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Pediatric Obesity/Behavioral Intervention

Interventions to increase physical activity in children 0–5 years old: a systematic review, meta-analysis and realist synthesis

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Summary

Objective: The objective of the study is to evaluate the effectiveness of interventions to increase physical activity (PA) in 0–5 year olds and to determine what works, for whom, in what circumstances.

Design: Systematic review, meta-analysis and realist synthesis.

Data sources: Embase and EBSCOhost (Academic Search Complete, CINAHL Complete, Global Health, MEDLINE Complete, PsycINFO, SPORTDiscus with full text), up to and including April 2017.

Eligibility criteria: Published in a peer-reviewed English language journal; randomized or controlled trial design; aimed to increase children's PA levels; reported on objectively assessed PA in children between 0 and 5.9 years at baseline and post-intervention.

Results: Thirty-four studies were included in the review, mostly conducted in the preschool/childcare setting. Meta-analyses showed an overall non-significant ($Z = 0.04$, $p = 0.97$) mean difference of 0.03 (95% CI = −1.57, 1.63) minutes/day for light-intensity PA ($n = 11$). The overall mean difference for moderate-intensity to vigorous-intensity PA ($n = 21$) was 2.88 (95% CI = 1.54, 4.23) minutes/day, indicating a small but significant overall positive effect ($Z = 4.20$, $p < 0.001$). The realist synthesis provided insights into the key contexts and mechanisms that appeared to be effective at changing children's PA.

Conclusion: Based on a quantitative and qualitative examination of the evidence, this review provides specific recommendations for effective early childhood PA interventions for practitioners and policymakers.

Keywords: physical activity, meta-analysis, realist review, early childhood.

Introduction

A growing body of research suggests that physical activity participation in early childhood (birth through 5 years of age) is important for health (1). Previous observational and experimental research has found that greater physical activity participation is associated with more favourable bone density, cardiovascular profiles, body composition and cognitive outcomes (2,3). Further, the early childhood period represent a period of time which is important for establishing healthy behaviour patterns, which may persist into middle childhood (4) and even early adulthood (5). Yet, despite the evidence for the importance of sufficient physical activity participation during this time, recent research suggests that many young children may not be active enough for optimal health benefits. Some studies suggest that young children's objectively assessed physical activity may be as low as 4% of the day (6). Assuming a 13-h waking day for a young child (7), this falls below the guideline of 180 min of light, moderate or vigorous-

intensity physical activity (LMVPA) per day recommended by government bodies internationally (8–10).

Over the past decade, many intervention programs have been implemented in an attempt to increase young children's physical activity levels. These interventions have predominantly been conducted in the home or childcare-based settings. Since 2010, six reviews synthesizing evidence from early childhood physical activity interventions have been published (11–16). Four of these reviews were focused solely on the childcare setting (11–14). The most recent of those reviews (in 2016) reported significant increases in children's physical activity for those interventions which included structured activity, were delivered by experts and used theory in planning and implementation (11). The remaining two reviews were inclusive of any setting (childcare and home/community) (15,16), and one (15) also included a meta-analysis. Small to moderate effect sizes were observed in this latter review; however, only studies published up to 2011 were included (15). Given the rapid growth of research in this domain within the past 6 years, an updated, comprehensive review across all settings is necessary.

An important concept to consider when reviewing evidence on physical activity interventions is that human behaviour (in this instance, children's physical activity) is highly complex and involves a multi-dimensional system of interconnected parts (17). Given this complexity, what works to increase physical activity in one context may not necessarily be indicative of what will work in another context, making overall synthesis of findings challenging (18). Traditional systematic reviews and meta-analyses, such as those published to date, when conducted on their own, do not reflect this heterogeneity; that is, they consider only the overall outcomes. However, the concept of realism addresses this challenge by examining how contextual factors influence outcomes through mechanisms (19). Realist reviews are a relatively new approach to synthesizing public health literature and seek to identify the *contexts* which trigger a *mechanism*, resulting in a change in the *outcome* of interest (19). By identifying these context-mechanism-outcome (CMO) configurations, one is able to understand *how and why, and in what circumstances* a particular intervention works. This is particularly useful for researchers and policymakers looking to implement physical activity programs within their community. Realist reviews have been used previously in disciplines such as health service delivery (20), medical education (21) and school feeding programs (22) and most recently have been applied to understanding family-based physical activity interventions in primary school children (23).

The present review takes a dual approach to evaluating the current literature on studies aiming to increase physical activity in early childhood. Findings from the meta-analyses will determine the overall effectiveness of the interventions conducted to date, whilst the realist review will provide evidence on 'what works, for whom, why, and in what circumstances'. Considered together, this review will provide a comprehensive evidence synthesis of interventions to increase physical activity in children between birth and 5 years of age.

Methods

This review is registered with PROSPERO International Prospective Register of Systematic Reviews (No.: CRD42016038743).

Search strategy and screening procedures

A systematic search of studies published up to, and including, April 2017 was conducted in Embase and EBSCOhost (including Academic Search Complete, CINAHL Complete, Global Health, MEDLINE Complete, PsycINFO, SPORTDiscus with full text). Table 1 outlines the search strategy applied. Reference lists of included articles were also searched to identify any additional papers not picked up by the database search.

