007; Jemmott et al., 2011), normative beliefs (Hill et al., 2007), and progression in PA stages of change (Mauriello et al., 2010; Neumark-Sztainer et al., 2003a,b).

The majority of the studies (78%) were theory-based, most of which applied one or more of the following theories: social cognitive theory (SCT), the theory of planned behaviour (TPB), the trans-theoretical model (TTM), and social–ecological models (SEM). SCT was the most frequently referenced theory and was applied either alone (n = 11) or in combination with the TPB (n = 5), the TTM (n = 5), or a SEM (n = 2). In addition to being applied in combination with SCT, the TPB and SEM each singularly informed three studies, and the TTM was the sole theory applied in two studies. Additional theories that were used (each in one study) included: self-determination theory, the theory of social action, the social marketing approach, the health promotion model (in combination with the TTM), intervention mapping, and Hellison's model. Of the 39 theory-based studies, 64.1% reported significant findings in measured PA and/or psychosocial outcomes, compared with 58.3% of the 12 non-theory-based studies. For each of the TPB, TTM, and SEM, 80% of the studies using them alone or in combination with other theories reported significant outcomes, compared with 69.6% of those using the SCT alone or in combination with other theories. Overall, studies that combined theories (n = 15) were more successful than those using only one (n = 24), with 80% and 54.2% reporting significant findings, respectively. Most of the studies that combined SCT with another theory (83.3%) reported significant findings, and with the exception of the TPB, each of the other theories (TTM and SEM) appeared to be most successful when paired with SCT.

Most studies (92%) reported intervention attrition rates, with a mean attrition rate of 15.6%. Some of the lowest attrition rates (below 5%) occurred when participants were not asked for a large additional commitment to the intervention (such as voluntary participation in exercise sessions that were delivered during non-school hours). This was achieved by either incorporating the intervention into the regular school curriculum (Lubans and Sylva, 2006; Neumark-Sztainer et al., 2010; Peralta et al., 2009; Taymoori and Lubans, 2008), or by delivering the intervention in single sessions in the form of tailored advice and/or counselling (Prochaska and Sallis, 2004; Robbins et al., 2006; Werch et al., 2003).

Adoption

The most commonly reported adoption elements were the descriptions of the intervention location and of the staff delivering the intervention (i.e., the delivery agents). The one study that did not provide a description of the intervention location identified the intervention as school-based, which allowed for an assessment of settings (see Table 1). The majority of the interventions that included a description of the delivery agents were either teacher-led (n = 21) or delivered by members of the intervention staff (n = 7). When reported, the inclusion criteria for setting and staff were vague and included a minimum enrolment number for schools (Simon et al., 2008) and a non-random selection procedure for teachers in order to either strengthen ecological soundness of the intervention (Fairclough and Stratton, 2006) or to adhere to negotiation agreements (Chatzisarantis and Hagger, 2009). No studies reported on either the adoption rate or on the characteristics of adoption/non-adoption.

Implementation

All studies documented the intervention duration, and included a description of the PA programme. Interventions ranged in duration from a single session (n = 2) to one or more (up to four) school years (n = 13). The extent to which the intervention was delivered as intended was reported by 54% of the studies and was conceptualized as student attendance/compliance/adherence (n = 12), staff adherence to protocol (n = 1), differences in implementation across study sites

