Effectiveness of Acceptance and Commitment Therapy (ACT) interventions for promoting

physical activity: A systematic review and meta-analysis

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1   Physical inactivity is the fourth leading cause of death worldwide and is a key risk

2   factor for non-communicable diseases (NCDs) such as cardiovascular disease, some cancers

3   and type 2 diabetes (Lee et al. 2012). Worldwide, inactivity is estimated to cause 9% of

4   premature mortality, and if inactivity were decreased by 10%, more than 533,000 deaths

5   could be averted every year (Lee et al. 2012). The World Health Organisation (WHO)

6   recommendations for adults aged 18–64 are for at least 150 minutes of at least moderate-

7   intensity aerobic physical activity (such as brisk walking or cycling) per week (WHO, 2019).

8   However, the majority of the world's population does not meet these recommendations (Ding

9   et al. 2016; Rhodes, Janssen, Bredin, Warburton, & Bauman, 2017), and globally physical

10   inactivity is on the rise (Lee et al. 2012). Given the public health burden associated with

11   physically inactive lifestyles, there is a critical need for interventions that are effective in

12   promoting the adoption and maintenance of regular physical activity, and over the last two

13   decades, a wide range of interventions have been developed and evaluated in efforts to

14   improve population levels of physical activity (PA) (Howlett, Trivedi, Troop, & Chater,

15   2019).

16   Grounding health promotion interventions in theory is often viewed as 'good practice'

17   (Glanz & Rimer, 2005; Taylor, Conner, & Lawton, 2012; Prestwich, Webb, & Conner,

18   2015), and in many cases the development and evaluation of physical activity interventions

19   has been guided by theory. The most common theories that have been used in the

20   development of physical activity interventions are intrapersonal and interpersonal theories,

21   such as the Health Belief Model (HBM; Rosenstock, 1974), the Stages of Change

22   (Transtheoretical) Model (TTM; Prochaska & Velicer, 1997), the Theory of Planned

23   Behaviour (TPB; Ajzen, 1991), and Social Cognitive Theory (SCT; Bandura, 1986) (Glanz et

24   al. 2005). All of these theories have in common that they attempt to promote behaviour

25   change by targeting factors such as an individual's knowledge, attitudes, beliefs, motivation,

26   and skills in order to increase their intention to engage in the target behaviour (Glanz &

27   Rimer, 2005; Rhodes & Nigg, 2011), and all have been shown to be effective at inducing a

28   small to medium effect size on physical activity behaviour (Gourlan et al. 2016). Recently,

29   however, there has been interest in the potential for basing health behaviour change

30   interventions on a relatively new contextual and acceptance-based approach known as

31   Acceptance and Commitment Therapy (ACT) (Zhang et al. 2018; Hayes, Strosahl, & Wilson,

32   1999; Hayes, Luoma, Bond FW, & Masuda, 2006).

33

34   **Acceptance and Commitment Therapy (ACT) and the Psychological Flexibility Model**

35   **of Behaviour Change**

36   Unlike many other behaviour change interventions, ACT doesn't aim to directly

37   change internal experiences (such as thoughts, beliefs about capability, memories, feelings, or

38   bodily sensations etc.), but instead aims to foster acceptance and mindfulness skills to enable

39   greater behavioural regulation in the presence of these internal experiences (Zhang et al.,

40   2018). This increase in behavioural regulation has been called 'psychological flexibility',

41   which is defined as "contacting the present moment fully as a conscious human being, and

42   based on what the situation affords, changing or persisting in behaviour in the service of

43   chosen values" (Biglan, Hayes, & Pistorello, 2008). In other words, fostering psychological

44   flexibility encourages individuals to change their relationships with internal experiences

45   (rather than changing the experiences themselves) in such a way that they can engage in

46   desired behaviours (e.g. increasing physical activity), even in the presence of difficult

47   thoughts (e.g. '*I'm too tired*', '*I don't have time to exercise*') and feelings (e.g. the physical

48   discomfort that comes with moderate-vigorous exercise).

49

50   To date, ACT is the most researched intervention model based on the psychological

51   flexibility model of behaviour change (Zhang et al., 2018). According to this model,

52   psychological flexibility is the ability to contact the present moment more fully as a

53   conscious human being, and to change or persist in behaviour when doing so serves valued

54   ends. To build psychological flexibility, ACT interventions target six core processes (Zhang

55   et al., 2018; Hayes et al., 1999; Hayes et al., 2006; Biglan et al., 2008): 1) *Acceptance* (the

56   willingness to have and accept private experiences); 2) *Defusion* (the ability to see thoughts

57   as descriptions of one's experience and not actual reality); 3) *Contact with the Present*

58   *Moment* (the ability to fully open to and aware of what is happening in the present moment);

59   4) *Self-As-Context* (awareness of an 'observing self', as distinct from the experiences

60   observed); 5) *Values* (directions in life that an individual can choose to guide their

61   behaviour); and 6) *Committed Action* (Engaging in a pattern of behaviour, in pursuit of short-

62   and medium-term health-related goals, that is consistent with identified values). More

63   detailed definitions of the six core ACT processes can be found in Supplementary Document

64   1. In addition to these six key processes, ACT interventions often begin with *Creative*

65   *Hopelessness*, the aim of which is to undermine the control agenda and promote a more

66   workable, expansive behavioural repertoire. The control agenda is the belief that people often

67   have that in order to engage in behaviours that are important or meaningful, they must first

68   control how they think or feel – for instance, to feel motivated, to feel less tired, or to have

69   more confidence. While not one of the six core processes targeted by ACT, *Creative*

70   *Hopelessness* is often viewed as being critical to opening an individual up to a new way of

71   relating to their internal experiences and is thought to help pave the way for working with the

72   six core processes. A more detailed definition of Creative Hopelessness can be found in

73   Supplementary Document 1.

74

75   **Acceptance and Commitment Therapy (ACT) for Physical Activity**

76   Generally, ACT-based interventions have shown promise for promoting a range of

77   health behaviours, including smoking cessation (Gifford et al. 2004; Gifford et al. 2011;

78   Hernández-López, Luciano, Bricker, Roales-Nieto, & Montesinos, 2009; Bricker et al., 2017;

79   Bricker et al., 2014) and weight management (Forman & Butryn, 2015; Lillis, Hayes,

80   Bunting, & Masuda, 2009; Lillis & Kendra, 2014), and evidence is emerging that ACT-based

81   interventions may be effective for promoting physical activity (Zhang et al., 2018). Although

82   physical activity confers many benefits, it is also inconvenient and requires considerable time

83   and energy, it may not be intrinsically enjoyable, and the discomfort associated with physical

84   activity initiation can be a strong contributor to premature termination (Ekkekakis,

85   Hargreaves, & Parfitt, 2013). Acceptance and Commitment Therapy (ACT), therefore, is

86   particularly suitable for physical activity because it encourages:

87   1. Experiential acceptance: ACT uses a variety of acceptance-based metaphors and

88   experiential exercises to increase awareness and acceptance of unwanted thoughts, feelings,

89   and sensations (such as the emotional and/or physical discomfort that may be experienced

90   during physical activity) in order to foster the ability to make room for unpleasant internal

91   experiences without trying to change or eliminate them (Hayes et al., 1999; Hayes et al.,

92   2006; Biglan et al., 2008);

93   2. Behavioural commitment to valued life-directions: ACT emphasizes the necessity

94   of identifying desired life directions (i.e. values) in domains related to health and fitness (e.g.

95   maintaining physical independence) in order to motivate engagement in behaviours that are

96   consistent with those values. ACT also aims to foster the willingness and ability to forego a

97   behaviour that is perceived as more pleasurable or requires less effort (e.g. sitting on the

98   couch after dinner and watching TV) in order to engage in a behaviour that is more consistent

99   with one's health and fitness values (e.g. going for a walk after dinner) (Hayes et al., 1999;

100 Hayes et al., 2006; Biglan et al., 2008).

101

102 **Behaviour Change Techniques (BCTs) – the 'Active Ingredients' of Interventions**

103   Behaviour Change Techniques (BCTs) have been defined as the 'active ingredients'

104 of behaviour change interventions in that they are "observable, replicable, and irreducible

105 component[s] of an intervention designed to alter or redirect causal processes that regulate

106 behaviour" (Michie et al., 2013, p4). In their development of a BCT taxonomy (the

107 Behaviour Change Technique Taxonomy version 1, BCTTv1), Michie et al. (2013) identified

108 93 individual BCTs, which cluster into 16 groups of BCTs.

109   Although it is considered best practice to develop behaviour change interventions

110 based on theory, some previous reviews have demonstrated that, on the whole, physical

111 activity interventions that are guided by a theory are no more effective that atheoretical

112 interventions (Conn, Hafdahl, & Mehr, 2011; Prestwich et al., 2014; McEwan et al., 2016;

113 Rhodes, Janssen, Bredin, Warburton, & Bauman, 2017). One explanation for this has been

114 that the main 'driver' of behaviour change is the specific BCTs used in interventions, rather

115 than the theory upon which the interventions are based (McEwan et al., 2019). If this were

116 the case, theory-based and atheoretical interventions could have similar effects if the same

117 BCTs were used in both types of intervention (McEwan et al., 2019). Consequently, it has

118 been recommended that the specific content of an intervention (in terms of the included

119   BCTs) is considered when examining the effectiveness of physical activity interventions, in

120   addition to the underlying theory on which the intervention is based (McEwan et al., 2019).

121   The main aim of this review was to examine the effectiveness of ACT-based

122   interventions for physical activity. However, the review is also intended to aid the

123   development of future ACT interventions for physical activity by describing the current state

124   of the field and highlighting how ACT theory has been applied to physical activity. ACT

125   interventions are typically defined by the theoretical processes of change that they target

126   (namely, *Acceptance*; *Defusion*; *Contact with the Present Moment*; *Self-As-Context*; *Values*;

127   and *Committed Action*), rather than being defined by the specific techniques used to target

128   those processes (Zhang et al., 2018; Hayes et al., 1999; Hayes et al., 2006; Biglan et al.,

129   2008; Hofmann a& Hayes, 2019). Consequently, it is currently unclear how the constructs

130   and content of ACT interventions relate to traditional BCTs (such as self-monitoring, action

131   planning, etc.) - and hence a key aim of this paper was to identify which ACT processes are

132   typically targeted by ACT-based interventions for physical activity, and also identify which

133   BCTs of the BCTTv1 (Michie et al., 2013) are included in the content of ACT-based

134   interventions.

