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*Interventions to improve physical activity during pregnancy: a systematic review on issues of internal and external validity using the RE-AIM framework*

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**Interventions to improve physical activity during pregnancy: A systematic review on issues of internal and external validity using the RE-AIM framework**

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28 **Abstract**

29 Background: Physical activity during pregnancy has significant health benefits for the mother  
30 and her child, however, many women reduce their activity levels during pregnancy and most  
31 are not sufficiently active. Given the important health benefits of PA during pregnancy,  
32 evidence that supports research translation is vital.

33 Objectives: To determine the extent to which physical activity interventions for pregnant  
34 women report on internal and external validity factors using the RE-AIM framework (reach,  
35 efficacy/effectiveness, adoption, implementation, and maintenance).

36 Search Strategy: Ten databases were searched up to 1 June 2015. Eligible published papers  
37 and unpublished/grey literature were identified using relevant search terms.

38 Selection Criteria: Studies had to report on physical activity interventions during pregnancy,  
39 including measures of physical activity during pregnancy at baseline and at least one point  
40 post intervention. Randomised controlled trials and quasi-experimental studies that had a  
41 comparator group were included.

42 Data Collection and Analysis: Reporting of RE-AIM dimensions were summarised and  
43 synthesised across studies.

44 Main Results: The reach (72.1%) and efficacy/effectiveness (71.8%) dimensions were  
45 commonly reported, however, the implementation (28.9%) and adoption (23.2%) dimensions  
46 were less commonly reported and no studies reported on maintenance.

47 Conclusions: This review highlights the under reporting of issues of contextual factors in  
48 studies of physical activity during pregnancy. The translation of physical activity  
49 interventions during pregnancy could be improved through reporting of representativeness of  
50 participants, clearer reporting of outcomes, more detail on the setting and staff who deliver  
51 interventions, costing of interventions and the inclusion of process evaluations and qualitative  
52 data.

53 PROSPERO registration number: CRD42015019801

54 Tweetable Abstract: The systematic review highlights the under reporting of contextual  
55 factors in studies of physical activity during pregnancy.

56

57 Key words: Physical activity, pregnancy, internal/external validity, translation, intervention,

58 RE-AIM

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60

## 61 **Introduction**

62 Physical activity (PA) during pregnancy has substantial physical and psychological health  
63 benefits for the mother and her child <sup>1-5</sup>, including reduced risk of developing gestational  
64 diabetes <sup>6</sup>, reduced incidence and severity of prenatal and postnatal depressive symptoms <sup>2, 7</sup>  
65 and the normalisation of birth weight <sup>3</sup>. Recommended levels of PA during pregnancy <sup>8</sup> are  
66 similar to the broader guidelines for PA in healthy adults <sup>9-11</sup>. Despite the benefits of PA and  
67 recommendations that women continue to be active during pregnancy, many women reduce  
68 their activity levels during pregnancy and most are not sufficiently active <sup>12-15</sup>. For example,  
69 a study in the US found that less than 20% of pregnant women were meeting the  
70 recommended levels of PA <sup>16</sup>. Pregnancy represents an opportunity to promote PA as women  
71 receive close medical attention and are often highly motivated to improve their health to  
72 benefit their children <sup>17</sup>.

73

74 To date, reviews of PA during pregnancy have focused on the efficacy of PA interventions on  
75 health and pregnancy outcomes <sup>3, 18, 19</sup> weight gain during pregnancy <sup>20, 21</sup>, and changing PA  
76 and diet to limit gestational weight gain <sup>22, 23</sup>. Only two systematic reviews have specifically  
77 examined the outcomes of interventions in terms of increasing PA during pregnancy <sup>24, 25</sup>.  
78 Currie et al.<sup>24</sup> reported that PA interventions incorporating behaviour change techniques help  
79 reduce the decline in PA throughout pregnancy. Pearce et al.<sup>25</sup> found that few of the PA  
80 interventions reviewed improved PA participation during pregnancy. Both of these reviews  
81 only included randomised controlled trials (RCTs) <sup>26</sup> and did not provide a thorough  
82 assessment of external validity of the included studies.