(n = 2), and technical problems such as server or programming errors and limited numbers of computers (n = 3). The remaining nine articles that reported on the extent to which the intervention was delivered as intended conducted process evaluations. An additional four studies conducted process evaluations but did not report the implementation results; therefore, in total, thirteen studies reported a process evaluation methodology. Two of these studies used the results to categorize schools according to their level of implementation (Haerens et al., 2007; Pate et al., 2005) and one identified the reported implementation barriers (e.g., resource issues, such as lack of time and personnel, and scheduling challenges) (Pate et al., 2005). All thirteen studies that conducted process evaluations provided information regarding who conducted the evaluation, with most being conducted by the teachers and/or other participating school staff members (Jones et al., 2008; Haerens et al., 2007; Fairclough and Stratton, 2006; Dzewaltowski et al., 2009; Pate et al., 2005). Of the remaining studies, two included evaluation feedback from the participants only (Marks et al., 2006; Lubans et al., 2009a), three included feedback from both teachers and participants (McKenzie et al., 2004; Neumark-Sztainer et al., 2003a; Singh et al., 2006), and three were conducted by an observer, one of which was noted to be trained (Webber et al., 2008) and the other two were identified as an independent evaluator who did not deliver the intervention (Chatzisarantis and Hagger, 2009; Murphy et al., 2006). The cost of delivering the intervention was mentioned in only four of the studies, three of which were limited to itemizing required staff with no estimate of monetary cost (McKenzie et al., 2004; Pate et al., 2005; Simon et al., 2008). The fourth study (Werch et al., 2005) provided a total estimated cost of implementation, which was reported as a per participant value.

Maintenance

All studies reported at least one follow-up of the primary study outcomes. Most followed up immediately post-intervention (62%), some within 3 months (16%), and the remaining at least 6 months following the completion of the intervention (6 to 15 months) (22%). Most of the studies reporting significant findings (66.7%) measured PA outcomes immediately following the intervention; however, the length of time between intervention completion and follow-up did not appear to influence measured outcomes, with 50%, 42.9% and 50% of the studies that followed up between 5 weeks and 6 months, 6 months and 12 months, and greater than 12 months post-intervention, respectively, reporting significant differences between experimental and control groups. The current status of the PA intervention was reported in seven studies. Two of these studies indicated that the intervention was not maintained (Bush et al., 2010; Robbins et al., 2006), three reported encouraging initiatives or optimistic feedback regarding maintenance (Pate et al., 2005; Prochaska and Sallis, 2004; Simon et al., 2008), and two reported evidence of the intervention being introduced and/or maintained in various school settings (as of time of individual publication) (Bayne-Smith et al., 2004; Neumark-Sztainer et al., 2003a). No studies reported on the cost of maintenance of the interventions.

Discussion

The RE-AIM reporting criteria were developed to determine both internal and external validity of interventions by addressing five components important for translation of research findings (Glasgow et al., 1999). Based on these criteria, most of the reviewed studies focused on internal validity (e.g., sample size; efficacy; type, frequency, intensity of intervention) rather than on issues of external validity (e.g., the percentage and representativeness of individuals and settings willing to participate in and adopt an intervention; the extent to which various components of an intervention were delivered as intended; costs associated with start-up, delivery, and maintenance).

Reach

Sample size and the characteristics of participants were reported with unanimous consistency across studies; however, factors related to external validity, such as the percentage and representativeness of the participants who were willing to participate in a given intervention, were less frequently reported. The paucity of data regarding representativeness of the study samples raise questions regarding the generalizability of the results to the wider target population and the potential for widespread implementation. Although regular participation in PA is an important goal for everyone, it is especially important for segments of the population that are more likely to experience barriers to active living. For example, ethnicity has been consistently related to PA levels, with non-Hispanic whites being more active than other ethnic groups (Sallis et al., 2000), and low- and medium-socioeconomic status neighbourhoods have reportedly fewer PA resources available than high-socioeconomic neighbourhoods (Estabrooks et al., 2003). Although minorities and other high-risk groups were targeted in a few of the studies, an important key to progress in making permanent changes to routine PA patterns in youth is identifying how and to what extent interventions can be modified or adapted to maximize participation of all populations.