135   To summarise, the aims of this review were to:

136   1. Determine the effectiveness of ACT interventions for physical activity though a meta-

137   analysis.

138   2. Identify the ACT processes targeted by effective interventions through coding intervention

139   descriptions and protocols (where available).

140   3. Identify the behaviour change techniques (BCTs) included in effective interventions

141   through coding descriptions and protocols (where available) using the BCTTv1.

142   4. Identify other intervention characteristics associated with effective interventions.

143

Methods

145   This systematic review followed a protocol registered with PROSPERO (registration

146   number: CRD42018115730) (Pears, Sutton, & Griffin, 2018) and used the PRISMA checklist

147   (provided in Supplementary Document 2) for reporting systematic reviews (Moher, Liberati,

148   Tetzlaff, & Altman, 2009).

149

150   **Inclusion and Exclusion Criteria**

151   Studies were required to meet the following criteria: (i) Randomized controlled trials

152   (RCTs) or pre-post designs; (ii) the intervention was designed to increase physical activity

153   (interventions targeting multiple health behaviours were excluded); (iii) the study must report

154   a physical activity behaviour outcome (either objective or subjective /self-report); (iv) the

155   study must include an intervention based on ACT (delivered individually or in a group; via

156   single or multiple sessions; by any provider, including fully-digitized interventions; in any

157   setting); (v) the study must target adult participants (≥18 years); (vi) the study must be

158   available in English language.

159

160   **Search Strategy**

161   Seven electronic databases were searched from 1980 up to June 26th 2018:

162   MEDLINE, EMBASE, PsycINFO, Web of Science, Scopus, CINAHL, and the Cochrane

163   Library. Searches were restricted to 1980 or later, as acceptance and commitment therapy

164   was not developed before 1982. The search strategy was designed and conducted with the

165   help of a university librarian (IK). The search terms were "acceptance and commitment

166   therapy" AND "physical activity". Physical activity is defined as any bodily movement

167   produced by skeletal muscles that results in energy expenditure. In daily life, physical activity

168   can be categorized into work-related, sports, conditioning, household, or other activities

169   (Caspersen, Powell & Christenson, 1985). Associated synonyms were identified and keyword

170   and subject heading searches were performed. The strategy was adapted for each database.

171   The full search strategy for each database can be found in Supplementary Document 3. To

172   address the grey literature the list published on the ACBS (Association for Contextual

173   Behavioural Science) website of ACT interventions for physical activity was searched.

174   Reference lists of included studies were hand searched. The search was updated on May 29th,

175   2019.

176

177   **Study Selection**

178   Two reviewers (SP/SS) independently screened titles and abstracts retrieved by the

179   search strategy. Full-text articles were then reviewed for eligibility by the same two

180   reviewers. The first instance where studies did not meet eligibility was recorded, and the

181   study was not assessed for further criteria. The selection of studies was recorded according to

182   the PRISMA guidelines. Conflicts between reviewers were resolved through discussion

183   between the two independent reviewers. Cohen's kappa (κ) was calculated as a measure inter-

184   rater reliability (Landis & Koch, 1977). Figure 1 shows the study search results and selection

185   process.

186

187   **Data Extraction**

188   One reviewer (SP) extracted the data into a standardized data extraction form

189   developed specifically for this review. Data extraction was verified by a second reviewer

190   (SS). Disagreements between reviewers were resolved through discussion.

191   Data were extracted on:

192   *Study characteristics:* number of participants randomized; total number allocated to

193   each trial arm; setting; design; trial arms; measurement times; physical activity outcome

194   measures (objective or self-report); retention (calculated as a percentage of those randomized

195   to the intervention and completed follow-up assessment).

196   *Participant characteristics:* age (mean and range); gender (% female); population.

197   *Effectiveness of intervention:* mean and standard deviation at baseline,

198   postintervention, and follow-up for all physical activity outcomes (objective and self-report);

199   effect size at post assessment and follow up. Where not reported, effect sizes were calculated

200   based on postintervention and follow-up means, standard deviations, and sample sizes for

201   each condition to produce standardized mean differences (SMD), with 95% confidence

202   intervals (CIs).

203   *Intervention and Comparator characteristics:* Description of trial arms; Delivery

204   provider; Format; Duration; Intensity (e.g. number of intervention contacts, duration of

205   contacts, number of modules); Materials; ACT processes; BCTs.

206

207   **Risk of Bias**

208   Two reviewers (SP and SS) independently assessed risk of bias using the revised

209   Cochrane Risk of Bias Tool 2.0 (Higgins et al. 2016). Studies were coded as *low*, *high* or

210   *some concerns* of bias in the following five domains: 1) Risk of bias arising from the

211   randomization process; 2) Risk of bias due to deviations from the intended interventions

212   (effect of assignment to intervention); 3) Risk of bias in missing outcome data; 4) Risk of

213   bias in measurement of the outcome; 5) Risk of bias in selection of the reported result. An

214   overall risk of bias rating of *low*, *high* or *some concerns* was given to each study based on the

215   following criteria: *Low risk:* Low risk of bias across all domains; *High risk:* High risk of bias

216   in at least one domain OR some concerns for multiple domains in a way that substantially

217   lowers confidence in the result; *Some concerns:* Some concerns in at least one domain, but

218   not to be at high risk of bias for any domain.

219

220   **ACT Processes**

221   Two reviewers (SP/SS) independently coded the ACT processes targeted in the

222   intervention conditions of the included studies using a fixed-choice format to specify whether

223   ACT processes were *explicitly named* (when ACT processes were explicitly named in the

224   manuscript), *identifiable* (when processes could be identified from the intervention

225   description, protocol or supplementary material, but were not explicitly named) or *absent*.

226   Cohen's kappa (κ) was calculated as a measure inter-rater reliability (Landis & Koch, 1977).

227   Disagreements between reviewers were resolved through discussion.

228

229   **BCTs**

230   Two reviewers (SP/SS) trained in the use of the Behaviour Change Technique

231   Taxonomy v1 (Michie et al. 2013) coded the BCTs in the intervention and comparator

232   conditions of the included studies. Coders independently coded the intervention and

233   comparator condition using a fixed-choice format to specify if BCTs were definitely *present*,

234   *probably present* (when techniques may have been used but this was uncertain) or *definitely*

235   *absent*. Only BCTs targeting physical activity behaviour of intervention participants were

236   coded. Cohen's kappa (κ) was calculated as a measure inter-rater reliability (Landis & Koch,

237   1977). Disagreements between reviewers were resolved through discussion.

238

239   **Statistical analysis**

240   For each study, we included the effect size for a physical outcome measure at the

241   longest follow-up time-point available, choosing where possible a continuous, objective

242   measure that best reflected overall physical activity.

243   A random effects meta-analysis calculated the pooled effect size, using the Chi-

244   Squared test (Q-Statistic) to test for heterogeneity between studies and the I_2 statistic to

245   estimate the proportion of variance due to real difference across studies rather than random

246   error, using the widely used cut offs of 25%, 50% and 75% to represent low, moderate and

247   high heterogeneity respectively (Higgins, Thompson, Deeks, & Altman, 2003). A random

248   effects meta-regression was planned to examine whether intervention components were

249   associated with intervention effect. We intended to assess publication bias using funnel plot

250   techniques, Begg's rank test and Egger's regression test, as appropriate given the known

251   limitations of these methods (Ruszni Nik Idris, 2012).

252

253   **Results**

254   A total of 1686 references were returned from the search strategy after removal of

255   duplicates (Figure 1). Fourteen articles were identified as potentially relevant, with seven

256   studies fulfilling all review criteria (Butryn, Forman, Hoffman, Shaw, & Juarascio, 2011;

257   Ivanova, Yaakoba-Zohar, Jensen, Cassoff, & Knäuper 2016; Kangasniemi, Lappalainen,

258   Kankaanpää, Tolvanen, & Tammelin, 2015; Martin, Galloway-Williams, Cox, & Winett,

259   2016; Moffitt & Mohr, 2015; Fletcher, 2011; Stevens, 2017). Cohen's kappa (κ) was 0.61 for

260   title selection, 0.62 for abstract selection and 1 for full-text selection, representing substantial

261   to perfect agreement. All seven included studies focused on physical activity interventions.

262   None reported on sedentary behaviour.

263

264   **Study characteristics**

265   Table 1 summarises study characteristics. The seven included papers reported seven

266   studies, including seven ACT-based interventions. Four studies were conducted in the USA

267   (Butryn et al., 2011; Fletcher, 2011; Martin et al., 2016; Stevens, 2017), one in Canada

268   (Ivanova et al., 2016), one in Australia (Moffitt and Mohr, 2015), and one in Finland

269   (Kangasniemi et al., 2015). One study was set in a university campus (Butryn et al., 2011),

270   one was set in the community (Martin et al., 2016), one was set in a centre for nutrition and

271   metabolism (Fletcher, 2011), and for four studies the setting was not specified (Ivanova et al.,

272   2016; Kangasniemi et al., 2015; Stevens, 2017; Moffitt and Mohr, 2015). There were six

273   randomized controlled trials (RCTs), and one pre-post study (Martin et al., 2016). Four

274   studies compared an ACT intervention with another intervention (Butryn et al., 2011;

275   Ivanova et al., 2016; Kangasniemi et al., 2015; Moffitt and Mohr, 2015), one study compared

276   an ACT intervention with two other interventions(Stevens, 2017), one study compared an

277   ACT intervention with a no-treatment (wait-list) control group (Fletcher, 2011), and one

278   study used a single-arm (pre-post) design (Martin et al., 2016).

279   In total, 526 participants were randomized. Sample size ranged from 28 to 138

280   (median = 72). Four of the studies (Ivanova et al., 2016; Kangasniemi et al., 2015; Martin et

281   al., 2016; Stevens, 2017) recruited healthy adult participants who were 'low active' /

282   'inactive'/ 'sedentary' / 'insufficiently active' (all defined as not currently meeting physical

283   activity recommendations), one study recruited participants who were low-moderately active

284   and also in the contemplation or preparation stage of the transtheoretical model (Moffitt and

285   Mohr, 2015), one recruited adult participants who had been or were currently enrolled in a

286   weight loss programme and were interested in increasing their physical activity (Fletcher,

287   2011), and one study recruited healthy college students (Butryn et al., 2011). Mean age of

288   participants ranged from 22.4yrs to 52.6yrs (median = 43.5yrs). Three studies recruited only

289   female participants (Butryn et al., 2011; Ivanova et al., 2016; Stevens, 2017), in the

290   remaining four studies ≥79% of participants were female. Time to final follow-up, measured

291   from randomisation or baseline measurement, varied from 8 weeks to 6 months (median = 3

292   months).