A research assistant (RA) performed title screening of all papers identified through the search. Two individuals (RA and JAH) screened the abstracts of remaining papers. Manuscripts were excluded when both authors agreed that they did not meet the inclusion criteria. Full texts of the remaining abstracts were then screened by the same two individuals in the same manner described in the preceding texts for the abstracts. No papers from the abstract screening stage required a third reviewer, but three papers from the full-text review were taken to the other members of the research team for consideration (KLD, KDH, TH).

Table 1 Search strategy used in review

Search	Search terms
1.	"physical* activ*" OR "active play" OR "active transport" OR "active games" OR sport* OR "motor activit*" OR "locomotor activit*" OR accelerom*
2.	infan* OR baby OR babies OR toddler* OR "young child*" OR child* OR "early childhood" OR "early years" OR preschool* OR pre-school*
3.	Intervention* or trial or "randomi*ed controlled trial" OR "controlled trial" OR RCT OR "primary prevention" OR strategy OR program* OR experiment* OR quasi
4.	1 AND 2 AND 3

Inclusion criteria

To be eligible for inclusion in the review, studies had to meet the following criteria:

- Be published in a peer-reviewed English language journal;
- Followed a randomized or controlled trial design and aimed to increase children's physical activity levels;
- Reported on objectively assessed physical activity as an outcome measure in children who were between 0 and 5.9 years old at both baseline and post-intervention (mean age ≤ 5.9 years);

Data extraction

A research assistant extracted the following data from the included papers: authors; sample characteristics (including age, sex and any other distinguishing characteristics if noted in the paper [including, socio-economic status, ethnicity, weight status]); study design, setting and duration of intervention; intervention strategies employed; description of control group; physical activity measurement tool; and results. Ten per cent of studies were checked by JAH for quality assurance.

Risk of bias

Risk of bias screening was completed independently by three members (JAH, KDH, TH) of the research team using a modified version of the National Collaborating Centre for Methods and Tools' Quality Assessment Tool for Quantitative Studies (24). Consistent with previous research (25), six methodological components of the included papers were assessed. These included selection bias (e.g. sample representativeness), study design (e.g. RCT), confounders (e.g. controlling for baseline differences between groups), blinding (e.g. whether the outcome assessor and/or participants were aware of group allocation), data collection methods (e.g. validity of tool(s) to measure physical activity) and withdrawals and dropouts (e.g. whether withdrawals were reported in terms of numbers and/or reasons). Each of these six sections was scored as 'weak', 'moderate' or 'strong' in accordance with the risk of bias screening tool; no overall rating was provided as per recommendations in the Cochrane Handbook for Systematic Reviews of Interventions (26). Inter-rater reliability of initial scoring was 68–79% (κ = 0.46–0.63). Discrepancies in scoring were discussed by the research team until a consensus was reached.

Meta-analysis

The meta-analysis was conducted using Review Manager 5.3. All manuscripts that reported light-intensity physical activity (LPA) or moderate-intensity to vigorous-intensity physical activity (MVPA) in minutes/day, or provided sufficient information in the manuscript for it to be calculated by the authors, were included. Given that few studies reported total physical activity (i.e. LMVPA), LPA and MVPA were examined as separate outcomes. The mean difference and standard error between intervention and control groups, as well as the sample size for both groups, were entered into Review Manager. Where the mean difference and standard error were not reported directly in the manuscript, they were calculated using Stata 14. A random-effects model was utilized for the meta-analysis. Heterogeneity was determined by examining the I^2 and Q statistics, provided as an output by Review Manager. For MVPA only (due to limited data for LPA), post hoc subgroup analyses were performed to examine differences by intervention settings (preschool vs. preschool + home/community vs. home/community only).

Realist review

The realist review was conducted following the RAMESES procedures (27). Initially, a program theory was developed a priori at round-table meetings of all authors. This involved iterative discussion of all possible context-mechanism-outcome (CMO) configurations that may influence physical activity in those aged 0–5 years old, continuing until a consensus was reached. For example, authors considered how contextual factors (e.g. child's sex, parents' education, neighbourhood physical environment barriers) might influence children's physical activity, through mechanisms (e.g. a change in parent or carer physical activity supportive practices, or a change time spent outdoors). This was then used as the framework against which the intervention studies were compared.

To maximize the data available for analysis in the realist synthesis, any 'sibling' papers published from the same interventions that explained 'how' the intervention may have 'worked' (e.g. mediator papers) were retrieved. They were included in the review if they reported details about the intervention that contributed to theory building, over and above what was provided in the main outcomes paper. Sibling papers were identified using references cited in the main outcomes papers, as well as by conducting searches of the study name (e.g. SHAPES) and the lead or final author's name in the same databases described in the preceding texts. This resulted in 15 sibling papers (28–42) retrieved across 10 interventions (43–52).