83

84 Assessing external validity when evaluating physical activity interventions in pregnancy is  
85 important because it enables conclusions to be reached about the generalizability of study  
86 findings to the broader population of pregnant women. Such conclusions can facilitate  
87 decision-making about what interventions are likely to be successfully implemented in what  
88 settings (e.g., clinical or community settings) and with what sub-populations of pregnant  
89 women. If external validity is low or unknown, then changes to the evaluations or the  
90 reporting of these evaluations, respectively, may be required.<sup>27</sup>.

91

92 The primary aim of this systematic review was to determine the extent to which PA  
93 interventions for pregnant women report on internal and external validity factors using the  
94 RE-AIM framework. A secondary aim was to examine whether there were differences in  
95 reporting of the RE-AIM dimensions and individual indicators by study design (RCTs  
96 compared to quasi-experimental designs).

97

## 98 **Methods**

### 99 **Literature search**

100 This review follows the Preferred Reporting Items for Systematic Reviews and Meta-  
101 Analyses (PRISMA) guidelines<sup>33</sup>. The systematic review protocol was registered with the  
102 International Prospective Register of Systematic Reviews (PROSPERO) on 14 May 2015 and  
103 updated on 3 November 2015.

104

105 Both published papers and unpublished/grey literature (abstracts were excluded) were eligible  
106 for inclusion in this review. We searched electronic databases, scanned the reference lists of  
107 included studies and relevant reviews, and wrote to the authors of included papers to

108 determine if they had conducted any additional research that we had not identified or had any  
109 further information relating to their published studies.

110

111 Individualised search strategies for each database were developed in collaboration with a  
112 professional librarian. Searches were performed up to 1 June 2015. We included ten  
113 databases in our main search strategy; Health Policy Reference Center via EBSCO;  
114 PsycINFO via EBSCO; Medline Complete via EBSCO; CINAHL Complete via EBSCO;  
115 Informit: Health Subset; Embase; Scopus; SportDiscus with full text via EBSCO; Global  
116 Health via EBSCO; Academic Search Complete via EBSCO. An example search strategy is  
117 included in Supplementary Table 1 (Table S1). We also conducted supplementary searches  
118 (e.g., Google advanced search, GreyLit, The Grey Literature Report) to identify additional  
119 literature, using similar search terms to our main search.

120

121 MC and BH conducted the screening and study selection process. Initially, MC and BH  
122 independently screened 605 records against the inclusion criteria (Cohen's kappa = 0.875;  
123 very good inter-rater agreement<sup>34</sup>). BH and MC then screened the remaining entries. We  
124 obtained full reports for all titles that appeared to meet the inclusion criteria or where there  
125 was any uncertainty. MC and BH, independently of each other, conducted a pilot full text  
126 screen of 50 reports using the inclusion criteria (Cohen's kappa = 0.901; very good inter-rater  
127 agreement<sup>34</sup>). MC and BH then screened the remaining full-text of reports. For the  
128 intervention studies that met the inclusion criteria for our review, qualitative studies, process  
129 evaluations, cost or other information relating to the intervention were included as companion  
130 papers.

131 **Inclusion criteria**

132 Studies were selected according to the following inclusion criteria: *Participants*: Women  
133 during pregnancy; *Intervention*: PA interventions, including where PA was the sole focus or  
134 part of interventions with multiple lifestyle factors. We excluded studies that included only  
135 pelvic floor exercises; *Comparators*: Comparison of alternative interventions, usual care, or  
136 no intervention; *Outcomes*: PA measured during pregnancy at baseline and at least one point  
137 post intervention initiation (but still during pregnancy); *Study Designs*: Randomised  
138 controlled trials and quasi-experimental that had a comparator including alternative  
139 interventions or usual care.

140 **Data Extraction**

141 *Study Characteristics*

142 We extracted then following data from each study: country, study design, control condition,  
143 number of participants and demographic characteristics, PA intervention description, measure  
144 of PA and timing of assessments, study results, other outcomes assessed.