293   Measurement of physical activity behaviour varied greatly. Physical activity

294   behaviour was objectively measured in five studies (one study measured number of visits to

295   an athletic centre (Butryn et al., 2011); one used an Actigraph to measure minutes of physical

296   activity per day (Kangasniemi et al., 2015); one estimated cardio-respiratory fitness as a

297   proxy measure of physical activity (Martin et al., 2016); one used a pedometer to measure

298   step count (Moffitt and Mohr, 2015); and one used a heart-rate monitor to measure total

299   minutes of physical activity over 30 days (Stevens, 2017)). Physical activity behaviour was

300   estimated by self-report in five studies (one study assessed hours per week of exercise using

301   the Godin Leisure-Time Exercise Questionnaire(Ivanova et al., 2016); two assessed MET-

302   minutes using the International Physical Activity Questionnaire (Fletcher, 2011; Moffitt and

303   Mohr, 2015); two assessed minutes of physical activity with 7-day recall (Kangasniemi et al.,

304   2015; Stevens, 2017); and one used The Voluntary Exercise Questionnaire to assess

305   voluntary exercise behaviour over the past month (Stevens, 2017)). Retention at follow-up

306   ranged from 68%-100% (mean =82.6%) in the intervention trial arms; and from 71-95%

307   (mean = 84.7%) in the comparator trial arms.

308   Overall risk of bias (Figure 2) was high for all seven studies. Five of the six RCTs

309   were coded as being at high risk of bias in missing outcome data (Fletcher, 2011; Ivanova et

310   al., 2016; Kangasniemi et al., 2015; Moffitt and Mohr, 2015; Stevens, 2017). All six RCTs

311   were coded as having some concerns in the domain of selection of the reported result. Risk of

312   bias could not be coded for the pre-post study (Martin et al., 2016), but overall risk was

313   judged to be high, given the lack of a control.

314

315   **Intervention Characteristics**

316   Table 2 shows the intervention characteristics, ACT Processes and BCTs present in

317   the intervention and comparator trial arms for each of the seven studies. The ACT-based

318   intervention was delivered by the lead author (an ACT interventionist) in one study (Ivanova

319   et al., 2016), by clinicians or students trained in the delivery of ACT in four studies (Butryn

320   et al., 2011; Kangasniemi et al., 2015; Fletcher, 2011; Stevens, 2017) , and two studies

321   (Martin et al., 2016; Moffitt and Mohr, 2015) did not specify who delivered the intervention.

322   ACT intervention delivery had a face-to-face component in six studies (Butryn et al., 2011;

323   Ivanova et al., 2016; Kangasniemi et al., 2015; Martin et al., 2016; Fletcher, 2011; Stevens,

324   2017) and was delivered via a self-managed DVD in one study (Moffitt and Mohr, 2015).

325   Two of the studies with a face-to-face component delivered the ACT intervention in a single,

326   individual session lasting 40-60minutes (Ivanova et al., 2016; Stevens, 2017). The remaining

327   four studies with a face-to-face component delivered the ACT intervention in a group setting,

328   with durations ranging from a single six-hour session (Fletcher, 2011) to eight 90-minute

329   sessions over 10 weeks (Martin et al., 2016). In three studies, the intervention condition was

330   an ACT intervention focusing on physical activity (Butryn et al., 2011; Ivanova et al., 2016;

331   Fletcher, 2011). In the four remaining studies, an ACT intervention was combined with

332   additional intervention components – self-monitoring with a pedometer plus feedback on

333   current physical activity (Kangasniemi et al., 2015), a walking programme (Martin et al.,

334   2016), and exercise prescription (Stevens, 2017).

335   Comparator conditions varied, including education on physical activity (Butryn et al.,

336   2011; Stevens, 2017), mailed feedback on physical activity (Kangasniemi et al., 2015),

337   implementation intentions (Ivanova et al., 2016), a pedometer-based walking programme

338   (Moffitt and Mohr, 2015), exercise prescription (Stevens, 2017), and wait-list control

339   (Fletcher, 2011).

340

341   **ACT Processes**

342   The number and name of ACT processes present in each of the ACT interventions are

343   reported in Table 2. On average, the number of ACT processes (including *Creative*

344   *Hopelessness*) targeted by ACT interventions was 5.7 (range 5-7). Cohen's kappa (κ) was

345   calculated for each ACT process and ranged from 0.59 (for *Contact-with-the-Present-*

346   *Moment*) to 1 (for *Acceptance, Self-As-Context,* and *Values*), representing moderate to perfect

347   agreement between raters. Table 3 shows the total number of studies targeting each of the

348   ACT processes. Of the six core ACT processes, *Defusion*, *Values* and *Committed Action* were

349   targeted by the ACT intervention in all seven studies, *Acceptance* was targeted in six studies

350   (Butryn et al., 2011; Fletcher, 2011; Ivanova et al., 2016; 2015; Martin et al., 2016; Moffitt

351   and Mohr, 2015; Stevens, 2017); *Contact-with-the-Present-Moment* was targeted in six

352   studies (Butryn et al., 2011; Fletcher, 2011; Ivanova et al., 2016; Kangasniemi et al., 2015;

353   Martin et al., 2016; Stevens, 2017), and *Self-As-Context* was targeted in three studies

354   (Fletcher, 2011; Kangasniemi et al., 2015; Martin et al., 2016;). *Creative Hopelessness* was

355   targeted by the ACT intervention in four studies (Butryn et al., 2011; Fletcher, 2011; Ivanova

356   et al., 2016; Moffitt and Mohr, 2015).

357   Three of the seven studies (Martin et al., 2016; Moffitt and Mohr, 2015; Stevens,

358   2017) explicitly named all processes targeted. In the remaining four studies, the number of

359   processes that were identifiable but not explicitly named ranged from one (two studies,

360   Butryn et al., 2011; Fletcher, 2011) to four (one study, Ivanova et al., 2016) (Table 2). *Self-*

361   *as-Context (SAC)* and *Creative Hopelessness (CH)* were more commonly identifiable but not

362   explicitly named –SAC was targeted in three studies (Fletcher, 2011; Ivanova et al., 2016;

363   Kangasniemi et al., 2015; Martin et al., 2016) but only explicitly named in one (Martin et al.,

364   2016;), and CH was targeted in four studies (Butryn et al., 2011; Fletcher, 2011; Ivanova et

365   al., 2016; Moffitt and Mohr, 2015) but only explicitly named in two (Fletcher, 2011; Moffitt

366   and Mohr, 2015). No ACT processes were targeted in the comparator interventions.

367

368   **BCTs (Behaviour change techniques) Applied in Intervention and Comparator groups**

369   The number and name of BCTs present in each of the intervention and comparator

370   conditions are reported in Table 2. On average, the number of BCTs was greater in the

371   intervention condition (mean of 7.0; range 0-11) than in the comparator condition (mean of

372   4.5; range 2-7) (Table 2). In four of the six studies with a comparator group (Fletcher, 2011;

373   Kangasniemi et al., 2015; Moffitt and Mohr, 2015; Stevens, 2017), the number of BCTs was

374   greater in the intervention condition than in the comparator condition and was equivalent in

375   both conditions in one study (Ivanova et al., 2016). The number of BCTs was greater in the

376   comparator condition than in the intervention condition in the one study in which the ACT

377   intervention was identified as *very promising* (Butryn et al., 2011).

378   Table 4 shows the total number of studies with BCTs present (and probably present)

379   in the intervention and comparator conditions. Overall, there were 22 different BCTs (out of a

380   possible 93) identified in the seven studies – 20 different BCTs were identified across the

381   intervention conditions (ACT intervention plus Additional Components) and 17 different

382   BCTs were identified across the comparator conditions. Cohen's kappa (κ) could not be

383   calculated for 61 BCTs as both raters agreed that these were not included in any of the

384   studies. For the 20 BCTs identified across the intervention conditions (ACT intervention plus

385   Additional Components), Cohen's kappa (κ) ranged from 0.7 to 1 representing substantial to

386   perfect agreement between raters. For the 17 BCTs identified across the comparator

387   conditions, Cohen's kappa (κ) ranged from 0.46 to 1 representing moderate to perfect

388   agreement between raters.

389

390   **BCTs in the intervention condition: ACT intervention.**

391   There were ten different BCTs across all ACT interventions (excluding any additional

392   components) (Table 4) with a mean of 2.6 (range 0-4) BCTs per intervention. The most

393   common BCTs were *1.2 Problem solving*, *1.3 Goal Setting (outcome)* and *1.9 Commitment*

394   (all of which were identified in 3 of the 7 ACT interventions). The BCTs *1.4 Action*

395   *Planning*, and *5.4 Monitoring of emotional consequences* were identified in 2 of the 7 ACT

396   interventions. The remaining five BCTs were identified in only one of the seven ACT

397   interventions.

398   In all six studies with a comparator, the comparator intervention contained more

399   BCTs (mean = mean of 4.5; range 2-7) than the ACT intervention (mean = 2.8; range 0-4).

400   Five BCTs were unique to the ACT intervention (not present in the additional components or

401   comparator intervention): *1.7 Review outcome goal(s)* (probably present in one intervention,

402   (Kangasniemi et al., 2015), *1.9 Commitment* (present in two interventions (Fletcher, 2011;

403   Stevens, 2017), probably present in one intervention (Moffitt and Mohr, 2015)), *5.4*

404   *Monitoring of emotional consequences* (present in two interventions (Martin et al., 2016;

405   Stevens, 2017)), *5.6 Information about emotional consequences* (present in one intervention

406   (Fletcher, 2011)), *15.4 Self-talk* (probably present in one intervention (Ivanova et al., 2016)).

407   **BCTs in the intervention condition: additional components.**

408   There were 14 different BCTs across the additional components (that were combined

409 with the ACT intervention) (Table 4) with a mean of 6.2 (range 4-8) BCTs per intervention -

410 this included one study (Fletcher, 2011) in which additional BCTs were identifiable as

411 probably present in the weight loss programme from which participants were recruited. The

412 most common BCTs were *1.1 Goal Setting (behaviour)*, *1.4 Action Planning*, *2.3 Self-*

413 *monitoring of behaviour* and *12.5 Adding objects to the environment* (all of which were

414 identified in 4 of the 4 interventions that combined ACT with additional components

415 (Kangasniemi et al., 2015; Martin et al., 2016; Moffitt and Mohr, 2015; Stevens, 2017)). The

416 remaining ten BCTs were identified as additional components in only 1-2 of the seven

417 studies. No BCTs were unique to the additional components (not present in the ACT

418 intervention or comparator intervention).