One research assistant experienced in analysing qualitative data was responsible for coding all papers. All papers were double-checked by JAH to ensure accuracy and consistency. Data (i.e. written text) were collected from the methods, results and discussion sections of each manuscript when they met the criteria for 'relevance' (i.e. if the text

contributed to theory building and/or testing) and 'rigour' (i.e. if the method used to generate that data is credible and trustworthy) as outlined in the RAMESES procedures (27). Consistent with previous research (23), text that hypothesised why the outcome occurred, but did not statistically test it, was considered. Where a study reported more than one physical activity outcome, it was considered to have a positive effect if at least one of the outcomes was significant.

Data from all available papers were then mapped against the program theory for each intervention. Separate models for each intervention were generated by the research team by reading through the full manuscript and coding manuscript text whenever a statement was made by the authors of the paper that identified a particular context or mechanism that was relevant to or explained physical activity behaviour change (or lack thereof). Any new contexts and mechanisms identified through reviewing the manuscripts were added to the original model. A final, comprehensive program theory synthesizing results from each intervention was generated and agreed upon by all members of the research team.

Results

Description of studies included in review

A total of 34 studies met in the inclusion criteria for the review (see Table S1 for a summary of studies). A flow chart of interventions included at each stage of the review is outlined in Fig. 1. Studies included in the review were predominantly from the USA (n = 17), with studies from Australia (4), the UK (3), Belgium (2), Canada (2) Germany (2), Netherlands (1), New Zealand (1), Switzerland (1) and Chile (1) also included. The majority of studies (n = 25) followed a cluster RCT design. Sample sizes of studies ranged from 18 to 885, and the majority (n = 30) were conducted with children between 3 and 5 years of age. Sixteen included studies were based in the childcare or preschool setting only, 11 were conducted in the preschool/childcare setting but included a home component, and 7 were conducted in the home or community setting only. The majority of studies did not explicitly state whether they were targeting LPA or MVPA or both; however, from examination of the intervention strategies, it appeared that most targeted MVPA, or both LPA and MVPA, rather than LPA only.

Table 2 summarizes key characteristics of the studies. Nineteen studies (55.9%) showed a positive effect on at least one measure of physical activity. Most studies in the review focused on targeting education or skill building rather than role modelling, goal setting or modification of the physical environment. Regardless of the context, most studies (n = 22) targeted changes in parent or provider practices as the mechanisms to increase children's physical activity.

Study quality

Table 3 outlines the results from the risk of bias assessment. Nearly all studies were scored as strong for study design and data collection methods, and about three-quarters were rated as strong for withdrawals and dropouts, and confounders. Most studies were rated as moderate quality for blinding and approximately half were scored as weak for selection bias.

Meta-analysis

Of the 34 studies included in the review, 11 studies (45,50,51,53–58,66) representing 1122 control and 963 intervention participants were included in the meta-analysis for LPA. Twenty-one studies (44,45,48–61,66–68,73) representing 3063 control and 2226 intervention participants were included for MVPA. Heterogeneity of studies was high (I^2 = 92% LPA; I^2 = 97% MVPA). The overall mean difference of LPA minutes/day was 0.03 (95% CI = −1.57, 1.63); this was not statistically significant (Z = 0.04, p = 0.97). The overall mean difference of MVPA minutes/day was 2.88 (95% CI = 1.54, 4.23), indicating a small but statistically significant overall positive effect (Z = 4.20, $p < 0.001$). Figure 2 displays forest plots of the meta-analysis results for LPA and MVPA.

Subgroup analyses showed that interventions conducted in the preschool setting only (mean difference: 2.91 [1.87, 3.94] minutes/day; Z = 5.52, $p < 0.001$) and conducted in the preschool setting including a parental component (mean difference 2.93 [0.43, 5.43] minutes/day; Z = 2.29, $p < 0.05$) were both effective at increasing children's MVPA. Too few studies reported physical activity outcomes from studies conducted in the home/community setting to examine differences in outcomes by this subgroup. A lack of variability in settings precluded the examination of subgroup analyses by setting for LPA.

Realist synthesis

All studies included in the review were considered for the realist synthesis; however, only 13 studies (44,45,47,51,57,58,61–63,66,69,70,74) provided contextual or mechanistic information at a level considered 'relevant' and 'rigorous'. Nearly all of these findings were attained from the main outcomes paper rather than any sibling papers acquired. Three additional factors identified through coding were not included in the original program theory. These included 'incentives', 'family/centre constraints experienced during the delivery of the program'