145 *RE-AIM evaluation*

146 Incorporating aspects of both internal and external validity, the RE-AIM framework (reach,  
147 efficacy/effectiveness, adoption, implementation and maintenance) was designed to focus  
148 attention on aspects of interventions that can improve the translation of strategies into  
149 practice<sup>28, 29</sup>. The RE-AIM framework has been applied to reviews of PA interventions for a  
150 range of population groups, including breast cancer survivors<sup>30</sup>, Latin Americans<sup>31</sup>, and  
151 people with type 2 diabetes<sup>32</sup>. The RE-AIM framework as also been applied to health  
152 interventions during pregnancy, including an evaluation of the Alcohol and Pregnancy  
153 Project<sup>35</sup> and a comparison of two approaches to promoting smoking abstinence in pregnant  
154 and postpartum women<sup>36</sup>.

155



156 RE-AIM dimensions include reach, efficacy/effectiveness, adoption, implementation and  
157 maintenance<sup>28, 29</sup>. Reach is a measure of individual-level participation, including the  
158 proportion of the population targeted that are affected by the intervention, as well as the  
159 representativeness of the participants to the target population. Efficacy/effectiveness  
160 measures include the effectiveness of the intervention, positive or negative consequences of  
161 the intervention, as well as behavioural, quality of life, and participant satisfaction outcomes.  
162 Adoption is concerned staff and settings, the proportion of existing or available settings that  
163 offer the intervention and how representative these settings are of the community as a whole.  
164 Implementation refers to the degree to which the intervention is delivered as intended, and  
165 evaluated based on the faithfulness of the program administrators to the design of the  
166 intervention. Finally, maintenance includes an individual and an institutional level component  
167 about the sustainability of the intervention.

168

169 We used the 21-item data collection tool that has been used in several previous systematic  
170 reviews which have on reported the RE-AIM dimensions<sup>31, 37, 38</sup>. This tool was the basis for  
171 calculating percentages of studies meeting criteria for the five RE-AIM dimensions (reach,  
172 efficacy/effectiveness, adoption, implementation, and maintenance). Of note, one of the  
173 maintenance indicators relates to maintenance of individual behaviour 6 months post  
174 intervention completion; given that we were interested in PA during pregnancy, this indicator  
175 was deemed not applicable and was not included in our reporting. In addition to the 21-items,  
176 we also included assessments of eight additional indicators that were applied by Galaviz et  
177 al.<sup>31</sup> to provide a more comprehensive assessment of the RE-AIM framework.

178

179 We developed a coding manual, based on the coding manual used by Blackman et al.  
180 (personal communication, 2015), and MC and BH piloted this on eight studies. We discussed

181 any areas where discrepancies in consistency of data extraction arose. MC and BH coded the  
182 remaining studies and if there were any uncertainties, these were discussed; resolution was by  
183 consensus with direct reference to the research article.

184

185 We summarised RE-AIM criteria using means and frequencies. First, the average proportion  
186 of indicators reported within each RE-AIM dimension was computed (i.e., number of  
187 indicators reported for a given dimension divided by the total number of possible indicators  
188 within the dimension). Second, the proportion of studies that reported specific indicators  
189 within each RE-AIM dimension were computed (i.e., number of studies that reported divided  
190 by total number of studies).

## 191 **Results**

192 Figure 1 presents the flow of studies included in this review; 52 documents (representing 38  
193 studies) met inclusion criteria. Note that Dodd et al.<sup>39</sup> included a nested trial; this was  
194 assessed as a separate study and therefore the paper by Dodd et al.<sup>39</sup> was counted as two  
195 studies for the purpose of this review. To simplify reporting and distinguish between these  
196 studies, we used the citation for the thesis on which the nested study was based<sup>40</sup>. Ten  
197 companion documents (which did not meet the inclusion criteria) were also identified and  
198 provided additional information for the data extraction.

199

200 Figure 1 here

201

## 202 **Study characteristics**

203 Study characteristics are summarised in Supplementary Table 2 (Table S2). For ease of  
204 reading throughout the Results section, for studies with more than one reference we have  
205 referenced each study using the first reference in Table S2. Of the 52 documents retrieved, 42

206 were peer-reviewed publications and 10 were theses. Of the 38 studies identified, 33 were  
207 RCTs and the remaining five were quasi-experimental trials <sup>41-45</sup>.

