



Review Article

A systematic review of the intervention characteristics, and behavior change theory and techniques used in mother-daughter interventions targeting physical activity

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ABSTRACT

Growing gender disparities in levels of physical inactivity put women and female youths at a greater risk of associated health problems. Mother-daughter interventions have been proposed as means to promote physical activity in this at-risk cohort. However, there is a lack of clarity as to if and why these types of interventions might be effective. This systematic review examined the intervention characteristics, and behavior change theory and techniques used in these interventions to promote physical activity for mothers and daughters. PubMed, EMBASE, PsycINFO, CINAHL and Cochrane Library (Wiley) databases were searched for English language studies from inception to 13th May 2020. Interventions of any design that targeted daughters and mothers' physical activity were included. Data was extracted using the Template for Intervention Description and Replication (TIDieR) checklist, and the Behavior Change Technique (BCT) Taxonomy v1. 4962 articles were screened and 11 unique studies met the inclusion criteria. The risk of bias in studies was generally high. Narrative summary highlighted that many studies used social cognitive theory as a theoretical foundation, were based in the community and less than three months in duration with multiple sessions per week. Thirty-seven behavior change techniques were identified across studies. Some techniques were deemed potentially effective including *credible source*, *information on the health consequences of the behavior* and the self-regulatory techniques of *goal-setting*, *self-monitoring* and *problem-solving*. Future research should consider the use of the TIDieR guidelines and BCT Taxonomy v1 to improve the quality of information for intervention development, implementation, and reporting phases.

1. Introduction

In recognition of the well-established health benefits of physical activity (PA), the World Health Organisation has set the objective of a 15% reduction in global levels of physical inactivity by 2030 (Bull et al., 2020). Unfortunately, worldwide, 27.5% of adults (Guthold et al., 2018) and 81% of adolescents (Guthold et al., 2020) do not meet the recommended PA guidelines, with levels of insufficient PA higher amongst women than men (Guthold et al., 2018). Worryingly, the gap between girls' and boys' levels of physical inactivity is widening, for example, in Ireland, there is a 17% difference in the prevalence of insufficient PA when comparing boys and girls in 2016. And this difference has increased from 10% in 2001 (Guthold et al., 2020). These gender

disparities put women and female youths at greater risk of developing or exacerbating adverse health consequences linked to physical inactivity (Hallal et al., 2012). Designing effective strategies to increase PA in women and girls is therefore a matter of public health priority.

The factors influencing adult and youth PA are multi-dimensional, occurring at intrapersonal, interpersonal and environmental levels (Bauman et al., 2012). One such interpersonal factor is familial influence which plays a central role in the development of lifestyle behaviors (Jago et al., 2010; Rhodes et al., 2020b). For example, parental support is positively correlated with child PA (Gustafson and Rhodes, 2006; Jago et al., 2010), while children and parents have shown positive associations in their respective PA patterns (Petersen et al., 2020; Uijtdewilligen et al., 2017). There is inconsistency however, in the literature

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regarding the specific impact of maternal PA on their child's level of activity, with some studies identifying a positive association (Fuemmeler et al., 2011; Sigmundova et al., 2020) and others reporting a weak association (Petersen et al., 2020), or no significant relationship between mother-daughter levels of PA (Barnes et al., 2015). Consequently, there is a need for further research to examine the relationship between mother and daughters' PA (Brunet et al., 2019).

Increasingly, family-based interventions have been identified as a method of improving PA behavior (Brown et al., 2016). However, the effects of these interventions are again inconsistent with some studies reporting an increase in the PA of mothers and daughters (Barr-Anderson et al., 2014) whereas others do not (Ransdell et al., 2001). This inconsistency may be due in part to poor study design, with a lack of clarity of the behavior change components included within these studies. A recent systematic review of mother-daughter interventions provided insight into the outcomes of these interventions (Barnes et al., 2018) but did not consider whether the interventions were theory-based, what constructs were targeted, and which behavior change techniques were used. Without this knowledge, it is difficult to fully examine why some interventions might have been effective and others were not. With increasing levels of physical inactivity in this population, it is imperative that we systematically examine interventions to learn about “what works, for whom, and in what contexts” (Fynn et al., 2020). Indeed, there are frameworks to support this approach. For example, the Behavior Change Technique (BCT) Taxonomy v1 (Michie et al., 2013) allows for the active ingredients within an intervention (i.e., behavior change techniques) to be identified and evaluated, while using the Template for Intervention Description and Replication (TIDieR) checklist provides insight into the critical components of intervention development and implementation, enhancing the quality, replication and cost effectiveness of interventions (Hoffmann et al., 2017). Thus, the application of tools such as this TIDieR checklist and BCT Taxonomy v1 can enable a more systematic and deeper examination of how and why interventions targeting this cohort may or may not be effective (Fynn et al., 2020). This review is the first to provide these insights for mother-daughter interventions, therefore advancing the evidence base for future intervention design and implementation. Hence, the overall aims of this review were:

- To examine the intervention effect on PA outcomes for daughters and their mothers.
- To establish the different characteristics of these interventions based on the TIDieR guidelines.
- To identify and evaluate behavior change theory and techniques used in these interventions.

2. Methods

The systematic review was prepared in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) 2020 guidelines (PRISMA checklist is available in Table S1) and was registered (registration number: CRD42020182159) with the International Prospective Register of Systematic Reviews (PROSPERO).

2.1. Search strategy

The electronic databases PubMed, EMBASE, PsycINFO, Cumulative Index to Nursing and Allied Health Literature (CINAHL) and Cochrane Library (Wiley) were searched for relevant articles using terms from medical subject headings (MESH) and keywords in the title/abstract in collaboration with a research librarian. The search strategy was based on previous systematic reviews (Barnes et al., 2018; Brown et al., 2016) and included terms relating to or describing the following four concepts: population AND target behavior AND intervention AND setting (Box 1). The full search strategies are shown in Table S2. The search extended from the year of the database inception up to and including 13th May 2020.

2.2. Eligibility criteria

The included studies were interventions for mothers and their 5–19-year-old daughters that targeted an increase in PA levels. Studies that targeted clinical populations, boys or ‘parent-daughter’ groups that did not specify the self-identified gender of the parents were excluded. Only mother-daughter interventions that took place in a community, after-school or home/online setting were considered. Studies that used either device-based measures or self-report measures of PA were included. Studies were of any design (e.g., RCTs, trials, quasi-experimental design). Only articles written in English were included in

Box 1 Search terms and concepts.	
Concept 1: Population	Concept 3: Study Type
Mother	Intervention
Mum	Trial
Mom	Cluster
Parent	Program
Daughter	Scheme
Girl	Experiment
Adolescent	Program
Teenager	
Schoolgirl	
Concept 2: Target Behavior	Concept 4: Setting
Physical activity	Community
Exercise	Home
Dance	School
Physical fitness	After-school
Sport	
Sedentary behavior	

the review (Table S3).

2.3. Study selection process

Search results were imported into Endnote X9 reference management software and duplicates removed. The first 100 titles were screened separately by two authors (C.B. and J.M.) resulting in 91% percent agreement. A further 100 titles were screened independently by the same two authors with 93% agreement, thereafter identification of titles was completed by one author (C.B.). Abstracts and full texts of all identified papers were independently screened by two authors (C.B. and J.M.) using Rayyan software (Ouzzani et al., 2016). Conflicts were resolved by discussion with a third author where needed (A.K.). Study authors were contacted for missing information regarding eligibility criteria ($n = 2$). Additional studies were identified via searches of reference lists of included studies ($n = 2$). Supplementary data where accessible was obtained (e.g., study protocol or process evaluation).