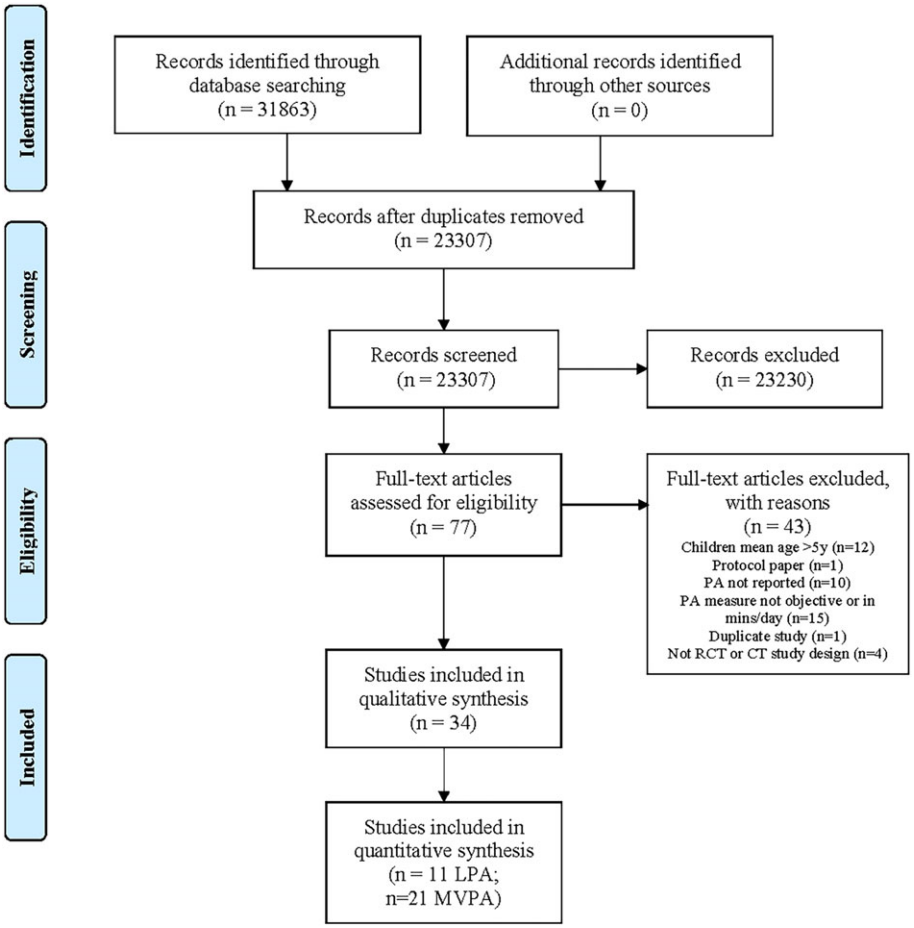

Figure 1 PRISMA statement flow chart. [Colour figure can be viewed at wileyonlinelibrary.com]

and 'interventionist/provider relationship'. The contexts in which the interventions were conducted were highly varied; however, the findings from these papers demonstrated some key outcome patterns which are highlighted in the final program theory model (Fig. 3).

'Tailoring' appeared to be the strategy or approach most consistently associated with improvements in children's physical activity. This included tailoring in the form of providing ongoing support to address current challenges to those delivering the program, as well as modifying materials to suit the target group (e.g. consideration of cultural practices). For example, when childcare centres experienced challenges implementing new practices, providing ongoing support to address context-specific barriers (tailoring) was effective at changing staff practices and subsequently child physical activity (61). Additionally, modifying materials to suit the local community, and drawing on community expertise and needs, appeared to be effective at improving children's physical activity (44).

In the context of the childcare setting, the method by which an intervention was delivered was important for increasing staff knowledge and changing social culture. More specifically, the 'hands-on' workshops (i.e. where staff had an opportunity to practice running physical activities for children) offered through some interventions appeared to increase childcare staff's knowledge regarding children's physical activity (57) whilst the use of structured sessions for delivery of content was effective at changing the social culture of the childcare centre (62). Practices became more 'routine' and incorporated into regular curriculum.

A number of studies attempted to change the practices of parents or providers. The realist review identified that doing so was effective at increasing children's physical activity but only when parent/provider practices were demonstrated to have actually improved (61,66,69).

Differences in intervention effects were demonstrated for two demographic characteristics, sex of the child and socio-economic position indicators (45,51). In one study, intervention group boys engaged in more VPA and MVPA, while intervention group girls engaged in more total PA and LPA (45). In a second study, higher MVPA levels were observed amongst girls only (51). Children from low