419   **BCTs in comparator condition.**

420   Seventeen different BCTs were present or probably present across the comparator

421 interventions (Table 4) with a mean of 4.5 (range 2-7) BCTs per intervention - again this

422 included one study (Fletcher, 2011) in which BCTs were identifiable as probably present in

423 the weight loss programme from which participants were recruited. The most common BCTs

424 were *1.1 Goal Setting (behaviour)*, *1.4 Action Planning*, and *2.3 Self-monitoring of behaviour*

425 (all of which were identified in 4 of 7 studies). The remaining fourteen BCTs were identified

426 in the comparator intervention of only 1-2 of the seven studies. Two BCTs were unique to the

427 comparator intervention (not present in the ACT intervention or additional components): *1.5*

428 *Review behaviour goal(s)* (probably present in one intervention, (Stevens, 2017)), *10.9. Self-*

429 *reward* (probably present in one intervention, (Stevens, 2017)).

430

431   **Statistical analysis**

432   Table 5 reports the physical activity outcomes for each study (outcomes included in

433   the meta-analysis are underlined). Six studies were included in the random effects meta-

434   analysis, four studies reported an objective measure of physical activity (Butryn et al., 2011;

435   Kangasniemi et al., 2015; Martin et al., 2016; Stevens, 2017), two studies reported only self-

436   report measures of physical activity (Fletcher, 2011; Ivanova et al., 2016). One study (Martin,

437   2015) was excluded from the statistical analysis because it was a pre-post study with no

438   control group.

439   The ACT-based physical activity interventions had a large, statistically significant

440   effect on physical activity behaviour, (SMD=1.21, 95% CI (0.16, 2.26), p=0.02). (Figure 3).

441   The Chi-square test indicates that statistically significant heterogeneity is present among

442   studies (x_2=104.39, p<0.00001) to a high degree (I_2=95%). After removing 1 outlier

443   (Fletcher, 2011), there was no significant heterogeneity present among the remaining five

444   studies (x_2=4.79, p=0.31; I_2=17%), and ACT-based physical activity interventions had a

445   small-to-moderate, statistically significant effect on physical activity behaviour, (SMD=0.32,

446   95% CI (0.07, 0.57), p=0.01). (Figure 4). There were an insufficient number of studies to run

447   the planned meta-regression. Publication bias was not assessed as there were inadequate

448   numbers of included trials to properly assess a funnel plot or more advanced regression-based

449   assessments.

450

451   **Discussion**

452   **The Effectiveness of ACT Interventions for Physical Activity**

453   The main aim of this review was to examine the effectiveness of ACT-based

454   interventions for physical activity. Seven studies, including six RCTs, reporting seven ACT-

455   based interventions were identified. After the removal of one outlier, the meta-analysis

456   showed a significant, small-to-moderate effect of ACT-based interventions on physical

457   activity. Given the high risk of bias across all seven studies, the heterogeneity in physical

458   activity outcome measures, as well as intervention and comparator characteristics, this

459   finding should be interpreted with caution. Nevertheless, the results of this meta-analysis

460   show promising results for ACT-based physical activity interventions.

461

ACT Processes Targeted by ACT-interventions for Physical Activity

463   Three ACT processes *Defusion*, *Values* and *Committed Action* were targeted by ACT-

464   based interventions in all seven of the identified studies, while *Acceptance* and *Contact-with-*

465   *the-Present-Moment* were targeted in six studies. Despite not being one of the six core ACT

466   processes, *Creative Hopelessness* was targeted by the ACT intervention in four studies,

467   whereas *Self-As-Context* (which is a core ACT process) was targeted in only three studies.

468   Given the low number of ACT-based intervention studies, that all studies targeted at least

469   five of the seven ACT processes, and that in four studies the ACT intervention was combined

470   with additional intervention components, it is not possible to speculate about which ACT

471   processes might be associated with effective interventions.

472   However, the following points are worth noting: (1) Only three of the seven studies

473   explicitly named all processes targeted; in the remaining four studies some processes were

474   identifiable but not explicitly named. For transparency, ease of replication and interpretation

475   of findings, future studies should explicitly name processes targeted; (2) No reasons were

476   given for why certain processes were targeted and others were not. Given the synergistic

477   nature of the ACT processes (inter-related and over-lapping processes) (Hayes et al. 1999;

478   Hayes et al. 2006) future studies should report the theoretical rationale for targeting some

479   ACT processes and not others; (3) It is interesting that the least commonly targeted process,

480   *Self-As-Context*, is also the process that is notoriously difficult to understand conceptually,

481   and one that practitioners often report that they struggle to address in practice (Westrup and

482   Wright 2017). This raises the question of whether a process that is considered to be central to

483   the ACT model is often left out of interventions because intervention developers find it too

484   tricky to incorporate, or whether the process is difficult to identify when it is not explicitly

485   named as a targeted process; (4) As already mentioned, in four of the seven studies, the ACT

486   intervention was combined with additional intervention components such as feedback on

487   current physical activity (Kangasniemi et al., 2015), a walking programme (Martin et al.,

488   2016; Moffitt and Mohr, 2015), and exercise prescription (Stevens, 2017). To appropriately

489   examine the effectiveness of ACT-based interventions for physical activity, we would

490   recommend that future studies include an 'ACT-only' intervention condition that includes no

491   additional intervention components.

492

493   ***Behaviour Change Techniques (BCTs) Present in ACT Interventions for Physical Activity***

494   Given that ACT processes are theoretical constructs, not intervention techniques, no

495   BCTs could be identified in an intervention based on the process name (e.g. *Acceptance*)

496   alone. Instead, BCTs could only be identified from intervention descriptions (Butryn et al.,

497   2011; Ivanova et al., 2016; Kangasniemi et al., 2015; Martin et al., 2016; Moffitt and Mohr,

498   2015; Fletcher, 2011; Stevens, 2017), protocols (Ivanova et al., 2016; Fletcher, 2011) or

499   fidelity checklists (Stevens, 2017). However, much of the intervention content did not fall

500   into the existing BCTTv1 categories – on average over the seven studies, ACT-based

501   interventions for physical activity included only 2.6 BCTs per intervention. This number is

502   surprisingly low for a physical activity intervention, especially one that is theory-based; a

503 recent meta-analysis of physical activity interventions for healthy inactive adults (Howlett et

504 al. 2019) found that the 26 included interventions contained an average of 8.4 BCTs. One

505 explanation for the finding of the low number of BCTs in ACT interventions for physical

506 activity is that four of the seven ACT interventions in this review were combined with

507 additional components, and that when considered together, the overall intervention (ACT +

508 additional components), the average number of BCTs was much higher at 7.0 BCTs per

509 intervention. Alternatively, it is possible that, as five of the seven studies did not include an

510 intervention protocol or fidelity checklist, BCT content could only be coded from

511 intervention descriptions in the main text, and these descriptions may have been insufficient

512 to identify the full number of BCTs in these interventions. This explanation is potentially

513 unlikely, however, as the average number of BCTs identified in the comparator conditions of

514 the current review (mean = 4.5 BCTs) is very similar to that of Howlett et al. (2019), who

515 identified an average of 5.1 BCTs in comparator conditions. Furthermore, only 2-4 BCTs

516 were identified in the ACT interventions for which full protocols (Ivanova et al., 2016;

517 Fletcher, 2011) or a comprehensive fidelity checklist (Stevens, 2017) were published.

518   An alternative explanation for these findings is that ACT interventions contain very

519 little in the way of 'active ingredients' as currently recognised and defined by the BCTTv1.

520 This explanation may be plausible given that the model of behaviour change (psychological

521 flexibility) and the behaviour change processes (*acceptance*, *defusion*, *contact-with-the-*

522 *present-moment*, *self-as-context*, *values*, and *committed action*) that underlie ACT are

523 relatively new in the field of behaviour change, having only been around for the last two-

524 three decades (Hayes et al., 1999; Hayes et al., 2006).

525   Interestingly, three of the five BCTs identified in this current review as being unique

526 to the ACT intervention (*1.9 Commitment*, *5.4 Monitoring of emotional consequences*, *5.6*

527   *Information about emotional consequences*) were not implemented in any of the 26 physical

528   activity interventions included in Howlett et al.'s review. Furthermore, Howlett et al. (2019)

529   found that the most frequently used BCTs in physical activity interventions were *1.1 Goal*

530   *setting (behaviour)* (22 studies) and *3.1 Social support (unspecified)* (20 studies) – neither of

531   which were included in any of the ACT interventions in the current review. Together, these

532   findings again could be seen to point to the possibility that interventions based on ACT (and

533   the psychological flexibility model) may include atypical BCTs (perhaps even some not

534   currently included in the BCTTv1) because they target unique behaviour change processes

535   not present in other models of behaviour change. However, it is important to note that goal-

536   setting as a technique can be (and often is) used to target the Committed Action process of

537   the psychological flexibility model (Hayes et al., 2006). Given that ACT interventions are

538   often defined in terms of the behaviour change processes they target, rather than the

539   individual techniques used to target those processes, it is possible that the ACT interventions

540   included in this review may have included goal-setting, but that this BCT could not be

541   identified from intervention descriptions, protocols, or fidelity checklists.

542   If ACT interventions do indeed contain 'active ingredients', and many of these are not

543   currently included in the BCTTv1, we would recommend that future work focus on

544   identifying what techniques are typically employed by ACT interventions, and ultimately aim

545   to determine whether these techniques meet the criteria for inclusion in the BCTTv1 –

546   namely that they:

547   (a) aim to change behaviour, (b) are proposed "active ingredients" of

548   interventions, (c) are the smallest components compatible with retaining the

549   proposed active ingredients, (d) can be used alone or in combination with other

550   BCTs, (e) are observable and replicable, (f) can have a measurable effect on a

551   specified behaviour/s, and (g) may or may not have an established empirical

552   evidence base. (Michie et al., 2013, p84).