2.4. Data extraction and management

2.4.1. General characteristics

General study characteristics (author, year, country of study, study name, study design, duration, setting, sample size, intervention aim, and target behavior measurement), participant characteristics (age, inclusion criteria, control description) and findings (PA, weight and fitness related outcomes) were extracted from the included studies, by one author (C.B.) and cross-checked by a second author (J.M.).

2.4.2. TIDieR checklist

The TIDieR checklist (Hoffmann et al., 2014) was used to describe the essential items for accurate intervention development and replication. Two authors independently extracted the TIDieR related data from all studies (C.B., A.K.) and discrepancies were resolved by consultation with a third author (J.M.). Measures for intervention duration (short ≤ 3 months, medium >3 to ≤ 12 months, long >12 months) and number of sessions (low ≤ 10 , medium >10 to ≤ 20 , high >20), attrition (low $\leq 13\%$, medium $>13\%$ to $\leq 26\%$, high $>26\%$) and adherence as measured by attendance rate (low $\leq 30\%$, medium $>30\%$ to $\leq 70\%$, high $>70\%$) were based on recent reviews (Lim et al., 2020; Madden et al., 2020).

2.4.3. Behavior change techniques

BCTs were assessed using the 93-item Behavior Change Technique Taxonomy v1 (Michie et al., 2013). Three authors reviewed BCTs, all having undertaken training in the use of the taxonomy. Only BCTs exclusively applied to the intervention groups were extracted (Samdal et al., 2017). Disagreement was resolved through discussions between coders and by consulting a fourth expert coder (A.H.). The relationship between BCTs and increases in mother-daughter PA was examined using a potential effectiveness ratio similar to other studies (Hynynen et al., 2016; Martin et al., 2013). Only studies that reported significance tests were included in this particular analysis. Interventions were deemed 'promising' where there was a significant change on a PA outcome relative to baseline, at any follow-up point whether from a between-group or within-group analyses. The BCTs that were present in 'promising' and 'non-promising' studies were identified, and BCTs were only considered if they were included in at least a third of the studies to reduce conflation of results. Then, a percentage BCT potential effectiveness ratio was calculated as the ratio of the number of times a BCT was present in 'promising' intervention groups divided by the number of times the BCT was present in all the intervention groups included in this analysis.

2.5. Risk of bias assessment

Risk of bias was assessed by two authors (J.M., G.O'D.).

Disagreements were resolved by discussion. For the RCTs included in the review, the Cochrane risk of bias tool (Higgins et al., 2011) was used, for the non RCTs, the ROBINS-I tool was applied (Sterne et al., 2016).

2.6. Data synthesis

Data were collated from across studies and presented in a narrative summary. Intervention characteristics and intervention effects according to outcome variables were presented descriptively. The TIDieR checklist and BCT Taxonomy v1 were also used to identify and describe key intervention components. These data were all presented in tabular format. A meta-analysis was not conducted on PA outcomes for several reasons. These reasons included, the small number of studies available for each PA outcome, the limited sample size within a number of studies, and the results of some PA measures not being sufficiently similar.

3. Results

3.1. Study selection

The initial search identified 10,123 records. Following the removal of duplicates, 4962 titles/abstracts were screened. Of these, 139 full text articles were reviewed with a citation search providing two additional records (Barr-Anderson et al., 2014; Olvera et al., 2013). This resulted in 16 articles representing 11 unique studies included in the review (Fig. 1). Three studies were categorized as "near misses". Two (Kargarfard et al., 2012; Salimzadeh et al., 2010) of the three were excluded as they reported fitness rather PA outcomes, while the third (Beech et al., 2003) was discounted as it did not specify the self-identified gender of the parent.

3.2. Characteristics of included studies

The characteristics of the eligible studies are provided in Table 1. Of the 11 included studies, six studies were RCTs (Alhassan et al., 2018; Barnes et al., 2015a; Olvera et al., 2010; Ransdell et al., 2003a, 2003b; Ransdell et al., 2005; Schwinn et al., 2014) and five studies were non-RCT studies (Arredondo et al., 2014; Barr-Anderson et al., 2014; Corr et al., 2019; Olvera et al., 2013; Ransdell et al., 2001). The six RCTs either compared the intervention group against a no-treatment control group (Barnes et al., 2015a; Ransdell et al., 2005; Schwinn et al., 2014) or compared two intervention groups (Alhassan et al., 2018; Olvera et al., 2010; Ransdell et al., 2003a, 2003b). The five non-RCTs were single arm interventions (Arredondo et al., 2014; Barr-Anderson et al., 2014; Corr et al., 2019; Olvera et al., 2013; Ransdell et al., 2001). Across these 11 studies, there were 14 intervention groups in total.

The largest sample size was 76 mothers and 76 daughters ($n = 152$) (Alhassan et al., 2018), while 11 mother-daughter dyads ($n = 22$) was the smallest (Arredondo et al., 2014). The age of mothers ranged from 28 to 50 years old and daughters from 7 to 17 years old.

Nine studies were conducted in the United States (Alhassan et al., 2018; Arredondo et al., 2014; Barr-Anderson et al., 2014; Olvera et al., 2010; Olvera et al., 2013; Ransdell et al., 2001; Ransdell et al., 2003a, 2003b; Ransdell et al., 2005; Schwinn et al., 2014). The remaining two were conducted in Australia (Barnes et al., 2015a) and Ireland (Corr et al., 2019). Five studies used device-based measures for PA outcomes (Alhassan et al., 2018; Barnes et al., 2015a; Barr-Anderson et al., 2014; Olvera et al., 2010; Olvera et al., 2013). Four studies used self-report measures for PA (Arredondo et al., 2014; Ransdell et al., 2001; Ransdell et al., 2003a, 2003b; Schwinn et al., 2014), while two studies used a combination of device-based (pedometers) and self-report measures (Corr et al., 2019; Ransdell et al., 2005).