Efficacy/effectiveness

All of the reviewed studies reported intervention outcomes. This consistency was expected since the measured outcomes of PA interventions are the focus of most published studies, and regardless of whether the trial is one of efficacy or effectiveness, positive outcomes are usually intended to be translated into health promotion research (Glasgow et al., 2003). By definition, efficacy trials are those that test the impact of an intervention under optimum conditions and therefore tend to provide one type of setting with expert staff and resources for a defined length of time, and to limit reach to a homogenous population through the use of eligibility and exclusion criteria. Comparatively, effectiveness trials test the impact of an intervention under real-world conditions with participants from a broad population, and are therefore conducted in multiple settings, use existing resources and/or procedures, rely on regular staff to implement the intervention, and are intended to be maintained, assuming there are positive results (Glasgow et al., 2003). For the interventions reviewed herein, the majority of the efficacy trials had durations of less than a school year and they were more likely to measure PA outcomes with objective measures, whereas the effectiveness trials were more likely to be longer than a school year and most of them used self-report or observation techniques to record PA levels. These findings are expected, according to the definitions and objectives of the two types of trials; however, there were no differences between the efficacy and effectiveness trials in terms of study design or intervention setting, and the percentages of trials targeting particular subpopulations were similar for both types. These findings are not consistent with the definitions, suggesting that there is some inconsistency of concepts among researchers with respect to efficacy and effectiveness trials.

A recent systematic review and meta-analysis reported that PA interventions, on average, achieve small to negligible increases in children's and youth's total activity volumes (Metcalf et al., 2012). This is supported by the results of other reviews, which report that interventions to promote PA in youth have been equivocal (Brown and Summerbell, 2009; Dobbins et al., 2009) or ineffective (Atkin et al., 2011). In the present review, the findings regarding intervention efficacy/effectiveness were more promising, with 55.1% of the reviewed studies reporting positive statistically significant differences between experimental and control groups in youth PA levels. Reasons for this could be the broad-based criteria applied to study selection, which did not discriminate based on sample size, intervention duration, or type of PA measured (i.e., overall levels versus school-related activity only),

and allowed for the inclusion of both objectively and subjectively measured outcomes. Furthermore, a few of the reviewed studies did not include a true control group (Marks et al., 2006; Peralta et al., 2009; Ransdell et al., 2003a; Werch et al., 2003; Zizzi et al., 2006). Due to these leniencies, the reviewed studies vary greatly and some had significant limitations (e.g., PA measures of unknown reliability and validity, lack of reporting of mediators of behaviour change), which makes it difficult to compare study outcomes.

Despite introducing a potential moderator of intervention efficacy/effectiveness (i.e., study quality), interventions with less rigorous designs were included in this review as they provide important information regarding potentially promising intervention strategies for promoting PA among youth. Furthermore, the focus of this review was on the quality of reporting across the RE-AIM components, which differentiates it from typical efficacy-based reviews that focus more on study design, validated measures, and statistical analyses. To that end, the degree to which attrition was considered in the follow-up analyses of the studies may have contributed to an overestimation of the positive outcomes. Only 15 of the studies reported using intent-to-treat analyses and therefore analysed data associated with all participants, including those who were lost to follow-up due to adherence or compliance issues. The remaining studies either did not specify ($n = 13$) or limited their study results to those who were present for follow-up assessments ($n = 22$), which introduces potential bias in the generalizability of the findings.

The finding that multi-level school-based interventions are the most successful is in line with other reviews reporting that the incorporation of environmental strategies into school-based PA interventions appears to be more effective than those incorporating curriculum-only approaches (Kahn et al., 2002; Timperio et al., 2004). All of the successful multi-level school-based interventions reviewed herein included both a curricular/instructional component as well as school environmental changes to increase support for PA among students. The instructional components all focused on engaging students in PA during class time (Pate et al., 2005; Sallis et al., 2003; Webber et al., 2008) and/or on enhancing behavioural skills known to influence PA participation (e.g., knowledge, attitudes, beliefs and motivation towards PA) (Dzewaltowski et al., 2009; Haerens et al., 2007; Pate et al., 2005; Simon et al., 2004; Taymoori and Lubans, 2008; Webber et al., 2008). Environmental changes included creating more opportunities for PA (e.g., procurement of PA equipment, promotion of active transportation, establishment of community partnerships) (Haerens et al., 2007; Sallis et al., 2003; Simon et al., 2006; Webber et al., 2008) and educating parents, faculty, staff and/or peers about the importance of social support and modelling (Dzewaltowski et al., 2009; Pate et al., 2005; Simon et al., 2006; Taymoori and Lubans, 2008). These findings suggest that behaviour-specific cognitions as well as environmental factors play an influential role in predicting the PA behaviour of youth, and are consistent with recent literature that highlights the need for school-based promotional efforts that include developing students' knowledge and skills while providing social support for healthy living (Pardo et al., 2013). The mixed results for internet-based and cell phone/computer-tailored advice programmes highlight an area where more research is merited.