208

209 Each of the studies included in this review reported several outcomes in addition to PA. The  
210 most common outcomes were behaviour change relating to diet <sup>39, 46-56</sup>, gestational weight  
211 gain <sup>43, 46-49, 52-59</sup>, improving outcomes for women who were obese/or had gestational diabetes  
212 mellitus (GDM) <sup>60-64</sup>, or the prevention of GDM <sup>43, 58, 65-67</sup>. Most interventions were  
213 unsupervised (n = 22<sup>39, 43, 45-47, 49, 50, 52-54, 56, 58, 59, 61, 64-66, 68-71</sup>). Six studies reported both  
214 objective and self-report measures of PA <sup>51, 58, 59, 71-73</sup>, two studies used only objective  
215 measures of PA <sup>67, 70</sup>, and the remaining 30 studies used self-report only. A number of  
216 different self-report measures were used; the most commonly used was the Pregnancy  
217 Physical Activity Questionnaire (PPAQ, n = 10) <sup>46, 49, 54, 63, 65, 66, 68, 73-75</sup>.

218

### 219 **RE-AIM evaluation**

220 On average, reach (72.1%) and efficacy/effectiveness (71.8%) were the most highly reported  
221 RE-AIM dimensions, fewer reported implementation (28.9%) or adoption (23.2%) and no  
222 studies reported maintenance indicators. Table 1 shows a detailed breakdown of the  
223 individual RE-AIM indicators, total and by study design.

224

225 Table 1 here

#### 226 *Reach*

227 On average, 3.6 (72.1%) of the 5 reach indicators were reported across the 38 studies; these  
228 indicators were more likely to be reported in RCTs than quasi-experimental studies (73.9%  
229 compared to 60.0%). Method to identify target population (n = 36, 94.7%), inclusion criteria  
230 (n = 35, 92.1%), exclusion criteria (n = 32, 84.2%), and participation rate (n = 25, 65.8%)

231 were all highly reported, however the characteristics of participants and non-participants (or  
232 other indicator of representativeness) was not highly reported (n = 9, 23.7%). The reporting  
233 of these indicators were similar across RCTs and quasi-experimental studies, except for  
234 inclusion criteria, which was more likely to be reported in RCTs (100% compared to 40%).

235

236 The number of participants in the studies ranged from 15<sup>42</sup> to 2212<sup>39</sup> (median = 151); the  
237 median participation rate was 58.8%. An indication of the representativeness of the sample  
238 was reported by nine studies (23.7%). Three interventions presented characteristics of non-  
239 participants (i.e., those who refused participation)<sup>51, 53, 60</sup>, four compared study participants to  
240 broader populations<sup>45, 50, 66, 67</sup>, one compared the sample with a large cohort study<sup>74</sup>, and one  
241 study compared the sample with other research and the broader population<sup>72</sup>. Other indicators  
242 assessed included per cent of participants who were excluded (e.g., were ineligible; n = 21,  
243 55.3% reported). No studies provided information on the cost of recruitment.

244

#### 245 *Efficacy/effectiveness*

246 On average, 2.9 out of 4 (71.8%) efficacy/effectiveness indicators were reported; these were  
247 more likely to be reported in RCTs than quasi-experimental trials (73.5% compared to 60%).  
248 Each of the included studies had measures of PA at baseline and at least one follow-up during  
249 pregnancy (100%). Data on attrition (specifically in relation to PA measures) were reported  
250 in 26 studies (68.4%), fewer measured quality of life or unintended consequences (n = 23,  
251 60.5%) or stated that they used intention-to-treat analysis (n = 22, 57.9%). RCTs were more  
252 likely than quasi-experimental studies to use intention-to-treat (n = 21, 63.6% compared to n  
253 = 1, 20%) and report on quality of life measures or unintended consequences (n = 22, 66.7%  
254 compared to n = 1, 20%); however, quasi-experimental studies were more likely to report on  
255 attrition (100% compared to 63.6%).