3.3. Risk of Bias

A summary of the risk of bias across studies is shown in supplemental

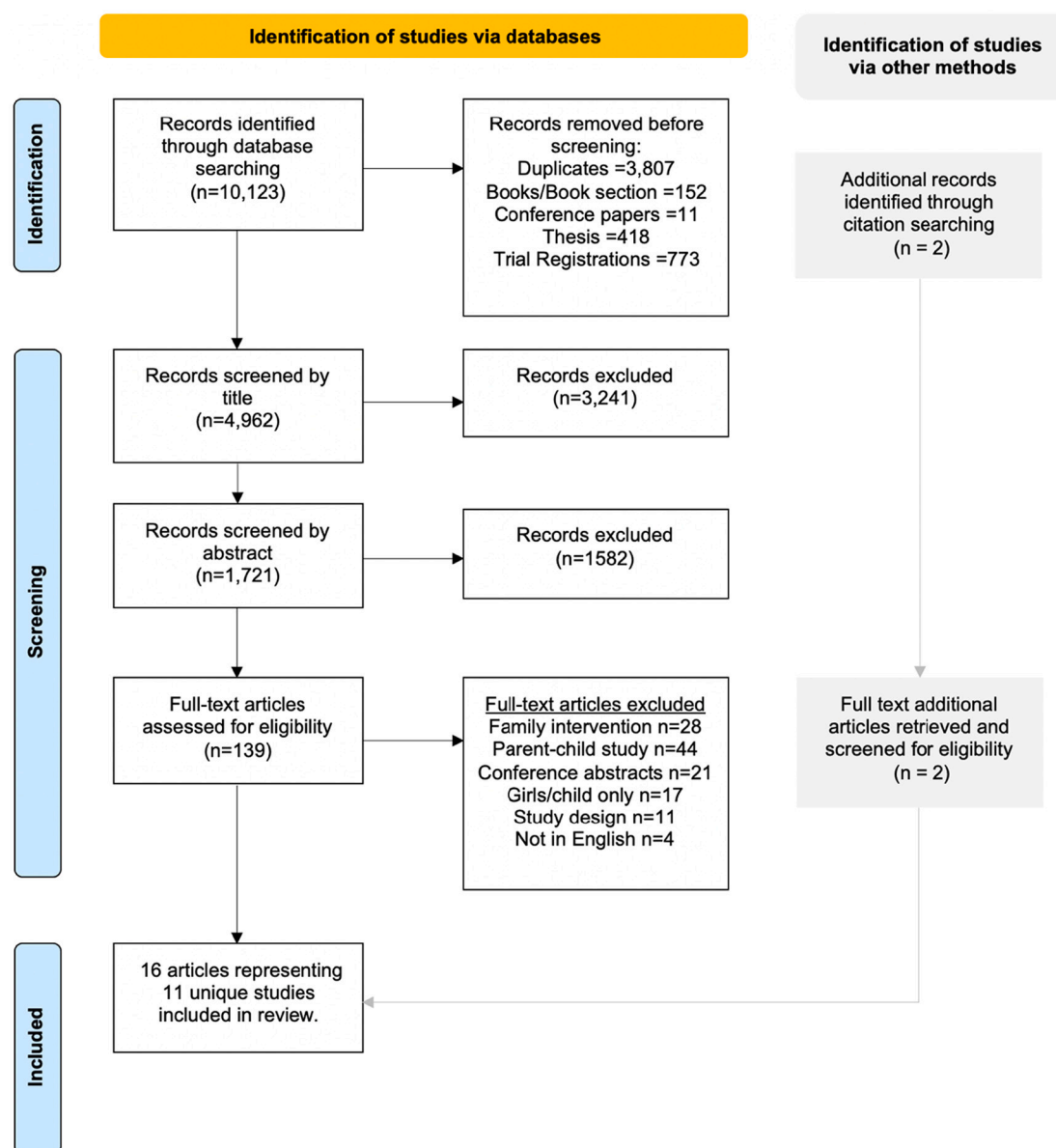


Fig. 1. PRISMA 2020 flow diagram of included studies (Page et al., 2021).

tables S4 and S5. For the RCTs, only Barnes et al. (2015a) was deemed to be at a low risk of selection and detection bias. All were deemed to be at high risk of performance bias due to the inability to blind participants to the intervention. With respect to attrition bias, two studies were classified as low risk (Alhassan et al., 2018; Barnes et al., 2015a) with the four other studies marked as high risk due to the increased levels of dropout (>than 20%), and/or the non-reporting of analyses plans (e.g., intention to treat analysis). All six RCTs were deemed at low risk of reporting bias. For the non-RCTs, all were deemed to be at critical risk of bias due the lack of a control group. Only one study was classified as being at low risk of bias due to deviations from the intended interventions and of have having a low risk of bias due to missing data (Arredondo et al., 2014). The majority of non-RCTs were deemed to be at serious of risk of bias due to the use of self-report measures and all studies were classified as being at moderate risk of selective reporting bias.

3.4. Study characteristics according to the TIDieR checklist

Table 2 represents a summary of “why,” “who,” “how,” “where,”

“when and how much,” “tailoring,” “modification,” and “how well” for the included studies with table S6 describing the full data extraction of the TIDieR characteristics.

3.4.1. Rationale/theory (why)

Eight studies specified a named theory, predominantly social cognitive theory ($n = 5$) (Alhassan et al., 2018; Barnes et al., 2015a; Olvera et al., 2010; Ransdell et al., 2001; Ransdell et al., 2003a, 2003b). One study used the behavior change wheel for intervention design (Corr et al., 2019). Two studies incorporated social cognitive theory with either family systems theory (Arredondo et al., 2014) or the social-ecological model (Barr-Anderson et al., 2014) as part of their intervention rationale. Of these eight studies, only four measured relevant theoretical constructs (Alhassan et al., 2018; Arredondo et al., 2014; Barnes et al., 2015a; Ransdell et al., 2003a, 2003b).

3.4.2. Materials and procedures (what)

Nine studies described the materials used in the interventions, involving newsletters, booklets, certificates, DVDs, stickers, log books, jump ropes, balls, weights, pedometers, and log books (Alhassan et al.,

Table 1
Study characteristics and findings.

Study (year, country)	Study design, duration, setting, sample size and target behavior measurement.	Intervention aim/rationale	Participant age (SD)	Findings
Randomized control trials				
Alhassan et al. (2018) (Burkart et al., 2017) USA	3 arm parallel group. RCT, 12 weeks, elementary school, Springfield, MA. 76 mother and daughter dyads. Device-based measures of PA using accelerometers	To examine the feasibility and efficacy of a 12-week culturally-tailored mother-daughter PA intervention on the PA levels of pre-adolescent African-American girls. Theory: Social cognitive theory	CH-M (IG): Mothers (n = 28) 35.5 yrs. (8.20), daughters (n = 28) 8.80 yrs. (1.40) CH (IG2): Mothers (n = 25) 36.80 yrs., (7.30), daughters (n = 25) 7.80 yrs. (1.0) CON (CG): Mothers (n = 23) 39.90 yrs. (7.70) Daughters (n = 23) 8.10 yrs. (1.10)	<i>At 12-week assessment</i> PA Daughters in the IG displayed significantly steeper rates of increase over time spent in afterschool VPA compared to the CG ($\gamma = -0.80$, $p < .001$) and the IG2 ($X^2(1) = 13.01$, $p < .001$). No significant rates of changes observed in daughters' total daily MVPA. Mothers in the IG showed a significant improvement in total daily MVPA ($\gamma = 0.07$, $p = .001$) compared to the CG.
Barnes et al., 2015a (MADE4Life Australia)	RCT. 20 weeks, 8-week program, 3 months follow up. After school sessions, community. 40 mothers and 48 daughters. Device-based measures of PA using accelerometers. Mothers self-reported PA. (Godin's MET mins)	To determine the feasibility and preliminary efficacy of a mother- daughter program targeting improvements in PA levels. Theory: Social cognitive theory	IG: Mothers (n = 21) 38.71 yrs. (4.41) Daughters (n = 25) 8.36 yrs. (1.72) CG: Mothers (n = 19) 39.53 yrs. (5.26), daughters (n = 23) 8.63 yrs. (1.76)	<i>Immediate postintervention (8 weeks)</i> PA No significant group by time effect for daughters' % time in MVPA (-0.08 : 95%CI $-1.49, 1.33$, $d = -0.03$, $p = .99$). Both IG and CG showed a within-group effects for %LPA $d = -0.46$. IG mothers increased their % time in MVPA by 0.38% (95%CI = $-0.35, 1.12$) compared with the control group who decreased by -0.14% (95%CI = $-0.93, 0.65$), showing a small effect size ($d = 0.25$, $p = .06$). A significant intervention effect was found for mothers %VPA ($p = .004$, $d = 0.25$). While a medium group by time effect size was recorded for mothers' self-reported MET minutes (295.58: 95%CI, $-64.76, 655.92$, $d = 0.42$). Weight IG daughters had no significant effect size for BMI z-scores compared with CG daughters (-0.12 : CI 95% $-0.30, 0.06$, $d = -0.10$). No significant effect size observed for mothers' BMI (kg/m^2) between IG and CG (-0.13 : CI $-0.85, 0.60$, $d = -0.22$). <i>At 3 months follow up</i> PA Non-significant effect size for IG daughters' % time in MVPA when compared with CG daughters (0.03: 95%CI $-1.20, 1.25$, $d = 0.01$). A significant within-group effect for IG for daughters' CPM $d = 0.20$. CG daughters showed a within-group difference for %LPA at follow-up. Non-significant effect for mothers' MVPA in the IG group compared to the CG ($p = .06$) A medium effect size was recorded for IG mothers' self-reported MET minutes when compared with CG mothers (367.43: 95%CI = $-163.27, 898.13$, $d = 0.53$). Weight No significant group by time effect for daughters BMI z-score (-0.06 : 95%CI = $-0.24, 0.13$, $d = -0.05$, $p = .39$). No significant group by time effect for mothers' BMI ($0.36 \text{ kg}/\text{m}^2$: 95%CI = $-0.28, 0.99$, $d = 0.07$, $p = .34$). <i>After 12 weeks intervention</i> PA Daughters in IG showed a statistically significant increase in MVPA compared to IG2 (6.40mins vs 2.60mins, $p < .05$). No significant difference in MVPA of daughters in the IG or IG2, when compared to baseline was reported. Neither IG nor IG2 mothers reported statistically significant changes in self-reported physical activity levels compared to baseline or between group.
(Olvera et al., 2010; Olvera et al., 2008) USA BOUNCE	RCT 12 weeks. Community based. 46 mothers and 46 daughters. Device-based measures of PA using accelerometer, for daughters. Mothers self-report measures PA through questionnaire.	To improve physical fitness and PA behavior in low-income Latino mothers and daughters. Theory: Social cognitive theory.	IG: Mothers (n = 26) 33.3 yrs. (4.6) Daughters (n = 26) 9.9 yrs. (1.10) IG2: Mothers (n = 20) 38.2 yrs. (10.6) Daughters (n = 20) 10.4 yrs. (1.1)	Fitness