553   Steven Hayes, who developed ACT, has often highlighted that although many of the

554   techniques in ACT are relatively distinct, many are also shared with other approaches,

555   particularly cognitive-behavioural approaches, and he has emphasised that it is important not

556   to view ACT simply as a collection of techniques, but instead as *"a perspective into which a*

557   *wide variety of [techniques], some identified with ACT and some not, can be deployed in a*

558   *coherent fashion linked to basic principles"* (Hayes et al., 2013, p9). ACT is a 'process-based

559   therapy' (Hofmann & Hayes, 2019) and the goal of any ACT intervention (whether it's

560   applied to health behaviour, mental health, or any other area) is to effect change the six core

561   processes (i.e. to increase psychological flexibility) in order to ultimately bring about a

562   change in behaviour (Hayes et al., 2013, p9). Furthermore, Hayes et al. (2013) have

563   speculated that understanding what techniques are effective is impossible without first

564   understanding behaviour change processes (Hayes et al., 2013), and Michie and Johnston

565   (2012) have highlighted the need for "linking active ingredients to an understanding of the

566   processes involved, that is, to the theoretical basis of behaviour change" (Michie & Johnston,

567   2012, p4). Consequently, in order to link the active ingredients of ACT interventions with the

568   underlying psychological flexibility model of behaviour change, we would also recommend

569   that researchers aim to clearly identify which specific techniques they have included in ACT

570   interventions (whether these BCTs are included in the BCTTv1 or not) and link these

571   techniques to the behaviour change processes they are intended to change.

572

573   **Other Intervention Characteristics**

574   It is well known that intervention effectiveness may depend not only the specific

575   content of the intervention, but also on other intervention characteristics such as how it is

576   delivered, by whom, to whom, in that format, with what intensity, and for how long

577   (Davidson et al., 2003). Again, there was an insufficient number of studies in the current

578   review to draw any conclusions about which of these characteristics may or may not be

579   associated with the effectiveness of ACT interventions for physical activity. Nonetheless, it is

580   perhaps useful to note that ACT interventions for physical activity: (i) have mostly been

581   delivered by trained clinicians or researchers (Butryn et al., 2011; Ivanova et al., 2016;

582   Kangasniemi et al., 2015; Martin et al., 2016; Fletcher, 2011; Stevens, 2017); (ii) can be

583   delivered in self-managed DVD format as well as face-to-face individual or group format;

584   (iii) can be delivered with a wide range of intensities and durations from as little as a single

585   40 minute session to eight 90-minute sessions.

586   **Strengths and Limitations**

587   A robust methodological approach and adherence to a published protocol and

588   PRISMA are strengths of this review. The use of the BCTTv1 (Michie et al., 2013) allowed a

589   thorough analysis of intervention components included in ACT interventions, and to the

590   authors' knowledge this is the first time ACT intervention content in any field has been coded

591   using the BCTTv1.

592   Several of the limitations of this review are a consequence of methodological

593   weaknesses of the included studies, but also represent opportunities for future research. First,

594   measurement of physical activity behaviour varied greatly, and only four of the six RCTs

595   included an objective measure of physical activity. We echo previous calls for future research

596   to standardize measurement of physical activity so that data can be pooled more meaningfully

597   (Autier & Pizot, 2016; Howlett et al., 2019).

598   A second limitation was that included studies were limited by small sample sizes

599   (with all but one study having fewer than 100 participants), and a predominance of female

600   participants. Given that the findings of this review add to the growing body of evidence that

601   ACT-based interventions have shown promise for promoting a range of health behaviours

602   including physical activity, we would recommend that future research focuses on exploring

603   the effectiveness of ACT for physical activity in large-scale, randomized controlled trials.

604   Although the predominance of female participants is typical of health behaviour research

605   samples, with males comprising about 20% of samples (Ryan et al., 2019), future research

606   should attempt to explore ways to increase recruitment of male participants, either in mixed-

607   gender or single-gender studies.

608   Finally, in all four studies where additional components were added to the ACT

609   interventions, the additional components contained more BCTs (identified using the

610   BCTTv1) than the ACT intervention itself. Additionally, in all six studies with a comparator,

611   the comparator intervention contained more BCTs (as identifiable using the BCTTv1) than

612   the ACT intervention. The addition of 'active ingredients' to many of the ACT intervention,

613   along with the high number of 'active ingredients' in the comparator conditions consequently

614   reduces the ability to draw conclusions about the effectiveness of ACT interventions for

615   increasing physical activity. We would recommend that future research: (i) minimise (ideally

616   to zero) the number of active ingredients in a control comparator condition; (ii) explore the

617   effectiveness of ACT interventions delivered with and without additional intervention

618   components (such as the addition of a pedometer, a walking programme, implementation

619   intentions, etc); (iii) clearly describe and name the behaviour change processes and

620   techniques used in ACT interventions, where possible using the standardised terminology of

621   the Behaviour Change Technique Taxonomy v1 (Michie et al., 2013), and highlighting where

622   necessary when the 'active ingredients' / behaviour change techniques used are not part of the

623   existing taxonomy.

Conclusions

625   ACT interventions show promise for increasing physical activity behaviour, but as yet

626   no definitive conclusions can be drawn regarding the most effective intervention components

627   or characteristics. Future development of ACT interventions for physical activity should

628   attempt to describe and name the ACT processes targeted by the intervention, and the

629   behaviour change techniques used to target those processes. Future trials should employ more

630   high-quality study designs, with larger sample sizes, longer-term follow-ups, and use a

631   standardised, objective measure of physical activity.

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Tables

Table 1: Selected characteristics of included studies

Author; year; Country	Participants N randomized N allocated to trial arms	Participants Age (range, mean); % female	Setting	Population	Design	Trial Arms	Measurement Times	PA Outcome Measure(s)	Retention % (N at follow-up /N randomized)	Overall Risk of Bias
Butryn et al.; 2011 USA	**54** ACT: 35 ED:19	18-35, 23.1yrs 100% F	University	College students	RCT	1. ACT 2. ED	**Baseline 5 weeks 8 weeks**	**PA behaviour**: 1. Number of days/week that participants entered the athletic centre **[O]**	ACT: 80% (28 /35) ED: 95% (18 /19)	High
Fletcher; 2011 USA	**72** ACT: 36 Control:36	18+yrs ACT = 53.1yrs Control= 52.1yrs 83% F	Center for Nutrition and Metabolism (CNM) at University Medical School.	Adults Current or past enrolment on weight loss programme Interest in increasing PA	RCT	1. ACT 2. Control	**Baseline 3 months**	**PA behaviour**: 1. MET-minutes (International Physical Activity Questionnaire, IPAQ, long form) **[SR]** 2. Estimated Kcal Expended during past week (International Physical Activity Questionnaire, IPAQ, long form) **[SR]**	ACT: 81% (29/36) Control: 89% (32/36)	High
Ivanova et al.; 2016 Canada	**39** ACT:18 II: 21	18-45yrs, 22.4yrs 100% F	Not specified	Adults Low active (not meeting minimum PA recs); Contemplation or Preparation Stages of Change	RCT	1. ACT 2. II	**Baseline 6 months**	**PA behaviour**: 1. Hours/week of at least moderate exercise expressed as an activity score (Godin Leisure-Time Exercise Questionnaire; GLTEQ) **[SR]**	ACT: 89% (16/18) II:.80% (16/20)	High
Kangasniemi et al.; 2015 Finland	**138** ACT+SM+FB:69 FB: 69	30-50yrs, 43.5yrs 83.3% F	Not specified	Adults Inactive (not meeting minimum PA recs)	RCT	1. ACT+SM +FB 2. FB	**Baseline 3months 6 months**	**PA behaviour**: 1. Health-enhancing physical activity (HEPA) time, min/day (Actigraph) **[O]** 2. Moderate-to-vigorous intensity physical activity (MVPA) time, min/day (Actigraph) **[O]** 3. Self-reported physical activity, min/day (7-day recall) **[SR]**	ACT+SM+FB: 78% (54/69) FB: 71% (49/69)	High
Martin et al.; 2015 USA	**28**	18+yrs, 50.47yrs 79% F	Community-based, university-affiliated mental health clinic	Adults 'Sedentary' (not meeting minimum PA recs)	Pre-post trial	1. ACT+WP	**Baseline 10 weeks**	**Cardio-respiratory fitness (CRF)**: 1. 1-mile walk-test time in seconds (Rockport 1-mile walk test) **[O]** 2. Estimated aerobic capacity (VO2max), in ml/kg/min (Rockport 1-mile walk test) **[O]**	ACT+WP: 68% (19/28)	High
Moffitt and Mohr; 2015 Australia	**76** ACT+WP: 39 WP:37	19-65yrs ACT+= 43.47yrs WP= 43.93yrs 83% F	Not specified	Adults Low or moderate PA In the contemplation or preparation stage of the transtheoretical model	RCT	1. ACT+WP 2. WP	**Baseline 4 weeks* 8 weeks* 12 weeks** *step count only	**PA behaviour**: 1. MET-minutes (International Physical Activity Questionnaire, IPAQ, long form) **[SR]** 2. Step count (in thousands), (G-Sensor 2026 Pedometer) **[O]** *(during and post-intervention only - no baseline)*	ACT+WP: 82% (32/39) WP: 73% (27/37)	High

Stevens; 2017 UA	**119** ACT+EP: 40 ED+EP:40 EP:39	21-65yrs, 39.22yrs 100% F	Not specified	Adults Insufficiently active for past 3 months (not meeting minimum PA recs)	RCT	1. ACT+EP 2. ED+EP 3. EP	**Baseline 1 month 3 months**	**PA behaviour**: 1.Total mins of exercise over 30 days (Heart rate monitor, HRM, data) **[O]** *(Month 1 only)* 2. Total mins of exercise over 30 days *(daily exercise journal)* **[SR]** *(Month 1 only)* 3. Self-reported exercise, min/week **[SR]** 4. PAR exercise min/week in past week (Stanford 7-day physical activity recall. PAR*)* **[SR]** *(baseline and Month 1 only)* 5. Voluntary exercise behaviour over the past month, score from 1-21 (The Voluntary Exercise Questionnaire, VEQ) **[SR]**	ACT+EP: 100% (40/40) ED+EP: 90% (36/40) EP: 95% (37/39)	High

ACT, Acceptance and Commitment Therapy; ED, education; EP, exercise prescription; F, female; FB, feedback; II, implementation intentions; N, number; O, objective; PA, physical activity; RCT, randomized controlled trial; SM, self-monitoring; SR, self-report; WP, walking programme.