256

257 An improvement in PA was reported in 19 studies<sup>41, 42, 46, 48, 51, 55, 58-60, 63, 65, 66, 68-72, 74, 75</sup>.

258 Attrition rates were examined specifically in relation to PA assessment; median attrition rates  
259 were high but similar across the intervention (21.4%) and control conditions (23.4%). Other  
260 indicators assessed included imputation procedures, which were specified in 10 studies  
261 (26.3%), and measure of PA relative to public health goal, which was reported in six studies  
262 (15.8%).

263

264 *Adoption (setting and staff)*

265 One average, 1.4 of the 6 indicators for adoption were reported (23.2%); quasi-experimental  
266 studies were slightly more likely to report these indicators than RCTs (33.3% compared to  
267 21.7%). Level of expertise of staff (delivery agent) were reported in almost all of the studies  
268 (n = 35, 92.1%) and 12 (31.6%) provided an explicit description of the characteristics of the  
269 intervention location. However, all other aspects were reported in less than 6% of studies:  
270 description of staff who delivered the intervention (i.e., explicit behavioural/demographic  
271 characteristics of staff; n = 2, 5.3%), rate of adoption at the setting or delivery agent level (n  
272 = 2, 5.3%), inclusion/exclusion criteria of delivery agent or setting (n = 2, 5.3%), method to  
273 identify staff who delivered the intervention (0%). Each of these indicators were more  
274 commonly reported in quasi-experimental studies than RCT studies, except description of  
275 staff who delivered the intervention.

276

277 Interventions were delivered by a range of staff, including researchers and practitioners, and  
278 several interventions were delivered by several different types of staff. Common examples of  
279 staff included midwife or nurse (including research midwife/nurse, obstetric nurse, student  
280 nurse)<sup>41, 43-45, 51, 64, 75</sup>, physiotherapist<sup>43, 57, 60, 67, 68, 74</sup> and professional exercise trainer or

281 exercise physiologist<sup>48, 55, 63, 65</sup>. Only two studies included explicit descriptions of study staff;  
282 one study described the staff as parish nurses fluent in Spanish<sup>64</sup> and a second reported that  
283 staff were bilingual and bicultural health educators<sup>46</sup>.

284

285 Most of the included studies named the intervention location, which included health care and  
286 community settings, however fewer (n = 12, 31.6%) provided an explicit statement of  
287 characteristics of the location of the intervention<sup>43, 44, 50, 51, 53, 57, 58, 65, 66, 72, 74, 76</sup>. The rate of  
288 adoption of delivery settings was reported by two studies<sup>43, 47</sup> and the inclusion criteria for  
289 the delivery agent for setting was reported in two studies<sup>43, 44</sup>.

290

### 291 *Implementation*

292 On average, 1 of the 3 (mean = 0.9, 28.9%) of the implementation indicators were reported;  
293 these indicators were slightly more likely to be reported in quasi-experimental studies than  
294 RCTs (33.3% compared to 28.3%). Intervention intensity (including all three elements of  
295 timing, duration and intensity) were described in 27 (71.1%) of the included studies. Fewer  
296 reported the extent to which the protocol was delivered as intended (n = 4, 10.5%) or  
297 measures of the cost of implementation (we included cost effectiveness evaluations; n = 2,  
298 5.3%). Intervention intensity and extent the study protocol was delivered as intended was  
299 more commonly reported in quasi-experimental studies, however measures of cost were only  
300 reported in RCTs. Reporting on the extent that the protocol was delivered as intended was  
301 reported in a number of ways including participant reporting of interactions with staff<sup>45, 56</sup>,  
302 an adherence scale<sup>77</sup> and staff audio diaries<sup>51</sup>. Additional indicators that we assessed  
303 included participant adherence to the intervention (n = 28, 73.7%), consistency of  
304 implementation across settings and delivery agents (n = 3, 7.9%), and use of qualitative  
305 methods to understand implementation (n = 2, 5.3%).