(continued on next page)

Table 1 (continued)

Study (year, country)	Study design, duration, setting, sample size and target behavior measurement.	Intervention aim/rationale	Participant age (SD)	Findings
Ransdell et al. (2005) (Ornes et al., 2005) USA Get-fit	RCT 6 months. Home based. 13 mothers and 13 daughters. Device-based measures of PA using pedometer. Self-report measures: Physical best PA questionnaire & aerobic activity days/week	A 6-month home based physical activity and fitness intervention in three generations of women.	IG: Mothers (n = 10) 37.81 yrs. (4.17) Daughters (n = 10) 10.75 yrs. (1.42) CG: Mothers (n = 3) 36.57 yrs. (4.08) Daughters (n = 3) 9.42 yrs. (1.51)	IG daughters had a statistically significant mean increase in the 20-meter shuttle run test of 6.40 laps compared to a mean increase of 1.90 laps for IG2 daughters ($p = .044$). Neither IG nor IG2 mothers reported statistically significant changes in VO2 ml/kg/min. <i>After 6 months intervention</i> All participants combined for analyses (mother, daughter and grandmother). PA IG ($n = 27$) had a significant group by time effect ($p = .001$) for average daily step count when compared to the CG ($n = 9$) (increase of 3095 steps vs decrease 899 steps). There were no significant effects in physical activity participation (aerobic activity d/wk.) either within group or group by time. Fitness CG showed a greater decrease in mile time (-2.73 mins) compared to IG (-0.68 mins). The group by time interaction was significant ($p = .009$). <i>After 12 weeks intervention</i> PA Mothers and daughters in both IG and IG2 reported a significant increase in participation in PA days/week (aerobic, muscular strength and flexibility) across time ($p < .05$). No significant group by time interaction, therefore no difference between changes in PA participation for IG and IG2. Fitness: No pre- to post-test changes were reported in IG or IG2 daughters for aerobic capacity (ml/kg/min). Mothers in both groups significantly increased their aerobic capacity over time ($p = .002$), however the group by time interaction was not significant ($p = .29$) Weight No significant changes in body fat % reported either within group or group by time for mothers or daughters in both IG and IG2.
(Ransdell et al., 2004; Ransdell et al., 2003a, 2003b) USA DAMET	RCT 12 weeks. Home based & community based 17 mothers and 17 daughters. Self-report measures: Fitnessgram PA questionnaire Aerobic activity days/week Muscular strength building days/week Flexibility activity days/week	To compare the effectiveness of a home- and community -based PA and fitness interventions for mothers and daughters. Theory: Social cognitive theory.	IG: Mothers (n = 10) 46 yrs. (8.54) Daughters (n = 10) 15.20 yrs. (1.23) IG2: Mothers (n = 7) 44 yrs. (6.11) Daughters (n = 7) 15.71 yrs. (1.5)	<i>After 3 online sessions</i> PA Within group changes for self-reported PA were minimal for both IG mothers and daughters, with no level of significance reported. Mothers in the IG showed a significant increase PA ($p < .05$) compared to CG, daughters showed no level of significance between groups. <i>At 5-month follow-up</i> PA Neither IG or CG mothers or daughters showed any significant effects for self-reported PA either within group or between groups.
Schwinn et al. (2014) USA	RCT 3 sessions – 5 months follow up Online 67 mothers and 67 daughters Self-report measures of PA (Kaiser survey)	To examine a short health and well-being program for low-income girls and their mothers, living in public housing, by improving dietary intake, increasing PA and reducing drug use risks.	IG: Mothers (n = 36) 36.43 yrs. (6.43) Daughters (n = 36) 11.83 (0.81) CG: Mothers (n = 31) 36.03 yrs. (5.94) Daughters (n = 31) 11.87 yrs. (0.96)	<i>After 8-week intervention</i> No significance tests computed due to small sample size. PA Mothers reported a mean increase in daughters PA hours per week of 86 min (23%) and a mean increase of 97 mins (32%) in their own PA hours per week. <i>End of intensive phase 1 (month 3)</i> No significance tests computed due to small sample size. PA
Non-randomized control trials Arredondo et al. (2014) USA	Pilot study. 8 weeks, Church in Chula Vista, California. 11 mother and daughter dyads. Self-report measures of PA, reported by mothers through questionnaire.	To assess the acceptability, feasibility and efficacy of a pilot study promoting PA preadolescent Latina daughters and their mothers in a church-based setting. Theories: Social cognitive theory and family systems theory.	IG: Mothers (n = 11) 36.67 yrs. (6.18), daughters (n = 11) 9.56 yrs. (1.13)	
Barr-Anderson et al. (2014) USA	Pilot intervention study. 9 months. Community. 12 mothers and 12 daughters.	A culturally-tailored intervention directed at changing PA, dietary and sedentary behaviors.	IG: Mothers (n = 12) 39.9 yrs. (5.68) Daughters (n = 12) 12.40 yrs. (1.34)	

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Table 1 (continued)