Although theory-based PA interventions appear to be more successful than atheoretical approaches in adults (Antikainen and Ellis, 2011), evidence supporting this finding in youth has been cited as less convincing (Lai et al., 2014). The results from the present review contribute to the evidence base that theory-based initiatives are more successful than atheoretical approaches in youth, and identify the SCT as the most commonly referenced theoretical framework. This is consistent with the literature on adult PA correlates, which supports the utility of the SCT (Bauman et al., 2002).

All reviewed interventions targeted PA, eighteen of which also targeted additional behavioural outcomes. Sixteen of these studies targeted dietary behaviour (e.g., dietary fat and sugar intake, fruit and vegetable consumption, calcium intake) (Bayne-Smith et al., 2004; Black et al., 2010; Dzewaltowski et al., 2009; Frenn et al., 2005; Jemmott et al., 2011; Jones et al., 2008; Lindgren et al., 2011; Lubans et al., 2009a; Murphy et al., 2006; Neumark-Sztainer et al., 2010, 2003a; Patrick et al., 2006; Peralta et al., 2009; Prochaska and Sallis, 2004; Schneider et al., 2008; Singh et al., 2006) and two targeted alcohol and drug use in addition to PA (Werch et al., 2003, 2005). Consistent with other systematic reviews (e.g., Brown and Summerbell, 2009), the findings from this review are inconclusive regarding whether it is more effective to target single or multiple behaviour change outcomes.

Adoption

Beyond describing where the study was taking place and the intervention staff who delivered the programme, adoption indicators were almost exclusively absent in the reviewed studies. For the efficacy trials, adoption information may have been considered irrelevant since settings were targeted and/or resources were provided. However, for effectiveness trials, evidence of differential adoption across participating sites is critical for evaluating the adaptability, feasibility and sustainability of a programme.

For both efficacy and effectiveness trials, the adoption rate, when applicable, along with the characteristics of intervention sites that agree to adopt the programme, are of significant interest to future programme development; therefore, future researchers who recruit from schools or elsewhere in the community should report the number of sites that were screened or invited, and include information regarding those settings that delivered the intervention versus those that did not. Reporting these findings and comparisons may highlight characteristics of the intervention design (e.g., resource and expertise requirements) that limit its adoption across a variety of contexts.

Implementation

With regard to intervention duration, the majority of the reviewed studies (48%) were at least 5 weeks but shorter than a school year. Seventeen studies were implemented over longer duration (≥ 1 school year), and nine studies were implemented over a period of time shorter than 5 weeks. Of these three categories, the studies of longer duration (≥ 1 school year) were the most successful, with the majority (76.5%) reporting significant intervention effects on PA levels, such as increased observed PA levels in physical education class (McKenzie et al., 2004) and decreased levels of sedentary behaviours (Neumark-Sztainer et al., 2010) compared with controls. For each of the other intervention length categories (<5 weeks and 5 weeks to <1 school year), approximately 44% of the studies reported significant differences between groups, which suggests that sustained contact over a prolonged period (at least 1 school year) may increase the likelihood of maintaining behaviour change. In contrast to other RE-AIM evaluations of behaviour change interventions (Allen et al., 2011; Antikainen and Ellis, 2011), the majority of the reviewed studies in this evaluation reported information on process evaluation. This type of information contributes to the generalizability of the findings, as it identifies the actual processes that were followed, rather than simply providing a description of an ideal scenario (Antikainen and Ellis, 2011). Ultimately, process evaluations provide the information necessary for modifying programmes in order to maximize efficacy and cost feasibility prior to dissemination (White et al., 2009); however, the cost of delivery was only reported in four of the reviewed studies.