Table 2 Key characteristics of studies (n = 34) included in the review

Characteristic	Proportion of studies N (%)	Citations	Favoured intervention N (%)
Setting			
Childcare/preschool setting only	16 (47%)	(47,50,51,53–65)+	10 (63%)
Childcare/preschool setting + home	11 (32%)	(44,45,48,52,66–72)+	8 (73%)
Home/community only	7 (21%)	(43,46,49,73–76)+	1 (14%)
Intervention duration*			
<4 weeks	2 (6%)	(54,55)	1 (50%)
4 to <8 weeks	3 (9%)	(56,58,75)+	1 (33%)
8 to <16 weeks	6 (18%)	(48,50,60,61,68,69)+	5 (83%)
16 to <25 weeks	6 (18%)	(45,47,57,70,71,76)+	3 (50%)
≥25 weeks	16 (47%)	(43,44,46,49,51–53,59,62–67,73,74)+	8 (50%)
Not stated	1 (3%)	(72)	1 (100%)
Intervention focus			
Physical activity only	19 (56%)	(46,50–62,64,65,67,69,71)+	12 (63%)
Multiple health behaviours	15 (44%)	(43–45,47–49,63,66,68,70,72–76)+	7 (47%)
Intervention facilitator (delivery to children)^			
Childcare staff member	23	(45,47,48,51–67,70–72)+	15 (65%)
Parent	11	(43,44,46,49,68,69,71–75)+	5 (45%)
External provider	3	(44,58,76)+	1 (33%)
Not stated	1	(50)	1 (100%)
Intervention delivery mode			
Face-to-face group workshop/meeting/training	27	(43–45,47–49,51–54,57–62,64–73,76)+	16 (59%)
Online	1	(44)+	1 (100%)
Print materials	18	(43–46,48,49,51,52,59,63,65–69,72,73,75)+	12 (67%)
CD	3	(48,68,71)	2 (67%)
One-on-one appointment/visit	2	(46,73)	0 (0%)
Telephone coaching	1	(49)	0 (0%)
Intervention strategy applied^			
Education	27	(43,45,48,49,51–54,57–69,71–76)+	17 (63%)
Goal setting	5	(49,59,60,69,73)+	3 (60%)
Skill building	18	(43,45–47,49,51–53,57,59–63,67,70,73,76)+	9 (50%)
Role modelling	9	(43,45–47,49,51,52,62,69)+	4 (44%)
Monitoring	11	(47,48,51,56,59–62,69,73,75)+	7 (64%)
Modification of the physical environment	7	(45,47,51,56,62,67,70)+	2 (29%)
Tailoring	16	(44,45,48,49,51,52,57,61–66,68,69,76)+	11 (69%)
Received PA monitor (pedometer)	2	(73,75)	1 (50%)
Incentives	3	(47,49,69)+	1 (33%)
Modification of policies	1	(55)	0 (0%)

*Percentages may not equal 100% due to rounding.
^Some studies included more than one facilitator, delivery mode or intervention strategy.
+Study included in the realist review.

socio-economic regions showed fewer positive changes in LPA and MVPA compared with children from mid or high socioeconomic regions (45). There was no evidence from the manuscripts that explained why this might be the case.

Four studies reported that the intervention dose was insufficient to impact on children's physical activity or on any of the mechanisms targeted (47,58,70,74). Three of the studies cited insufficient frequency or duration of intervention sessions (four group sessions for parents over 18 months (74); 60-min physical activity session for children once a week (58); 15–20-min physical activity session 4 days per week (70)), and the other postulated the short duration of the intervention program (4 months (47)) Despite education being the most commonly targeted mechanisms across most contexts, there was no evidence that this strategy was effective at changing children's physical activity levels.

Discussion

This review aimed to synthesize evidence of the effectiveness of interventions to increase physical activity in 0–5-year-old children. It included a meta-analysis to determine the overall effectiveness of interventions conducted to date, as well as a realist review to explore the notion of 'what works, for whom, why and in what circumstances'. Taken together, the findings from this review provide a comprehensive

Table 3 Methodological quality for studies (n = 34) included in the review

Study	Selection bias	Study design	Confounders	Blinding	Data collection methods	Withdrawals and dropouts
Alhassan (2007) (55)	Weak	Strong	Strong	Moderate	Strong	Strong
Alhassan (2012) (53)	Weak	Strong	Strong	Moderate	Strong	Strong
Alhassan (2013) (54)	Weak	Strong	Strong	Moderate	Strong	Strong
Alhassan (2016) (66)	Weak	Strong	Strong	Moderate	Strong	Strong
Annesi (2013) (56)	Moderate	Strong	Strong	Moderate	Strong	Weak
Annesi (2013) (57)	Strong	Strong	Strong	Moderate	Strong	Strong
Bellows (2013) (69)	Weak	Strong	Strong	Weak	Strong	Moderate
Bonis (2014) (63)	Weak	Strong	Strong	Moderate	Strong	Weak
Bonvin (2013) (62)	Strong	Strong	Strong	Moderate	Strong	Strong
Campbell (2013) (43)	Strong	Strong	Strong	Moderate	Strong	Strong
Cardon (2009) (58)	Moderate	Strong	Weak	Moderate	Strong	Strong
Chow (2016) (59)	Moderate	Strong	Weak	Moderate	Strong	Strong
Cottrell (2005) (77)	Weak	Strong	Weak	Weak	Strong	Weak
De Bock (2013) (44)	Strong	Strong	Strong	Moderate	Strong	Moderate
De Craemer (2014) (45)	Weak	Strong	Weak	Moderate	Strong	Weak
De Vries (2015) (46)	Moderate	Strong	Strong	Moderate	Weak	Strong
Finch (2014) (47)	Strong	Strong	Weak	Moderate	Strong	Weak
Fitzgibbon (2011) (48)	Strong	Strong	Strong	Weak	Strong	Strong
Fitzgibbon (2013) (70)	Strong	Strong	Strong	Weak	Strong	Strong
Goldfield (2016) (60)	Moderate	Strong	Weak	Moderate	Strong	Strong
Harvey-Berino (2003) (78)	Moderate	Strong	Strong	Moderate	Strong	Strong
Jones (2011) (68)	Strong	Strong	Weak	Moderate	Strong	Strong
Jones (2016) (67)	Moderate	Strong	Strong	Moderate	Strong	Moderate
Moir (2016) (79)	Weak	Strong	Weak	Moderate	Strong	Strong
O'Dwyer (2012) (80)	Weak	Strong	Strong	Moderate	Strong	Strong
O'Dwyer (2013) (73)	Weak	Strong	Strong	Strong	Strong	Strong
Ostbye (2012) (49)	Weak	Strong	Strong	Moderate	Strong	Moderate
Palmer (2016) (50)	Weak	Strong	Weak	Moderate	Strong	Weak
Pate (2016) (51)	Weak	Strong	Strong	Moderate	Strong	Moderate
Reilly (2006) (74)	Weak	Strong	Weak	Moderate	Strong	Strong
Roth (2015) (52)	Moderate	Strong	Strong	Strong	Strong	Strong
Salazar (2014) (81)	Moderate	Strong	Weak	Moderate	Strong	Weak
Stark (2010) (82)	Weak	Strong	Weak	Moderate	Strong	Strong
Trost (2008) (61)	Moderate	Strong	Strong	Moderate	Strong	Strong