Study (year, country)	Study design, duration, setting, sample size and target behavior measurement.	Intervention aim/rationale	Participant age (SD)	Findings
	Self-reported measures: Self-reported Time in SB hr./day and time in MVPA min/day.	Theory: Social cognitive theory and the social-ecological model.		Daughters ($n = 8$) reported a mean MVPA (min/day) as 30.20 ± 28.23 an increase of 7.50mins compared with baseline. Mothers ($n = 8$) reported a mean 33 mins increase in daily MVPA from 14.7 ± 19.77 to 47.7 ± 27.20 . When compared with baseline. Weight Daughters ($n = 8$) showed a decrease of 0.20% in BMI and mothers ($n = 8$) showed a decrease in BMI of 2.70 kg/m^2 , when compared with baseline <i>End of maintenance phase 2 (month 9)</i> PA Daughters ($n = 5$) reported a daily increase of 18.20 mins MVPA and mothers ($n = 5$) reported a daily increase of 11.70 mins MVPA compared with baseline. Weight Compared with baseline daughters ($n = 5$) showed a decrease of 3.80% in BMI and mothers ($n = 5$) showed a BMI decrease of 2.30 kg/m^2 .
Corr et al. (2019) Ireland SOLE MATES	Single arm feasibility trial. 6 weeks. University & home-based. 27 mothers and 31 daughters. Device-based measures of PA using pedometer. Self-report measures through PAQ-A questionnaire.	To evaluate the feasibility of a six-week mother-daughter multi-component PA program. Theory: The behavior change wheel	IG: Mothers ($n = 27$) 44.9 yrs. (6.08) Daughters ($n = 31$) 14.00 (1.20)	<i>After 6 weeks intervention</i> PA Daughters showed a statistically significant increase in average steps per day when compared with baseline, (7181 ± 1926 v's 5788 ± 1595 , $d = 0.81$, $p = .007$). Mothers reported a statistically significant increase in average steps per day when compared with baseline (9666 ± 3157 Vs 6791 ± 2705 , $d = 1.0$, $p = .009$). Daughters demonstrated a statistically significant change ($p = .01$) in their self-report of PA through PAQ-A questionnaire, when compared with baseline.
Olvera et al. (2013) USA	Summer intervention - non experimental design. 4 weeks. 99 mothers and 99 daughters. Device-based measures of PA using accelerometer (daughters only).	To determine the effectiveness of a PA summer intervention designed to reduce adiposity and increase aerobic endurance in Hispanic and African American girls.	IG: Mothers ($n = 99$) 38.8 yrs. (6.6) Daughters ($n = 99$) 11.20 yrs. (1.6)	<i>After 4 weeks intervention</i> PA Daughters displayed a significant increase in MVPA (9-5 pm, Monday to Friday) from week 1 to week 4 of the summer camp ($p < .001$), however no data was collected at either pre or post-test. Fitness Daughters 1-mile run/walk minutes decreased significantly by 2.43 mins ($p < .001$) when compared to baseline. Weight A statistically significant effect for daughters' body fat (-2.49% , $p < .001$), waist (-5.63 cm , $p < .001$) and BMI (-0.41 kg/m^2 , $p < .05$) when compared to baseline.
Ransdell et al. (2001) USA DAMET pilot	Pilot study 12 weeks, 6 months follow up University campus 12 mothers and 14 daughters Self-report measures of PA using PA exercise participation survey d/wk.	The evaluate the design and implementation of a mother- daughter PA intervention. Theory: Social cognitive theory	IG: Mothers ($n = 12$) 40.7 yrs. (6.4) Daughters ($n = 14$) 13.9 yrs. (1.50)	<i>After 12 weeks intervention</i> PA No significant increases in PA behavior (days/week) were reported for mothers or daughters compared to baseline. Fitness No significant improvement in VO2 peak ml/kg/min in either mothers or daughters ($p = .52$) across time. <i>6 month follow up</i> PA No significant increases in PA behavior (days/week) were reported for mothers or daughters compared to baseline. Fitness Measures not reported

Abbreviations: IG = intervention group, IG2 = intervention group 2, CG = control group, PA = physical activity, MVPA = moderate-to-vigorous physical activity, VPA = vigorous physical activity, LPA = light physical activity, CPM = counts per minute, BMI = body mass index, VO2Max = maximum oxygen uptake, PAQ-A = physical activity questionnaire for adolescents, NS = non-significant, Cohen's d effect sizes, $d = 0.2$ (small effect), $d = 0.5$ (medium effect), $d = 0.8$ (large effect), statistically significant values: $P > .005$ (no significance), $p < .05$ (significant effect), $p < .01$ (highly significant), $p < .001$ (extremely significant).

Table 2
TIDieR characteristics and intervention outcomes.

Study arm	Outcomes		Why?	What?			Who?		How?			Where & when			How much?					Tailoring Modification		How well?								
	PA	PA	Theory	Materials	Procedures			RT	HCP	Exer/ Dnce/ health	M&D	M&D Sep	D only	Community	After- school	Home/ online	Duration		Number of sessions					Attrition			Adherence			
					Daughter	Mother	Dance										Fitness/ activity	Walking	Low: ≤13%	Med: >13- ≤26%	High: >26%			Low: ≤30%	Med: >30- ≤70%	High: >70%				
Randomized control trials																														
Alh '18	IG	✓	✓	●	●	●		●		●	●				●		●				●	○	○		●	●				
Alh '18	IG2	✓	n/a	●	●	●		●		●			●		●		●				●	○	○		●	●				
Bar '15	IG	✓/✓	✓/X	●	●		●	●			●			●			●		●		●	○		●				●		
Olv '10	IG	✓	X	●	●		●		●	●	●			●			●				●	●	○		●		●			
Olv '10	IG2	X	X	●	●		●			●	●			●			●			●	●	○		●		●				
Rdl '05	IG	?	?	○	●		●		○		●				●		●				●	●	○		●			●		
Rdl '03	IG	✓	✓	●	●		●				●			●			●				●	●	○		●			●		
Rdl '03	IG2	✓	✓	●	●		●		○		●				●		●				●	●	○		●			●		
Sch '14	IG	X/X	✓/X	○	○		○		○		●				●		●		●		●	○		○	●			●		
Non-randomized control trials																														
Arr '14	IG	✓*	✓*	●	●		●		●	●	●		●		●			●		●		●	○		○			●		
B-A '14	IG	✓/✓*	✓/✓*	●	●		●		●		●			●			●		●		●	○		●		○				
Cor '19	IG	✓	✓	●	●			●			●			●			●		●		●	○		○		●				
Olv '13	IG	✓	n/a	○	○		●			●			●		●			●			●	○	○		○			●		
Rdl '01	IG	X/X	X/X	●	●		●		○		●			●			●			●	○	○		○		●		●		
Total		✓10/2 × 3/2	✓8/1 × 3/3	11	12	2	10	2	7	3	6	11	2	1	9	2	3	11	3	4	3	7	10	0	2	3	6	2	4	7

IG = Intervention group, IG2 = Intervention group 2, n/a = not applicable, PA = physical activity, ✓ = effect, X = no effect, ● = reported, ○ = not reported, ? = unclear, * = No significance tests conducted, ✓/✓ = 2 outcome points, post-test/follow-up, RT = Research Team, HCP = Health Care Professionals (Child Psychologists, Exercise Physiologists, Dieticians), Exer/Dnce/Health = (Fitness Instructors, Dance Teachers, Health Advisors, Youth Leaders), M&D = Mothers and daughters participated in group classes together, M&D Sep = Mothers and daughters were in separate classes, D only = Daughters only participated in class. Attrition measured as drop off rate recorded. Adherence measured as attendance rate recorded.

Table 3
Behavior change techniques identified across intervention groups.

Behavior change technique	All intervention groups (n = 14)	
	Frequency	%
6.1 Demonstration of the behavior	13	93
4.1 Instruction on how to perform the behavior	12	86
8.1 Behavioural practice/rehearsal	11	79
9.1 Credible source	10	71
2.3 Self-monitoring of behavior	7	50
5.1 Information about health consequences	7	50
8.6 Generalization of target behavior	7	50
1.1 Goal setting (behavior)	6	43
1.2 Problem solving	6	43
3.1 Social support (unspecified)	5	36
8.7 Graded tasks	5	36
12.6 Body changes	5	36
3.3 Social support (emotional)	4	29
10.2 Material reward (behavior)	4	29
12.5 Adding objects to the environment	3	21
15.4 Self-talk	3	21
1.3 Goal setting (outcome)	2	14
1.5 Review behavior goal(s)	2	14
5.6 Information about emotional consequences	2	14
7.1 Prompts/cues	2	14
8.3 Habit formation	2	14
10.1 Material incentive (behavior)	2	14
15.1 Verbal persuasion about capability	2	14
1.4 Action planning	1	7.1
1.8 Behavioral contract	1	7.1
2.1 Monitoring of behavior by others without feedback	1	7.1
2.2 Feedback on behavior	1	7.1
2.7 Feedback on outcome(s) of behavior	1	7.1
5.3 Information about social and environmental consequences	1	7.1
8.2 Behavior substitution	1	7.1
10.3 Non-specific reward	1	7.1
10.10 Reward (outcome)	1	7.1
12.3 Avoidance/reducing exposure to cues for the behavior	1	7.1
13.1 Identification of self as role model	1	7.1
13.2 Framing / reframing	1	7.1
15.2 Mental rehearsal of successful performance	1	7.1
15.3 Focus on past success	1	7.1