306

307 *Maintenance*

308 Maintenance of the program was not reported in any of the studies and no studies reported on  
309 the cost of maintenance. An additional indicator was included, which was the use of  
310 qualitative data to understand setting level institutionalization; this was not reported in any  
311 study.

312 **Discussion**

313 **Main Findings**

314 We conducted a systematic review of PA interventions during pregnancy to identify reporting  
315 of elements relevant to internal and external validity that may inform the translation of  
316 interventions. We found that reporting was higher for aspects of internal validity, such as  
317 explicit inclusion and exclusion criteria, than issues of external validity, such as staff a  
318 description of staff who delivered the intervention or the method to identify staff who  
319 delivered intervention. The findings of our review also revealed several differences in  
320 reporting of RE-AIM dimensions between RCTs and quasi-experimental studies, however  
321 these were not substantial.

322

323 Individual level indicators, such as inclusion and exclusion criteria and participation rate,  
324 were well reported, however, the representativeness of participants was not. Other reviews of  
325 PA interventions have found low reporting of the representativeness of participants<sup>37, 78</sup>.

326 Given that, on average, 40% of women refused participation in the included studies,  
327 examination of the representativeness of participants is important. Among the studies that  
328 reported on aspects of generalisability, some reported that characteristics of participants and  
329 non-participants were similar or representative of their study population (e.g.,<sup>51</sup>); in contrast,  
330 others found demographic or behavioural differences (e.g.,<sup>45, 53</sup>). Knowing who declined to

331 participate in studies, and their reasons for doing so, may help in the development of targeted  
332 and accessible interventions for these populations.. Examples from this review include the  
333 comparison of study participants to the host maternity hospital population characteristics <sup>50</sup>,  
334 women giving birth in the district and state <sup>45</sup>, and the national pregnant population <sup>67</sup>.

335

336 Measures of PA at follow-up and attrition rates were highly reported, but intention-to-treat  
337 analysis and measures of quality of life or negative consequences were less well reported.  
338 Although there is strong evidence that PA is beneficial during pregnancy <sup>3,6</sup>, reporting of  
339 negative outcomes and adverse events is important because pregnancy is a time of  
340 physiological changes for women <sup>79</sup>. For example, blood volume and cardiac output increase  
341 during pregnancy, and other metabolic functions are altered to provide for the demands of the  
342 fetus <sup>79</sup>. Nineteen studies reported positive outcomes, in terms of higher levels of PA in the  
343 intervention compared to the control condition. Comparison of effectiveness across  
344 interventions is difficult, however, due to high levels of attrition (on average, over 20%), and  
345 heterogeneity in the detail of reporting of findings. Furthermore, only 15.8% reported PA  
346 participation relative to public health recommendations during pregnancy. Reporting of the  
347 effect of PA programs in a meaningful way, where comparisons can be made across  
348 interventions, allows decision-makers to assess the relative effectiveness of interventions.

349

350 The cost of delivery of interventions is a key factor in determining the translation of research  
351 findings in to practice. The need to make the best use of limited resources at all levels, from  
352 the national health service level to the local level, is imperative <sup>80,81</sup>. Two studies included in  
353 our review reported on the cost effectiveness of the intervention; one showed the intervention  
354 was not cost effective <sup>82</sup> and a second showed it was cost neutral <sup>83</sup>. Although several other  
355 studies commented that the intervention was not resource intensive (e.g.,<sup>56,61</sup>), they did not



356 report actual costs. The emphasis of research on PA has been on achieving significant  
357 outcomes, which often produce interventions that are intensive, expensive, and demanding <sup>84</sup>.  
358 Low-intensity interventions that are less efficacious, but have the potential to be delivered to  
359 large numbers of women, may have a more pervasive impact and be more cost-effective than  
360 high intensity interventions that are delivered to fewer women <sup>85</sup>. However, the state of the  
361 evidence for PA interventions in pregnancy does not yet allow us to draw this conclusion.  
362 The inclusion of indicators of the cost of interventions to promote PA during pregnancy are a  
363 priority.