evaluation of the present literature that can be used by policymakers, practitioners and researchers aiming to increase young children's physical activity.

Overall, a small but statistically significant positive effect was found for interventions targeting increases in children's MVPA, while no evidence of effect was observed for changing their LPA. A previous meta-analysis of physical activity interventions for preschool children found a small to moderate effect on total physical activity and a moderate effect on MVPA (15). Although it is not possible to conclusively explain why stronger effects are seen for MVPA, it is possible that this may occur because most interventions to date have focused on developing programs with physical activities that are of an intensity that would foster changes in MVPA rather than LPA or total physical activity (e.g. activities in the form of outdoor active play, structured gross movement sessions in childcare settings). Alternatively, it is possible that LPA was analysed in many studies as a secondary outcome measure, given that there is more evidence for the health benefits of MVPA compared with LPA at the present time (1). This finding suggests that those individuals wanting to impact children's LPA may need to consider targeting reductions in sitting time (e.g. replacing typical sitting activities or environments with opportunities for children to stand and move around freely) rather than the provision of specific active play opportunities. However, a recent meta-analysis found that interventions targeting physical activity were more effective at reducing children's objectively measured sedentary time than those specifically targeting children's sedentary time (25). Given the small number of studies included in both meta-analyses, it is possible that these findings may be a reflection of the individual studies that were included in each review. Nonetheless, efforts to promote physical activity to date appear to be efficacious, although hindered by small overall effects, potentially due to the high heterogeneity reported across studies. For example, positive, negative and null findings of individual studies may attenuate the results of meta-analyses. Hence, the realist review process is a

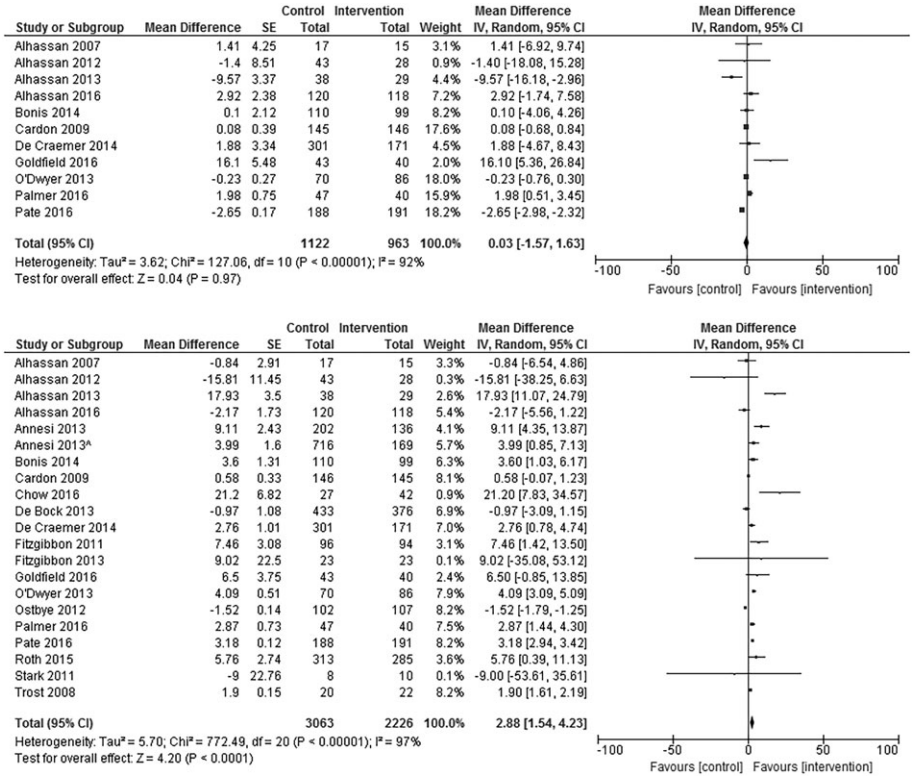

Figure 2 Forest plot of the mean overall difference (95% CI) of LPA (top) and MVPA (bottom) for each study included in the meta-analysis.

welcome addition to meta-analyses when synthesizing literature.