2018; Arredondo et al., 2014; Barnes et al., 2015a; Barr-Anderson et al., 2014; Corr et al., 2019; Olvera et al., 2010; Ransdell et al., 2001; Ransdell et al., 2003a, 2003b; Ransdell et al., 2005). The remaining studies did not describe any materials used (Olvera et al., 2013; Schwinn et al., 2014). All studies, except one (Schwinn et al., 2014), reported the procedures involved in the PA component of the interventions such as, dance (Alhassan et al., 2018) fitness, interactive games and activities (Arredondo et al., 2014; Barnes et al., 2015a; Barr-Anderson et al., 2014; Olvera et al., 2010; Olvera et al., 2013; Ransdell et al., 2001; Ransdell et al., 2003a, 2003b; Ransdell et al., 2005) and group walking (Corr et al., 2019; Ransdell et al., 2005).

3.4.3. Intervention provider (who)

The PA component of the interventions was delivered by research team members (Barnes et al., 2015a; Corr et al., 2019; Ransdell et al., 2003a, 2003b), exercise physiologists (Arredondo et al., 2014; Olvera et al., 2013), fitness instructors (Olvera et al., 2010) and dance teachers (Alhassan et al., 2018). Four studies had additional educational components delivered by the research team (Alhassan et al., 2018; Barnes et al., 2015a; Corr et al., 2019; Ransdell et al., 2003a, 2003b), two used health coaches to provide supplementary support (Arredondo et al., 2014; Barr-Anderson et al., 2014) and two studies used child psychologists and dietitians to deliver health advice (Olvera et al., 2010; Olvera et al., 2013). Information regarding intervention provider was not explicitly reported in two studies (Ransdell et al., 2001; Ransdell et al., 2005). Two interventions were home-based (Ransdell et al., 2003a, 2003b; Ransdell et al., 2005), and one intervention was online (Schwinn et al., 2014) and thus were not 'delivered' by the intervention providers.

3.4.4. Mothers and daughters, together or separate (how)

Mothers and daughters participated together in 11 interventions (Alhassan et al., 2018; Barnes et al., 2015a; Barr-Anderson et al., 2014; Corr et al., 2019; Olvera et al., 2010; Ransdell et al., 2001; Ransdell et al., 2003a, 2003b; Ransdell et al., 2005; Schwinn et al., 2014), two interventions were delivered to mothers and daughters separately (Arredondo et al., 2014; Olvera et al., 2013), while one intervention was for daughters only (Alhassan et al., 2018). Only the home-based intervention groups (Ransdell et al., 2003a, 2003b; Ransdell et al., 2005), and the online intervention (Schwinn et al., 2014) were not face-to-face.

3.4.5. Location of intervention (where and when)

Nine interventions took place in a community setting (Arredondo et al., 2014; Barnes et al., 2015a; Barr-Anderson et al., 2014; Corr et al., 2019; Olvera et al., 2010; Olvera et al., 2013; Ransdell et al., 2001; Ransdell et al., 2003a, 2003b), two were after-school (Alhassan et al., 2018), two took place in family homes (Ransdell et al., 2003a, 2003b; Ransdell et al., 2005) and one was online (Schwinn et al., 2014).

3.4.6. Intervention schedule and intensity (when and how much)

Eleven interventions were of a short duration (≤ 3 months) (Alhassan et al., 2018; Arredondo et al., 2014; Barnes et al., 2015a; Barr-Anderson et al., 2014; Corr et al., 2019; Olvera et al., 2010; Olvera et al., 2013; Ransdell et al., 2003a, 2003b; Schwinn et al., 2014) and three were of medium duration (> 3 to ≤ 12 months) (Barr-Anderson et al., 2014; Ransdell et al., 2001; Ransdell et al., 2005). Seven intervention groups had a high number of sessions (> 20 sessions) (Alhassan et al., 2018; Olvera et al., 2010; Ransdell et al., 2001; Ransdell et al., 2003a, 2003b; Ransdell et al., 2005), three had a medium number of sessions (> 10 to ≤ 20 sessions) (Barr-Anderson et al., 2014; Olvera et al., 2010; Olvera et al., 2013) and four had a low number of sessions (≤ 10 sessions) (Arredondo et al., 2014; Barnes et al., 2015a; Corr et al., 2019; Schwinn et al., 2014).

3.4.7. Adaptations (tailoring and monitoring)

Ten intervention groups featured tailoring in their interventions through personalized goal setting (Arredondo et al., 2014; Barnes et al., 2015a; Barr-Anderson et al., 2014), problem solving (Barr-Anderson et al., 2014; Schwinn et al., 2014), progressive weekly goals (Corr et al., 2019; Ransdell et al., 2005), and individualization of the intensity and frequency of the exercise component (Olvera et al., 2010; Ransdell et al., 2003a, 2003b). None of the studies reported any modifications.

3.4.8. Attrition and adherence (how well)

Two studies reported low levels of attrition ($\leq 13\%$) (Barnes et al., 2015a; Schwinn et al., 2014), two reported medium levels of attrition ($> 13\%$ to $\leq 26\%$) (Olvera et al., 2010; Ransdell et al., 2003a, 2003b) and five studies reported high levels of attrition ($> 26\%$) (Alhassan et al., 2018; Barr-Anderson et al., 2014; Ransdell et al., 2001; Ransdell et al., 2003a, 2003b; Ransdell et al., 2005). Three studies did not report any levels of attrition (Arredondo et al., 2014; Corr et al., 2019; Olvera et al., 2013). One study (Alhassan et al., 2018) reported a low adherence rate ($\leq 30\%$), three studies reported medium adherence rates ($> 30\%$ to $\leq 70\%$) (Corr et al., 2019; Olvera et al., 2010; Ransdell et al., 2001), and six high adherence rates ($> 70\%$) (Arredondo et al., 2014; Barnes et al., 2015a; Olvera et al., 2013; Ransdell et al., 2003a, 2003b; Ransdell et al., 2005; Schwinn et al., 2014). No information regarding adherence was stated in one study (Barr-Anderson et al., 2014).

3.5. Behavior change techniques

Of the 93 behavior change techniques in the BCT taxonomy v1, 37 were coded as present at least once across the 14 intervention groups (see Table 3). Fourteen BCTs (38%) were coded once, seven BCTs (19%) were identified twice and 16 BCTs (43%) were reported more than twice. The highest number of BCTs coded as present in an intervention