364

365 The reporting of staff and setting level indicators was low and similar to previous reviews of  
366 PA interventions in other populations <sup>30,31</sup>. Details of the settings where interventions are  
367 delivered and staff who deliver interventions allow an assessment of whether an intervention  
368 produces a generalised effect or whether implementation varies according to local conditions.  
369 The staff involved in research studies often have high levels of training, expertise, or  
370 supervision, or they are employed solely to deliver the intervention being evaluated rather  
371 than having multiple competing responsibilities <sup>86</sup>. It is important to document the extent to  
372 which staff are willing to be involved in a study, their characteristics, and the level of training  
373 or skill required to implement the intervention <sup>87</sup>.

374

375 Process evaluations, including the use of qualitative research, can assist in understanding  
376 participant level and setting and staff level indicators. Several reported participant  
377 compliance to the intervention of less than 50% <sup>40,50,72</sup>, and half of the intervention included  
378 in the review had no impact on PA behaviour. Poston et al.<sup>51</sup> conducted a comprehensive  
379 process evaluation following Steckler and Linnan's <sup>88</sup> framework and provided important  
380 insights in to intervention delivery. Such evaluations are recommended in future studies.

381

382 The findings of our systematic review revealed differences between RCTs and quasi-  
383 experimental designs in the reporting of RE-AIM dimensions but these were not substantial.  
384 Studies using RCT designs tended to more highly report individual level factors whereas  
385 studies with quasi-experimental designs tended to report contextual factors more often. There  
386 have been criticisms of RCTs for their focus on internal validity at the expense of external  
387 validity and not providing information on how results can be implemented in practice <sup>89</sup>; we  
388 found that the quasi-experimental studies followed a similar pattern. Our comparison of  
389 RCTs and quasi-experimental studies must be interpreted with caution, however, due to the  
390 small number of quasi-experimental studies that we identified (n=5).

### 391 **Strengths and Limitations**

392 Our systematic review was novel in that it was first to assess issues of internal and external  
393 validity of physical activity interventions during pregnancy. Our review was comprehensive,;  
394 we identified a greater number of studies than previous reviews (14<sup>24</sup> and 9<sup>25</sup> studies). The  
395 review has some limitations, however. We only included studies with baseline and post  
396 intervention assessments of PA. Thus, studies that targeted gestational weight gain but did  
397 not assess PA behaviour did not meet the inclusion criteria for this review (e.g., <sup>90</sup>). Second,  
398 our review included studies that targeted health outcomes as well as those specifically  
399 focused on PA behaviour change and therefore there was a level of heterogeneity in aims and  
400 type of intervention delivery in the included studies. Finally, the researchers of the reviewed  
401 studies may have collected some of the information required to complete a RE-AIM  
402 evaluation, but did not report this in the articles and their intention may be to publish this  
403 information in the future <sup>78</sup>.

404 **Interpretation**

405 Our findings showed that although researchers frequently report on the internal validity of  
406 studies of PA during pregnancy, they do not report external validity as extensively<sup>28, 91</sup>. The  
407 translation of research to enhance PA during pregnancy could be improved through the  
408 reporting of information relating to the representativeness of study populations, clearer  
409 reporting of the effectiveness of interventions, more detail of the setting and staff who deliver  
410 interventions, costing of interventions, and the inclusion of process evaluations and  
411 qualitative data.

412 **Conclusions**

413 Reporting of issues of external validity needs to be improved so that physical activity  
414 interventions during pregnancy can be translated in to practice. The onus should fall on  
415 funding bodies, researchers, journals, and policy makers to ensure that this detail becomes  
416 standard practice when designing, conducting, and reporting findings of interventions<sup>92</sup>.  
417 Given the important health benefits of PA during pregnancy, evidence that supports research  
418 translation is vital.

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420 **Disclosure of Interests:** Nil

421 **Contribution to Authorship:**

422 MC was responsible for the study design, literature search, data extraction and analysis, and  
423 drafting the article. BH had significant input in to the study design, data extraction and  
424 provided critical reviews of the content of the article. CJG and HS had input in to the study  
425 design and interpretation of data and provided critical reviews of the content of the article.  
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768 List of Figure Captions:

769

770 **Figure 1.** Flow diagram of studies included in the review

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