Table 2: Intervention characteristics, ACT Processes and BCTs present in the Intervention and Comparator Trial Arms

Author; year	Description of Trial Arms	Delivery Provider	Format / Duration/ Intensity/Materials	ACT Processes (N) Explicit (identifiable*)	BCTs (N) Present (probably present*)
Butryn et al.; 2011	**ACT:** ACT intervention focusing on PA. **ED:** Education intervention focusing on PA.	Advanced graduate student & Clinical Psychologist	Face-to-face Group 2 x 2-hr sessions (2 weeks apart)	**ACT: (N=6)** Acceptance Defusion Contact Present Moment Values Committed Action Creative Hopelessness* **ED: (N=0)**	**ACT: (N=0)** **ED: (N=3)** 2.3 Self-monitoring of behaviour* 4.1 Instruction on how to perform the behaviour* 5.3 Information about social and environmental consequences*
Fletcher; 2011	**ACT:** ACT intervention focusing on PA **Control:** Wait-list control	Qualified, doctoral level graduates experienced in the delivery of ACT	**ACT:** Face-to-face Group 1 x 6hr workshop **Control:** N/A	**ACT: (N=7)** Acceptance Defusion Contact Present Moment Self-As-Context* Values Committed Action Creative Hopelessness **Control: (N=0)**	**ACT: (N=4 +4)** 1.2 Problem solving* 1.9 Commitment 5.1 Information about health consequences 5.6 Information about emotional consequences 1.2 Problem solving* 1.3. Goal setting (outcome)* 2.4. Self-monitoring of outcome(s) of behaviour* 2.7. Feedback on outcome(s) of behaviour* **Control: (N=4)** 1.2 Problem solving* 1.3. Goal setting (outcome)* 2.4. Self-monitoring of outcome(s) of behaviour* 2.7. Feedback on outcome(s) of behaviour*
Ivanova et al.; 2016	**ACT:** ACT intervention focusing on PA. **II:** Implementation intentions (II) intervention focusing on PA	ACT Interventionist (lead author)	Face-to-face Individual 1x 40min session	**ACT: (N=6)** Acceptance Defusion Contact Present Moment* Values* Committed Action* Creative Hopelessness* **II: (N=0)**	**ACT: (N=2)** 1.3. Goal setting (outcome)* 15.4 Self-talk* **II: (N=2)** 1.1 Goal setting (behaviour) 1.4 Action Planning
Kangasniemi et al.; 2015	**ACT+SM+FB:** ACT intervention focusing on PA plus feedback (FB) on PA. **FB:** Feedback (FB) on PA.	**ACT+SM+FB:** Three-five group leaders trained in ACT and supervised by researcher **FB:** N/A	**ACT+SM+FB:** Face-to-face Group 6 x 90min sessions (over 9 weeks) Pedometer Written feedback (via mail) **FB:** Written feedback (via mail)	**ACT: (N=5)** Defusion* Contact Present Moment Self-As-Context* Values Committed Action **FB: (N=0)**	**ACT+SM+FB: (N=4 +7)** 1.2 Problem solving* 1.3. Goal setting (outcome)* 1.4 Action Planning 1.7. Review outcome goal(s)* 1.1 Goal setting (behaviour)* 1.4 Action Planning* 1.6. Discrepancy between current behaviour and goal* 2.2. Feedback on behaviour 2.3 Self-monitoring of behaviour 2.7. Feedback on outcome(s) of behaviour

12.5 Adding objects to the environment

FB: (N=6)
1.1 Goal setting (behaviour)*
1.4 Action Planning*
1.6. Discrepancy between current behaviour and goal*
2.2. Feedback on behaviour
2.3 Self-monitoring of behaviour
2.7. Feedback on outcome(s) of behaviour

Martin et al.; 2016	**ACT+WP:** ACT intervention focusing on PA plus based walking programme	**ACT+WP:** Not specified	**ACT+WP:** Face-to-face Group 8 x 90min sessions (over 10 weeks)	**ACT: (N=6)** Acceptance Defusion Contact Present Moment Self-As-Context Values Committed Action	**ACT+WP: (N=1 +8)** 5.4 Monitoring of emotional consequences 1.1 Goal setting (behaviour) 1.4 Action Planning 2.1. Monitoring of behaviour by others without feedback* 2.3 Self-monitoring of behaviour 2.4. Self-monitoring of outcome(s) of behaviour 4.1 Instruction on how to perform the behaviour 8.7 Graded tasks 12.5 Adding objects to the environment
Moffitt and Mohr; 2015	**ACT+WP:** ACT intervention focusing on PA plus pedometer-based walking programme **WP:** Pedometer-based walking programme	**ACT+WP:** Not specified **WP:** Not specified	**ACT+WP:** DVD (113 min): 5 x 15-25min modules Face-to-face Individual 1 x information session Information booklet **WP:** Face-to-face Individual 1 x information session Information booklet	**ACT: (N=5)** Acceptance Defusion Values Committed Action Creative Hopelessness **WP: (N=0)**	**ACT+WP: (N=4 +7)** 1.3. Goal setting (outcome)* 1.4 Action Planning* 1.9 Commitment* 12.5 Adding objects to the environment 1.1 Goal setting (behaviour) 1.4 Action Planning 2.1. Monitoring of behaviour by others without feedback* 2.3 Self-monitoring of behaviour 5.3 Information about social and environmental consequences 8.7 Graded tasks 12.5 Adding objects to the environment **WP: (N=7)** 1.1 Goal setting (behaviour) 1.4 Action Planning 2.1. Monitoring of behaviour by others without feedback* 2.3 Self-monitoring of behaviour 5.3 Information about social and environmental consequences 8.7 Graded tasks 12.5 Adding objects to the environment
Stevens; 2017	**ACT+EP:** ACT intervention focusing on PA plus exercise prescription **EDUC+EP:** Education intervention focusing on PA, plus exercise prescription **EP:** Exercise prescription	**ACT + EP & EDUC+EP:** Research Assistant 3 clinical psychology doctoral students trained to deliver workshop protocols **EP:** Research Assistant	**ACT + EP and EDUC + EP:** Face-to-face Individual 1x 45-60min workshop Handout Exercise prescription **EP:**	**ACT: (N=5)** Acceptance Defusion Contact Present Moment Values Committed Action **EDUC + EP: (N=0)**	**ACT+EP: (N=3 +5)** 1.2 Problem solving 1.9 Commitment 5.4 Monitoring of emotional consequences 1.1 Goal setting (behaviour) 1.4 Action Planning 2.3 Self-monitoring of behaviour 4.1 Instruction on how to perform the behaviour* 12.5 Adding objects to the environment

Exercise prescription	EP: (N=0)	EDUC+EP: (N=8+5)
		1.1 Goal setting (behaviour)
		1.2 Problem solving
		1.3. Goal setting (outcome)*
		1.4 Action Planning
		1.5 Review behaviour goal(s)*
		4.1 Instruction on how to perform the behaviour
		5.1 Information about health consequences
		10.9. Self-reward*
		1.1 Goal setting (behaviour)
		1.4 Action Planning
		2.3 Self-monitoring of behaviour
		4.1 Instruction on how to perform the behaviour*
		12.5 Adding objects to the environment
		EP: (N=5)
		1.1 Goal setting (behaviour)
		1.4 Action Planning
		2.3 Self-monitoring of behaviour
		4.1 Instruction on how to perform the behaviour*
		12.5 Adding objects to the environment

ACT, Acceptance and Commitment Therapy; BCTs, Behaviour Change Techniques; ED, education; EP, exercise prescription; F, female; FB, feedback; II, implementation intentions; N, number; O, objective; PA, physical activity; RCT, randomized controlled trial; SM, self-monitoring; WP, walking programme.

Text in grey shows the characteristics and BCTs of the additional intervention components that were added to the ACT intervention.

Table 3: Total number of studies targeting ACT processes

ACT Process	N studies targeting ACT process (identifiable)
Acceptance / Willingness	6
Defusion	7 (1)
Contact with the Present Moment	6 (1)
Self-as-Context	3 (2)
Values	7 (1)
Committed Action	7 (1)
Creative Hopelessness	4 (2)

ACT, Acceptance and Commitment Therapy; N, number

Table 4: Total number of studies with BCTs present (probably present) in the intervention and comparator conditions

BCT Grouping (BCTTv1)	BCT Number and Name (BCTTv1)	N studies with BCT in Intervention condition		N studies with BCT in Comparator condition	N studies with BCT in either condition
		ACT Intervention	Additional Components		
1. Goals and planning	1.1 Goal setting (behaviour)	0	**4** (1)	**4** (1)	**4** (1)
	1.2 Problem solving	**3** (2)	**1** (1)	**2** (1)	**3** (2)
	1.3. Goal setting (outcome)	**3** (3)	**1** (1)	**2** (2)	**5** (5)
	1.4 Action Planning	**2** (1)	**4** (1)	**4** (1)	**4**
	1.5 Review behaviour goal(s)	0	0	**1** (1)	**1** (1)
	1.6. Discrepancy between current behaviour and goal	0	**1** (1)	**1** (1)	**1** (1)
	1.7. Review outcome goal(s)	**1** (1)	0	0	**1** (1)
	1.9 Commitment	**3** (1)	0	0	**3** (1)
2. Feedback and monitoring	2.1. Monitoring of behaviour by others without feedback	0	**2** (2)	**1** (1)	**2** (2)
	2.2. Feedback on behaviour	0	**1**	**1**	**1**
	2.3 Self-monitoring of behaviour	**0**	**4**	**4** (1)	**5** (1)
	2.4. Self-monitoring of outcome(s) of behaviour	0	**2**	**1**	**2**
	2.7. Feedback on outcome(s) of behaviour	0	**2** (1)	**2** (1)	**2** (1)
4. Shaping knowledge	4.1 Instruction on how to perform the behaviour	0	**2** (1)	**2** (1)	**2** (1)
5. Natural consequences	5.1 Information about health consequences	**1**	0	**1**	**2**
	5.3 Information about social and environmental	0	**1**	**2** (1)	**2** (1)
	5.4 Monitoring of emotional consequences	**2**	0	0	**2**
	5.6 Information about emotional consequences	**1**	0	0	**1**
8. Repetition and substitution	8.7 Graded tasks	0	**2**	**1**	**2**
10. Reward and threat	10.9. Self-reward	0	0	**1** (1)	**1** (1)
12. Antecedents	12.5 Adding objects to the environment	**1**	**4**	**2**	**4**
15. Self-belief	15.4 Self-talk	**1** (1)	0	0	**1** (1)

ACT, Acceptance and Commitment Therapy; BCTs, Behaviour Change Techniques; BCTTv1 Behaviour Change Technique Taxonomy version 1; N, number