Intervention approaches supported by evidence from the realist review

A few key intervention approaches were supported by evidence from the realist review. The findings highlighted the importance of tailoring for increasing young children's physical activity participation. In the studies examined, tailoring took a variety of forms, including the consideration of cultural and community needs. This is consistent with key health promotion principles (81), and provides empirical evidence for the efficacy of this approach when targeting increasing physical activity participation in young children. Interestingly, similar findings were observed in a recent realist review focused on examining family-based interventions to increase physical activity in primary school-aged children (23), suggesting that tailoring should be a crucial component for researchers and practitioners to consider prior to developing and implementing any physical activity initiative within their population group of interest.

In the context of the childcare setting, providing materials that are structured in nature and designed in a way that can be easily worked into daily routines may be important for changing children's physical activity (57). It is likely that seeking input into the proposed program early from childcare centre staff, as well as pilot testing materials with those involved, would be the most efficacious mechanism for achieving this. Additionally, evidence from our realist review suggests that ensuring any workshops delivered to childcare staff provides opportunities for hands-on experience is important for intervention success. It may in fact be that these hands-on opportunities differentiate those programs that purport to build staff skills in promoting physical activity to children, from those that actually do so. These strategies, combined with ongoing support provided in the form of tailoring to address challenges that arise during program implementation (61), may result in the best chance of changing young children's physical activity.

There was very little evidence that could be synthesized for interventions conducted in the home setting, largely because few studies have been conducted to date that focused on this setting specifically. Nonetheless, from the evidence that was available from these studies and those including both a preschool and home component, it was found that changing parent or provider practices (e.g. incorporating movement opportunities into the day) was effective at changing children's physical activity, but only when parent or provider practices were reported to be *actually* changed

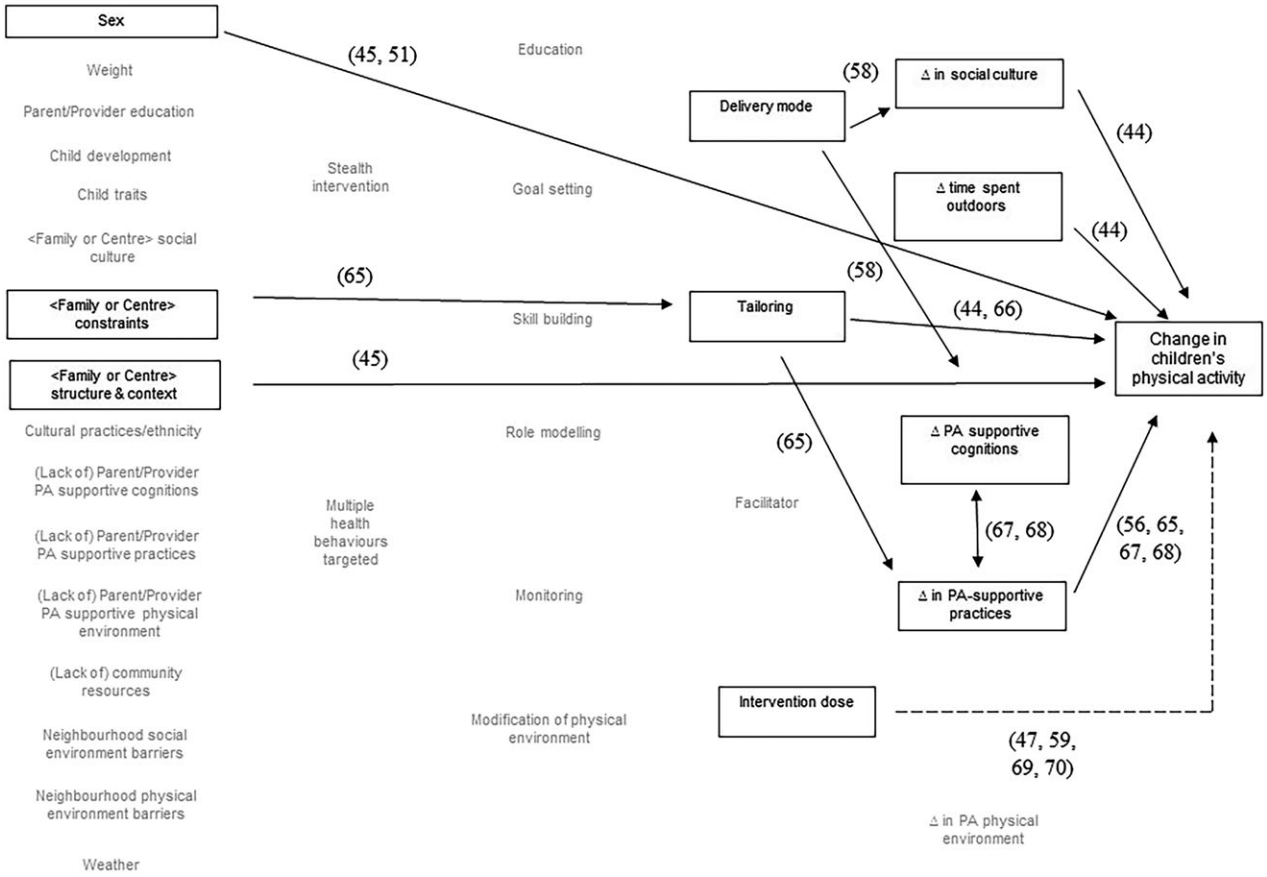

Figure 3 Results of the final program theory with references. *Dashed line denotes evidence that intervention dose was insufficient to increase children's physical activity levels.