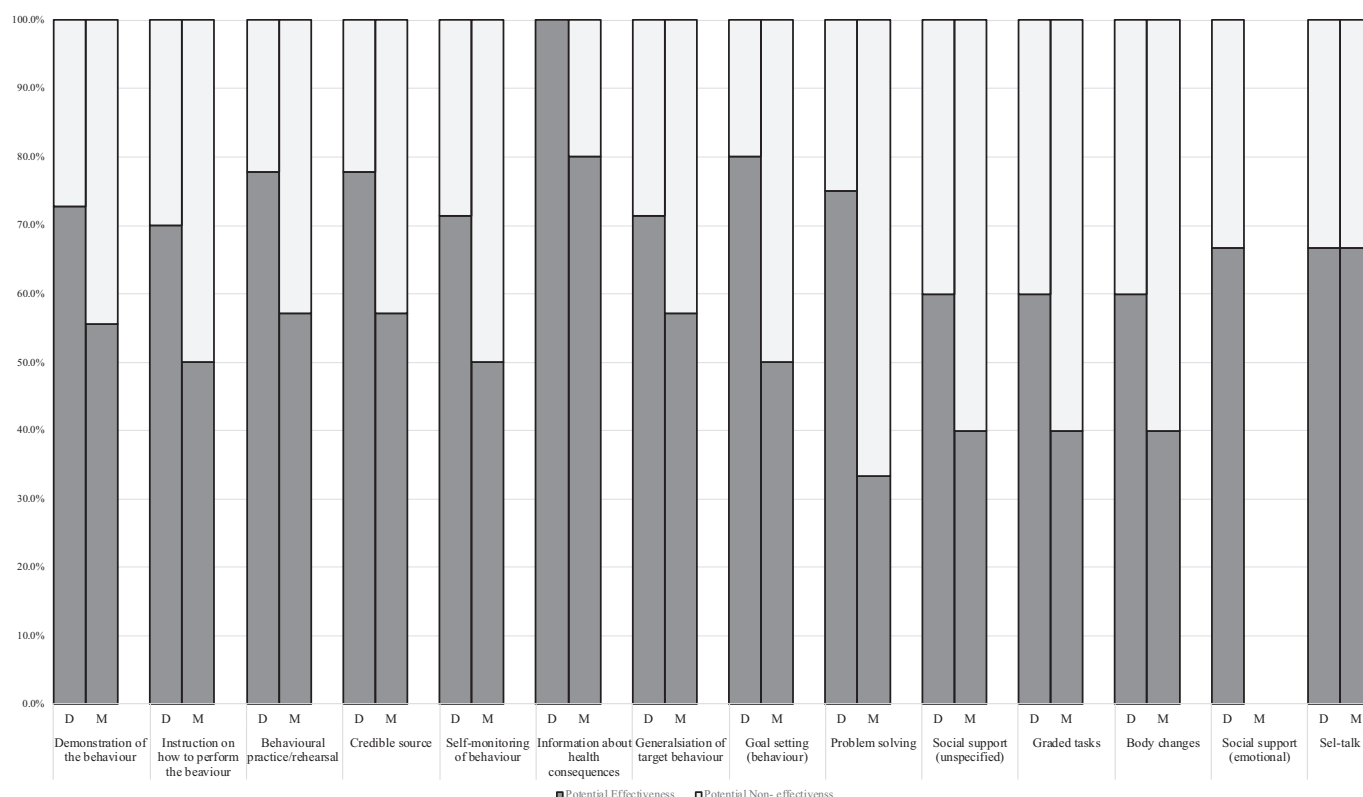


Fig. 2. BCT potential effectiveness ratio, the BCTs are listed by frequency in the intervention groups, with the most frequently identified BCTs on the left.

group was 18 (Ransdell et al., 2001), the lowest was one (Schwinn et al., 2014), and the mean was 10.

The most frequently coded BCTs were *demonstration of behavior* ($n = 13$), *instruction on how to perform the behavior* ($n = 12$), *behavioral practice/rehearsal* ($n = 11$) and *credible source* ($n = 10$).

3.6. PA outcomes

3.6.1. PA outcomes for RCTs and non-RCTs

For the nine intervention groups targeting daughters' PA as part of an RCT, there was a significant increase in PA from baseline to post intervention in five groups (Alhassan et al., 2018; Barnes et al., 2015a; Ransdell et al., 2003a, 2003b) and a between-group change for one group (Olvera et al., 2010) (see Table 1). Four of eight intervention groups targeting mothers' PA levels as part of an RCT reported an increase in PA levels either from baseline to post-intervention ($n = 3$) (Alhassan et al., 2018; Ransdell et al., 2003a, 2003b) or a between group change ($n = 1$) (Barnes et al., 2015a). For the non-RCT studies, one study showed a significant increase in PA levels for daughters and mothers (Corr et al., 2019), and another for daughters only (Olvera et al., 2013). Two non-RCTs did not perform statistical tests due to small sample sizes but reported mean changes in PA from baseline to follow-up. Both of these studies reported a mean increase in PA levels for both daughters and mothers (Arredondo et al., 2014; Barr-Anderson et al., 2014).

3.6.2. PA outcomes according to the TIDieR components

The core intervention characteristics associated with increases in mother-daughter PA are reported. Of the 11 intervention groups where mothers and daughters participated together, the majority showed increases in PA for daughters (Alhassan et al., 2018; Barnes et al., 2015a; Barr-Anderson et al., 2014; Corr et al., 2019; Olvera et al., 2010; Ransdell et al., 2003a, 2003b). For the intervention groups underpinned by a named theory, 82% reported an increase in daughters' PA ($n = 9$; (Alhassan et al., 2018; Arredondo et al., 2014; Barnes et al., 2015a; Barr-

Anderson et al., 2014; Corr et al., 2019; Olvera et al., 2010; Ransdell et al., 2003a, 2003b), compared to 33% of intervention groups that did not report a theory ($n = 1$) (Olvera et al., 2013). There was heterogeneity in who delivered the interventions that resulted in increases in PA outcomes for daughters or mothers. Three of these interventions were delivered by the research team members only (Barnes et al., 2015a; Corr et al., 2019; Ransdell et al., 2003a, 2003b), one intervention was delivered by health care professionals only (Olvera et al., 2013), one intervention was delivered by the research team, health care professionals (exercise physiologist) and lay health advisors (Arredondo et al., 2014), while the remaining interventions ($n = 3$) were provided by a combination of exercise/dance/health advisors and research team members or health care professionals (Alhassan et al., 2018; Barr-Anderson et al., 2014; Olvera et al., 2010). Of the intervention groups involving a high number of sessions (21+), 71% showed positive PA outcomes for daughters (Alhassan et al., 2018; Olvera et al., 2010; Ransdell et al., 2003a, 2003b) and 50% for mothers (Alhassan et al., 2018; Ransdell et al., 2003a, 2003b). In terms of duration, 11 intervention groups were delivered in less than 3 months, with 91% of these groups showing an increase in mother-daughter PA ($n = 10$; (Alhassan et al., 2018; Barnes et al., 2015a; Barr-Anderson et al., 2014; Corr et al., 2019; Olvera et al., 2010; Ransdell et al., 2003a, 2003b). Three intervention groups were delivered for longer than 3 months, and of these, only one demonstrated an increase in mother-daughter PA (Barr-Anderson et al., 2014).

3.6.3. PA outcomes according to BCTs

Fourteen BCTs were identified as present in at least three of the nine studies in this review and were included in this analysis of potential effectiveness (see Fig. 2). The most frequently reported BCTs (i.e., *demonstration of behavior*, *instruction on how to perform the behavior*, *behavioral practice/rehearsal*, *credible source*) had a potential effectiveness ratio of at least 70% for daughters but for mothers it was typically lower (<60%). However, the BCTs with the highest potential

effectiveness ratio were not the most frequently observed, with *goal setting (behavior)* and *information on the health consequences of the behavior* having ratios of 80% and 100% respectively. Other self-regulatory related techniques such as *self-monitoring* and *problem-solving* were also identified in at least 70% of promising interventions.

4. Discussion

To our knowledge, this is the first systematic review to provide detailed insight into the behavior change theory and techniques used in interventions to increase PA in mother-daughter dyads, as well as examining intervention characteristics using the TiDieR guidelines. We included 11 studies which detailed 14 interventions. There were six RCTs included in this study and all were deemed to be at a high risk of bias, while all non-RCTs were judged to be at a critical risk of bias. Thus, the results of these studies should be viewed with caution due to these methodological concerns, however, a number of interventions showed an increase in PA outcomes mothers and daughters. Many of these studies used social cognitive theory as a theoretical foundation, were less than 3 months in duration, with multiple sessions per week. A number of behavior change techniques showed promise across these studies such as, information on the health consequences, and goal-setting.