Table 5: Physical activity outcomes

Author; year	Physical activity (PA) outcome measure(s)	Timepoint	Mean (SD)	SMD (95%CI)
Butryn et al.; 2011	1. Number of days/week that participants entered the athletic centre [O]	Baseline	ACT= 1.15 (1.43); ED= 1.17 (1.36)	
		5 weeks	ACT= 1.89 (1.43); ED = 1.00 (1.15)	**0.66** (0.05 to 1.27)
		8 weeks	ACT= 1.50 (15.56); ED= 0.89 (1.48)	**0.05** (-0.54 to 0.64)
Fletcher; 2011	1. MET-minutes (International Physical Activity Questionnaire, IPAQ, long form) [SR]	Baseline	ACT= 2862.3 (144.00); Ctrl= 2180.9 (150.00)	
		3 months	ACT= 3956.4 (261.60); Ctrl = 2332.9 (246.00)	**6.33** (5.17 to 7.48)
	2. Estimated Kcal Expended during past week (International Physical Activity Questionnaire, IPAQ, long form) [SR]	Baseline	ACT = 1958.3 (1243.20); Ctrl = 1878.6 (1239.00)	
		3 months	ACT= 1572.8 (1594.20); Control = 1851.4 (1395.00)	**-0.18** (-0.65 to 0.28)
Ivanova et al.; 2016	1. Hours/week of at least moderate exercise expressed as an activity score (GLTEQ) [O]	Baseline	ACT =9.81 (11.98); II =14.53 (12.37)	
		6 months	ACT =23.59 (21.42); II=18.18 (12.71)	**0.30** (-0.40 to 1.00)
Kangasniemi et al.; 2015	1. Health-enhancing physical activity (HEPA) time, min/day (Actigraph) [O]	Baseline	ACT+FB =6.4 (7.4); FB=5.8 (6.1)	
		3 months	ACT+FB =10.1 (9.9); FB =9.0 (11.8)	**0.10** (-0.27 to 0.47)
		6 months	ACT+FB =11.9 (14.0); FB =10.3 (13.4)	**0.12** (-0.27 to 0.50)
	2. Moderate-to-vigorous intensity physical activity (MVPA) time, min/day (Actigraph) [O]	Baseline	ACT+FB =26.2 (12.4); FB =22.8 (12.5)	
		3 months	ACT+FB =27.4 (14.5); FB =24.3 (14.9)	**0.21** (-0.17 to 0.58)
		6 months	ACT+FB =29.5 (17.6); FB=26.6 (16.8)	**0.17** (-0.22 to 0.55)
	3. Self-reported physical activity, min/day (7-day recall) [SR]	Baseline	ACT+FB=15.4 (14.6); FB =11.6 (11.4)	
		3 months	ACT+FB=17.4 (14.3); FB =15.6 (15.7)	**0.12** (-0.26 to 0.49)
		6 months	ACT+FB =25.1 (18.0); FB =18.9 (14.5)	**0.37** (-0.02 to 0.76)

Martin et al.; 2016	1. **CRF** 1-mile walk-test time in seconds (Rockport 1-mile walk test) [O]	Baseline	ACT=980.95 (99.34)	
		10 weeks	ACT=916.26 (102.54)	**0.65†** (-0.01 to 1.29)
	2. **CRF** Estimated aerobic capacity (VO2max), in ml/kg/min (Rockport 1-mile walk	Baseline	ACT=24.43 (6.71)	
	test) [O]	10 weeks	ACT=27.34 (6.83)	**-0.43†** (-1.07 to 0.21)
Moffitt and Mohr; 2015	1. MET-minutes (International Physical Activity Questionnaire, IPAQ, long form) [SR]	Baseline	ACT+WP= 540.09 (608.82); WP = 466.13 (419.68)	
		12 weeks	ACT+WP =1892.72 (2840.93); WP= 776.72 (731.63)	**0.51** (-0.01 to 1.03)
	2. Step count (in thousands), (G-Sensor 2026 Pedometer) [O]	4 weeks	ACT+WP = 35.48 (21.47); WP = 23.16 (14.28)	**0.66** (0.13 to 1.18)
		8 weeks	ACT+WP = 34.04 (24.44); WP = 27.41 (25.63)	**0.26** (-0.25 to 0.78)
		12 weeks	ACT+WP = 42.68 (33.28); WP =20.04 (17.23)	**0.82** (0.29 to 1.36)
Stevens; 2017	1. Total mins of exercise over 30 days (Heart rate monitor, HRM, data) [O]	1 month	ACT+EP =659.64 (496.85); EP= 517.15 (361.759)	**0.32** (-0.13 to 0.77)
	2. Total mins of exercise over 30 days, daily exercise journal [SR]	1 month	ACT+EP =886.45 (575.70); EP= 679.47 (442.44)	**0.40** (-0.05 to 0.85)
	3. Total mins of exercise over 30 days (daily exercise journal) [SR]	Baseline	ACT+EP =70.83; EP= 92.39	**X**
		1 month	ACT+EP =192.93; EP= 182.96	**X**
		3 months	ACT+EP =179.17; EP= 121.32	**X**
	4. PAR exercise min/week in past week (Stanford 7-day physical activity recall. PAR) [SR]	Baseline	ACT+EP =50.45; EP= 54.41	**X**
		1 month	ACT+EP =179.74; EP= 125.06	**X**
	5. Voluntary exercise behaviour over the past month, score from 1-21 (The Voluntary Exercise Questionnaire, VEQ) [SR]	Baseline	ACT+EP =6.33; EP= 6.25	**X**
		1 month	ACT+EP =12.67; EP= 11.71	**X**
		3 months	ACT+EP =9.73; EP= 9.36;	**X**

ACT, Acceptance and Commitment Therapy; Ctrl, Control; ED, education; EP, exercise prescription; FB, feedback; II, implementation intentions; N, number; M, mean; O, objective; PA, physical activity; RCT, randomized controlled trial; SD, standard deviation; SR, self-report; SM, self-monitoring; WP, walking programme.

*Where possible effect sizes were calculated based on postintervention and follow-up means, standard deviations, and sample sizes for each condition to produce standardized mean differences (SMD) with 95% confidence intervals (CIs). Positive effect sizes indicated favourable changes in the ACT intervention groups, compared to the comparator groups. Effect sizes of >0.2, >0.5 and >0.8 represent small, medium and large effects, respectively. **X** = unable to calculate effect size. Outcomes included in the meta-analysis are underlined.

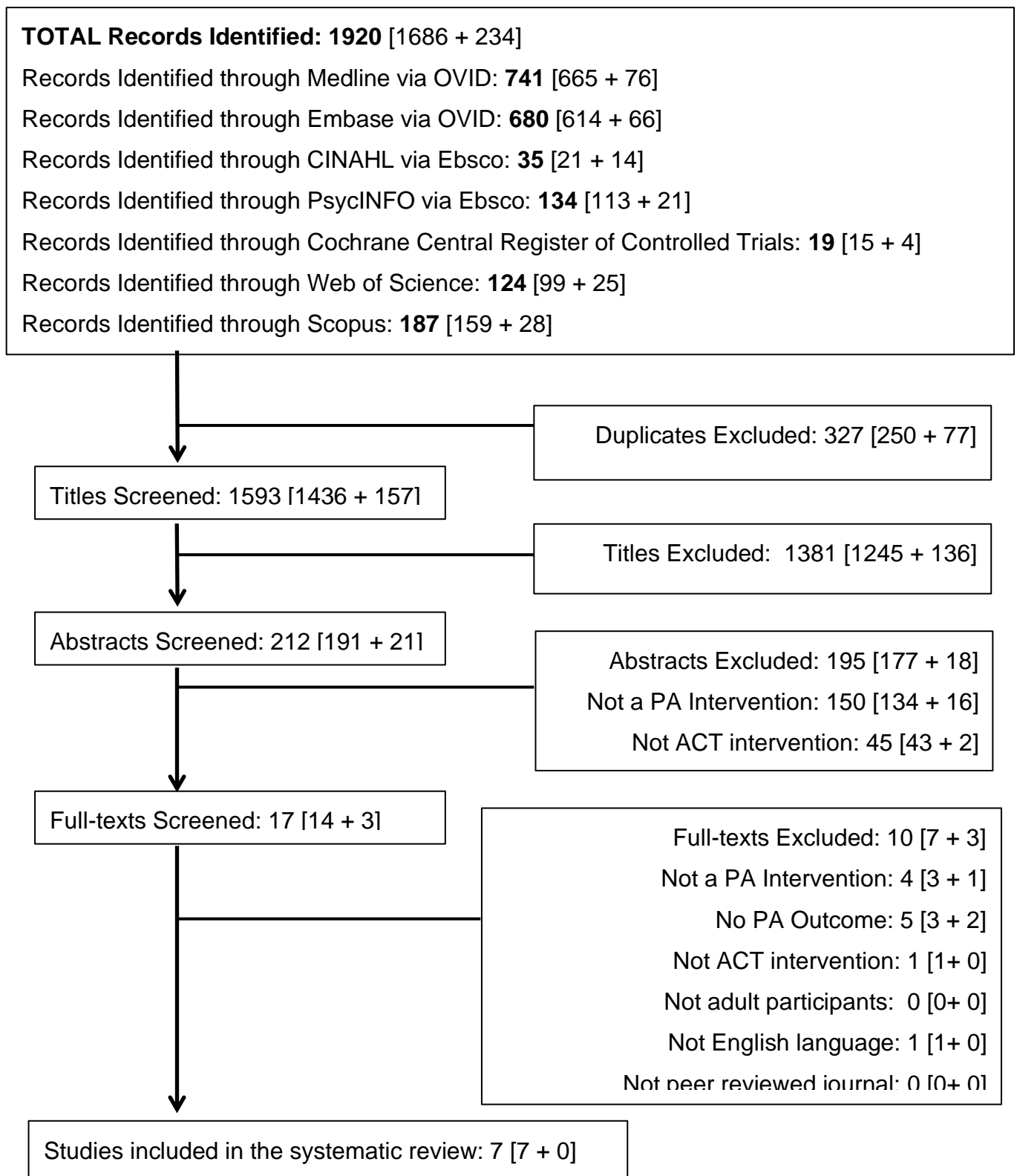† pre-post effect sizes are given when there was no comparator group.