through the intervention. This is consistent with previous longitudinal work suggesting that parents and providers play an important role in children's physical activity levels (77,80), and highlights the need for programs that can effectively reach and change behaviour of the targeted adult population. Given that few intervention programs in early childhood report on mediating factors and/or changes in the targeted constructs (e.g. parent practices) post-intervention, it is challenging to discern why, in some intervention programs, parent or provider practices would be effectively changed while others not. It is possible that the differences in effectiveness of changing provider practices may result from the context in which the proposed program is being developed (e.g. the receptivity of parents to the intervention ideas of increasing physical activity) (78), the intervention design (i.e. intervention not effectively designed to elicit a change in parent practices) and/or a lack of reporting of this information in manuscripts. Therefore, future work should ensure that the context of the study and study participants are considered and reported in detail, and that the targeted constructs are measured and evaluated, in order to potentially help explain intervention outcomes in the sample group.

Intervention approaches not supported by evidence from the realist review

There were also notable findings regarding why interventions were *not* effective at changing children's physical activity. Despite being the most commonly targeted across many contexts (17 out of 27 studies), there was no evidence to suggest that educational strategies alone were effective at changing mechanisms or young children's behaviour. This echoes previous family-based intervention research focused on primary school aged children (23). We also did not find evidence that educational approaches coupled with other intervention targets were particularly effective.

Several studies included in the realist review mentioned the intervention dose as insufficient to impact on mechanisms or elicit a change in children's physical activity (47,58,70,74). Two of the studies reported this in terms of the number of daily sessions of physical activity required

(58,70) and the other discussed the short duration of the intervention program (47). A previous systematic review on sedentary behaviour interventions in early childhood supports this latter finding, as it identified that longer term interventions (i.e. ≥6 months in duration) were more effective than shorter duration interventions (i.e. <6 months in duration) (25). All of these studies that reported on insufficient intervention dose in this study varied in context; no clear determination about the most effective intervention dose in certain contexts could be ascertained from the data collected.

Intervention approaches with limited evidence available

A few noteworthy contexts and mechanisms were frequently absent in studies. These included incorporating goal setting, role modelling and monitoring strategies and aiming to implement changes to the physical environment. Parental goal setting was shown to be an effective intervention approach in a previous realist review focused on family-based intervention strategies (23) and parental monitoring in a recent review on determinants of children's physical activity (79). However, it is possible that because the majority of our evidence was drawn from research conducted in the childcare setting, goal setting may be a less efficacious and/or less feasible strategy in this context. Alternatively, perhaps these are strategies that should be more frequently implemented in intervention programs for preschool children to be able to evaluate their efficacy.

Finally, few studies aimed to change the physical environment as a mechanism of increasing children's physical activity. Some previous cross-sectional work has demonstrated a positive association between aspects of the physical environment and children's physical activity (82), although the efficacy of the association between characteristics and change in children's physical activity is less well established (79). It would be advantageous for research to investigate environmental change where possible in future work.

Strengths and limitations

Key strengths of this review include the comprehensive nature of the combined systematic review, meta-analysis and realist review, and the examination of both children's LPA and MVPA. However, it is not without limitations, based on the studies available for inclusion in the review. All studies were drawn from high-income countries and published in English language journals. Thus, findings may not be applicable internationally. Additionally, the large proportion of studies rated as 'weak' in the risk of bias assessment and the fact that not all studies could be included in the meta-analysis may have impacted the results. Lastly, whilst the realist review has synthesized the evidence base at present, it has highlighted the dearth of information available on how and why intervention programs might have 'worked' (or not). Results, although indicative of the extant evidence, should be interpreted with caution until a larger volume of studies are available.

Recommendations and conclusions

This study evaluated the current evidence base around increasing physical activity in children age 5 and under. Overall, a small, positive intervention effect was observed for children's MVPA, with no effect observed for their LPA. Based on the findings from the realist review, we put forth the following recommendations for practitioners and policymakers:

1. Interventions should be tailored to the target group of parents or care providers, in particular in the form of cultural considerations, community needs and the provision of ongoing support.
2. In the context of the childcare setting, the delivery of structured physical activity sessions that can be easily incorporated into the daily 'routine' and are delivered through a hands-on approach may be most effective at increasing children's MVPA.
3. Programs should focus on changing parent or provider practices to affect change in children's physical activity levels, and also on measuring changes in parent or provider behaviour, to help elucidate the impact of those behaviours on children's physical activity.

Conflict of interest statement

The authors have no conflicts of interests to declare.

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Supporting information

Additional supporting information may be found online in the Supporting Information section at the end of the article. https://doi.org/10.1111/obr.12763

Table S1: Summary of studies included in review[#]

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