Among the successful multi-level interventions reviewed herein, a common strategy was to have the programme implemented by the school staff themselves without external financial, material or organizational support (Haerens et al., 2007; Webber et al., 2008). These effectiveness trials adapted implementation strategies to local conditions by incorporating key elements of the intervention into existing curricula and through the reallocation of existing resources (McKenzie et al.,

2004; Pate et al., 2005; Simon et al., 2008). By placing an emphasis on building the capacity of the school staff (Dzewaltowski et al., 2009), the success of these interventions may in part be reflective of easier implementation due to the limited reliance on external support.

Maintenance

Consistent with other systematic reviews of PA interventions that used the RE-AIM framework (Allen et al., 2011; White et al., 2009), maintenance was the least reported dimension. Information on the cost of continued delivery and institutionalization of interventions was seldom reported; however, because most studies did not have a goal to achieve and track maintained delivery, these measures were likely considered to be of limited relevance. Future effectiveness trials should be designed with the intention of being maintained in order to determine which setting-level variables facilitate and inhibit the intervention's ability to be institutionalized.

Overall, the reported significant differences in PA levels can only be considered short term benefits due to a lack of follow-up assessments. Only seven of the studies that reported significant outcomes included follow-up measures at least 6 months post-intervention. Optimistically, five of these seven studies (Bronikowski and Bronikowska, 2011; Jemmott et al., 2011; Ortega-Sanchez et al., 2004; Taymoori and Lubans, 2008; Werch et al., 2003) reported that the positive intervention effects were maintained at follow-up, which ranged from 6-months to 15-months post-intervention. At long-term follow-up (greater than 6 months), fewer differences in measured outcomes were significant when compared to immediate follow-up, which indirectly suggests that linking participants to support resources may be beneficial. This potentiality, coupled with the lack of information regarding the institutionalization of interventions, further highlights an area requiring further research. Follow-up greater than 6 months didn't appear to change the outcome, suggesting that maintenance can be measured accurately at this time point.

While this review highlighted that increased reporting of issues related to external validity is required to fully evaluate the comparative utility of PA interventions targeting youth, there are some limitations to our understanding of the mechanisms of the behaviour change under study. In order to develop a comprehensive understanding of the successful elements of PA interventions, inclusion of mediation analyses would be of assistance; however, this was beyond the scope of the current review. This heterogeneity lead to significant variations in reported significant outcomes, and since overall PA levels were rarely reported, it cannot be determined whether or not the participants compensated for higher activity levels during the intervention by reducing their activity outside of the intervention parameters. Finally, while searching for PA studies, there was no consideration of publication bias, and it is possible that not all articles related to the interventions reviewed (i.e., companion papers) were recovered.

Conclusions

Numerous systematic reviews have focused on the efficacy of PA interventions in youth; however, many have commented on the potential lack of generalizability of their findings (e.g., Camacho-Miñano et al., 2011; Kriemler et al., 2011; van Sluijs et al., 2011). To address the identified gap between research findings and their application in real-world settings, this review used the RE-AIM framework to expand the assessment of interventions beyond efficacy. To the best of the authors' knowledge, this is the first review of PA interventions in youth conducted using the RE-AIM framework.

In conclusion, results of this RE-AIM review emphasize the need for researchers to tailor their designs of future PA interventions in youth to be able to report on elements of both internal and external validity. For all of the reviewed studies of PA interventions, there was a shared focus on reporting internal validity factors, and a shared underreporting of adoption, implementation and maintenance indicators. In order for health promoters, schools and policy makers to successfully promote regular PA in youth, interventions need to be designed so that they are easy to implement, are cost-effective, and are likely to be maintained. The data provide evidence that interventions should be at least 1 year in duration, include follow-up measures at 6 months, and employ teacher-delivered, school-based strategies combining social environmental approaches with instructional-based lessons. However, due to under-reporting of the costs associated with the research process from recruitment through to implementation, adoption rates, and maintenance, there is not currently enough information to identify what will maximize efficacy/effectiveness of an intervention while being cost effective and time effective.

Conflict of interest statement

The authors declare that there are no conflicts of interest.

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