Seventy two percent of studies reported using theory to underpin their intervention, mostly social cognitive theory. For studies that reported using theory, positive associations with PA outcomes were shown in 82% of studies. At times though, it was unclear as to how the theory was applied. For example, there was limited discussion about how the theoretical constructs might be targeted and only 50% of these studies reported that they measured the related theoretical constructs, primarily efficacy beliefs. Hence, it could be argued that many of the interventions were 'theory inspired rather than theory based' (Michie and Abraham, 2004). Improved specification of the links between intervention components and theoretical constructs would assist in determining the effects of theory-based interventions on intervention effectiveness (Hagger and Weed, 2019). The use of social cognitive theory is appealing as it can enable an examination of the efficacy beliefs that exist within close relationships such as mother-daughters (Beauchamp et al., 2019), and efficacy beliefs are also a consistent predictor of physical activity behavior (Bauman et al., 2012). However, motivational and environmental factors also have a key role to play in changing behavior (Gardner et al., 2016). Consequently, there is a need to look beyond social cognitive theory to theoretical approaches such as family systems theory (Rhodes et al., 2020a), transactive goal dynamics theory (Carr et al., 2019) or integrated approaches such as the behavior change wheel (Michie et al., 2011).

We used the BCT v1 taxonomy to code the behavior change techniques within studies. Our review highlighted that the most frequently reported BCTs were *demonstration of behavior*, *instruction on how to perform behavior*, *behavioral practice/ rehearsal*, and *credible source*. This is perhaps unsurprising due to the nature of the interventions, i.e., group-based activity classes led by an expert practitioner (Keogh et al., 2015). However, when we examined the BCTs associated with promising interventions, a slightly different picture emerged. Specifically, *information on the health consequences* of being active and *behavioral goal-setting* were included in at least 80% of the promising interventions. Other self-regulatory techniques also appear to be important such as *problem solving*, and *self-monitoring*, both were identified in at least 70% of interventions that were deemed promising. Indeed, previous research has highlighted how combining self-regulatory related BCTs (i.e., *self-monitoring*, *goal-setting* and *problem solving*) can lead to greater effects than using the techniques in isolation (Michie and Abraham, 2004). Interestingly, BCTs such as *goal-setting* were less likely to be associated with increasing mothers' levels of PA across interventions. It may be that these interventions primarily looked to increase daughters' PA and saw mothers' increases in PA as a by-product. Dyadic interventions targeting

pairs such as mother-daughters are believed to more effective when either shared system-oriented (i.e., both dyad members have the same goal for themselves and for the other person) or shared target-oriented type-goals are set (both dyad members have the same goal for one member in the dyad) (Carr et al., 2019; Fitzsimons et al., 2015). In the studies included in the review, it was unclear as to the specificity of mother and daughter goals and whether they applied this shared system or targeted oriented approach. Future research should carefully consider how goal-setting is used and how goals are aligned within mother-daughter dyads.

While both the application of theory to underpin an intervention and the specification of BCTs as the active ingredients of the intervention is important, intervention effectiveness can also be influenced by components such as, who delivered it, when and where it was delivered and for how long (Gardner et al., 2016). To assess these elements across studies, we used the TiDieR guidelines (Hoffmann et al., 2014). Who delivered the intervention seemed to have little impact on the intervention outcomes, a finding in line with other reviews of PA interventions (Zubala et al., 2017). In terms of when and where, the interventions were primarily delivered in an after-school or community context. Only three were delivered outside these contexts with mixed effects on PA behavior (i.e., two studies were home-based, and one was an online intervention) highlighting the need for greater testing of home/online interventions. Indeed, researchers have called for increased investigation into PA family-based interventions delivered in the home (Rhodes and Lim, 2018). Most of the interventions were less than 3 months in duration with 81% of these positively associated with an increase in mother-daughter PA behavior. This finding is in line with a review of pre-adolescent PA interventions that also found greater effectiveness in interventions of less than 12 weeks (Biddle et al., 2014). Furthermore, most interventions that had a positive effect on PA levels included at least two interventions sessions per week. There is typically little guidance as to how many sessions or how much contact with intervention providers is needed to change PA behavior (Zubala et al., 2017), thus, the study findings may provide some initial guidance for this particular population. How well the intervention was delivered focused on attrition and attendance at intervention sessions. The findings were varied with only half the interventions having attendance rates above 70%. Only one study reported on the delivery of content as planned (Barnes et al., 2015a). This is a similar finding to a recent review (Howlett et al., 2018). However, it is important that further studies address this gap as without a clear assessment of intervention fidelity, we are unable to clearly understand why an intervention may or not have been effective.

The review found a high risk of bias across both the RCTs and non-RCTs. For example, for the RCTs, only one study clearly reported allocation concealment (Barnes et al., 2015a), and four out of the six studies were at high or unclear risk of bias for missing data and how it was treated. The non-RCTs also contained serious methodological concerns, with none of these studies incorporating a control group, and most only using self-report PA outcome measures. Consequently, the review findings must be treated with caution, and there is a requirement for more rigorously designed and evaluated studies examining the effects of PA-based interventions for daughters and their mothers. This review provides a unique contribution to the literature by augmenting our understanding of the key intervention characteristics, and behavior change theory and techniques used in mother-daughter PA interventions. For researchers, the review highlights the need to consider theories other than social cognitive theory to underpin interventions, and to more accurately describe how interventions are informed by and test the particular theory. Future studies should also more clearly detail how goal setting is used within interventions and whether goals might align or differ across mother-daughter dyads. Finally, there were few interventions in the review that were delivered in the home or through an online environment. Considering the Covid-19 pandemic, there is an urgent need to design and examine interventions that are delivered remotely and/or in the home. For practitioners, the review provides

some clarity as to characteristics of interventions that might increase PA levels of girls and their mothers, specifically, interventions that are less than 12 weeks in duration, have multiple sessions per week, and incorporate some form of self-regulation.

4.1. Strengths and limitations

There were a number of strengths to this review. The application of the TIDieR guidelines enabled us to identify the key characteristics of interventions targeting mother-daughter PA and highlighted how some aspects were poorly reported such as the fidelity of intervention delivery. Alongside this, we used the BCT Taxonomy v1 to identify the active ingredients of the interventions, and this information can be used to inform the development of future interventions with this cohort. Future research should consider the use of such guidelines and methodological tools in describing interventions as well as increased formative work with both mothers and daughters to help develop interventions that are feasible, acceptable and implementable (Brown et al., 2020; O'Cathain et al., 2019; Yardley et al., 2015). Also, the inclusion of studies beyond RCTs allowed for a more pragmatic approach to try to understand which components might be helpful in this particular context. However, there were also limitations to this review. While the inclusion of non-RCTs in this review facilitated a more pragmatic approach, the methodological issues associated with this type of design should be acknowledged and can weaken the evidence base. Meta-analysis of PA outcomes was not possible due to the heterogeneity of the data. For BCT potential, we classified interventions as promising based on whether there was between or within-group change on at least one form of PA, and while in line with previous reviews (e.g., (Gardner et al., 2016; Nyman et al., 2018)), it was somewhat arbitrary. Similarly, the criteria of BCTs having to be used in at least three studies may have limited our understanding as it excluded BCTs that may have been effective but were rarely reported in studies.

5. Conclusion

This review is the first to assess mother-daughter interventions targeting PA using the TIDieR guidelines and the BCT v1 taxonomy. In doing so, the study contributes to our understanding of the key components of mother-daughter interventions targeting PA whilst applying a note of caution due to the risk of bias. The review findings may offer a useful starting point for the additional research that is necessary to expand the knowledge of PA-based interventions for daughters and their mothers in a way that is more clearly defined, programmed, and evaluated.

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Declaration of Competing Interest

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ypmed.2021.106764>.

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