TOTAL Records Identified: 1920 [1686 + 234]

Records Identified through Medline via OVID: **741** [665 + 76]

Records Identified through Embase via OVID: **680** [614 + 66]

Records Identified through CINAHL via Ebsco: **35** [21 + 14]

Records Identified through PsycINFO via Ebsco: **134** [113 + 21]

Records Identified through Cochrane Central Register of Controlled Trials: **19** [15 + 4]

Records Identified through Web of Science: **124** [99 + 25]

Records Identified through Scopus: **187** [159 + 28]

Duplicates Excluded: 327 [250 + 77]

Titles Screened: 1593 [1436 + 157]

Titles Excluded: 1381 [1245 + 136]

Abstracts Screened: 212 [191 + 21]

Abstracts Excluded: 195 [177 + 18]
Not a PA Intervention: 150 [134 + 16]
Not ACT intervention: 45 [43 + 2]

Full-texts Screened: 17 [14 + 3]

Full-texts Excluded: 10 [7 + 3]
Not a PA Intervention: 4 [3 + 1]
No PA Outcome: 5 [3 + 2]
Not ACT intervention: 1 [1+ 0]
Not adult participants: 0 [0+ 0]
Not English language: 1 [1+ 0]
Not peer reviewed journal: 0 [0+ 0]

Studies included in the systematic review: 7 [7 + 0]

Figure 1. Flow diagram of systematic selection of papers in review. Total numbers are shown

in **bold**. Results of the original search (conducted 26th June 2018) plus the results of the

updated search (conducted 29th May 2019) are show in [square brackets].

	Randomization process	Deviations from intended interventions	Missing outcome data	Measurement of the outcome	Selection of the reported result	Overall Bias
Butryn et al.; 2011	?	−	+	+	?	−
Fletcher; 2011	?	+	−	?	?	−
Ivanova et al.; 2016	+	+	−	?	?	−
Kangasniemi et al.; 2015	?	+	−	?	?	−
Martin et al.; 2015	na	na	na	na	na	−
Moffitt and Mohr; 2015	?	+	−	?	?	−
Stevens; 2017	?	+	−	−	?	−

+ Low risk

? Some concerns

− High risk

na not assessed

Figure 2. Risk of bias assessment according to Version 2 of the Cochrane risk-of-bias tool for randomized trials (RoB 2.0).
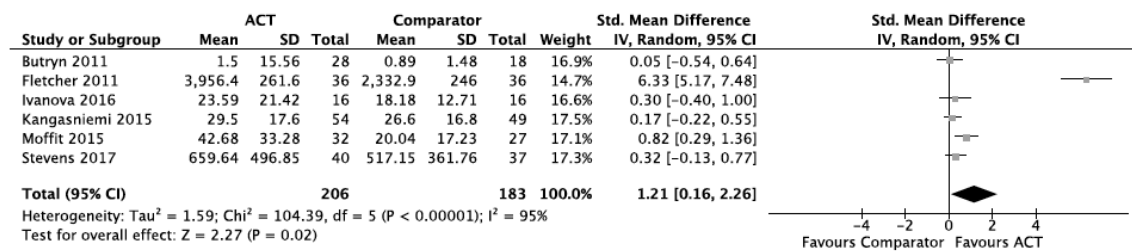
Study or Subgroup	ACT Mean	SD	Total	Comparator Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
Butryn 2011	1.5	15.56	28	0.89	1.48	18	16.9%	0.05 [−0.54, 0.64]
Fletcher 2011	3,956.4	261.6	36	2,332.9	246	36	14.7%	6.33 [5.17, 7.48]
Ivanova 2016	23.59	21.42	16	18.18	12.71	16	16.6%	0.30 [−0.40, 1.00]
Kangasniemi 2015	29.5	17.6	54	26.6	16.8	49	17.5%	0.17 [−0.22, 0.55]
Moffit 2015	42.68	33.28	32	20.04	17.23	27	17.1%	0.82 [0.29, 1.36]
Stevens 2017	659.64	496.85	40	517.15	361.76	37	17.3%	0.32 [−0.13, 0.77]
Total (95% CI)			206			183	100.0%	1.21 [0.16, 2.26]

Heterogeneity: Tau² = 1.59; Chi² = 104.39, df = 5 (P < 0.00001); I² = 95%
Test for overall effect: Z = 2.27 (P = 0.02)

Favours Comparator   Favours ACT

Figure 3: Forest plot of the effect of ACT-based interventions versus Comparators on physical activity behaviour expressed as standardised mean difference.

Study or Subgroup	ACT Mean	SD	Total	Comparator Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
Butryn 2011	1.515	15.56	28	0.89	1.48	18	15.3%	0.05 [−0.54, 0.64]
Ivanova 2016	23.59	21.42	16	18.18	12.71	16	11.5%	0.30 [−0.40, 1.00]
Kangasniemi 2015	29.5	17.6	54	26.6	16.8	49	30.6%	0.17 [−0.22, 0.55]
Moffit 2015	42.68	33.28	32	20.04	17.23	27	18.3%	0.82 [0.29, 1.36]
Stevens 2017	659.64	496.85	40	517.15	361.76	37	24.3%	0.32 [−0.13, 0.77]
Total (95% CI)			170			147	100.0%	0.32 [0.07, 0.57]

Heterogeneity: Tau² = 0.01; Chi² = 4.79, df = 4 (P = 0.31); I² = 17%
Test for overall effect: Z = 2.54 (P = 0.01)

Favours Comparator   Favours ACT

Figure 4: Forest plot of the effect of ACT-based interventions versus Comparators on physical activity behaviour expressed as standardised mean difference, after removing one outlier.

Authors' contributions

Both authors contributed to designing the review protocol, screening the identified studies, extracting data, and analysing and interpreting the findings. SP drafted the manuscript. Both authors read, contributed to and approved the final manuscript.

Disclosure statement

The authors report no potential conflict of interest.

Data availability statement

The authors confirm that the data supporting the findings of this study are available within the article and its supplementary materials.

Supplementary Document 1: The Interacting Psychological Skills/ Processes Identified in the ACT Transdiagnostic Model of Psychological Flexibility (Hayes et al. 1999)

PROCESS	DEFINITION (HAYES ET AL. 2016)
Acceptance / Willingness (A)	"Acceptance is taught as an alternative to experiential avoidance. Acceptance involves the active and aware embrace of those private events occasioned by one's history without unnecessary attempts to change their frequency or form, especially when doing so would cause psychological harm. For example, anxiety patients are taught to feel anxiety, as a feeling, fully and without defense; pain patients are given methods that encourage them to let go of a struggle with pain, and so on."
Defusion (D)	"Cognitive defusion techniques attempt to alter the undesirable functions of thoughts and other private events, rather than trying to alter their form, frequency or situational sensitivity. Said another way, ACT attempts to change the way one interacts with or relates to thoughts by creating contexts in which their unhelpful functions are diminished. For example, a negative thought could be watched dispassionately, a person could thank their mind for such an interesting thought, label the process of thinking ("I am having the thought that I am no good"), or examine the historical thoughts, feelings, and memories that occur while they experience that thought."
Contact with the Present Moment (CPM)	"ACT promotes ongoing non-judgmental contact with psychological and environmental events as they occur. The goal is to have clients experience the world more directly so that their behavior is more flexible and thus their actions more consistent with the values that they hold. A sense of self called "self as process" is actively encouraged: the defused, non-judgmental ongoing description of thoughts, feelings, and other private events."
Self-as-Context (SAC)	""I" emerges over large sets of exemplars of perspective-taking relations (what are termed in RFT "deictic relations"), but since this sense of self is a context for verbal knowing, not the content of that knowing, it's limits cannot be consciously known. Self as context is important in part because from this standpoint, one can be aware of one's own flow of experiences without attachment to them or an investment in which particular experiences occur: thus defusion and acceptance is fostered. Self as context is fostered in ACT by mindfulness exercises, metaphors, and experiential processes."

Values (V)	"Values are chosen qualities of purposive action that can never be obtained as an object but can be instantiated moment by moment. ACT uses a variety of exercises to help a client choose life directions in various domains (e.g. family, career, spirituality) while undermining verbal processes that might lead to choices based on avoidance, social compliance, or fusion (e.g. "I should value X" or "A good person would value Y" or "My mother wants me to value Z")."
Committed Action (CA)	"Finally, ACT encourages the development of larger and larger patterns of effective action linked to chosen values. In this regard, ACT looks very much like traditional behavior therapy, and almost any behaviorally coherent behavior change method can be fitted into an ACT protocol, including exposure, skills acquisition, shaping methods, goal setting, and the like. Unlike values, which are constantly instantiated but never achieved as an object, concrete goals that are values consistent can be achieved and ACT protocols almost always involve therapy work and homework linked to short, medium, and long-term behavior change goals."
Creative Hopelessness (CH)**	"**Purpose:** To notice that there is a control agenda in place and notice the basic unworkability of that system; to name the system as inappropriately applied control strategies; to examine why this does not work. **Method:** Draw out what things the client has tried to make things better, examine whether or not they have truly worked in the client's experience, and create space for something new to happen. **When to use:** As a precursor to the rest of the work in order for new responses to emerge, especially when the client is really struggling."

References

Hayes, S. C., Strosahl, K., & Wilson, K. G. (1999). Acceptance and commitment therapy: An experiential approach to behavior change. New York, NY: Guilford Press.

Hayes SC, Luoma JB, Bond FW, Masuda A, Lillis J. (2006) Acceptance and Commitment Therapy: Model, processes and outcomes. *Behaviour Research and Therapy*; 44:1–25.

** definition taken from https://contextualscience.org/facing_the_current_situation_creative_hopelessnesscontrol_is_a_problem

Supplementary Document 2: Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	Title Page, page 1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	2-7
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	7
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	7
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	7-8
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	8-9
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	Supplementary Document 3

Section/topic	#	Checklist item	Reported on page #
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	9
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	9-10
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	9-10
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	10-11
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	11
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	11
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	NA
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	12
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	12
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	13-15

Section/topic	#	Checklist item	Reported on page #
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome-level assessment (see Item 12).	14-15, Figure 2
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group and (b) effect estimates and confidence intervals, ideally with a forest plot.	14-18, Tables 1-5
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	20, Figures 3-4
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	NA
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	20
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., health care providers, users, and policy makers).	20-26
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review level (e.g., incomplete retrieval of identified research, reporting bias).	26-27
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	28
FUNDING			

Section/topic	#	Checklist item	Reported on page #
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	65

Supplementary Document 3: Search Strategy

<small>OVERVIEW</small>

Databases Searched
Medline via OVID
Embase via OVID
CINAHL via Ebsco
PsycINFO via Ebsco
Cochrane Central Register of Controlled Trials
Web of Science
Scopus

RCT <small>FILTER</small>: SIGN filter for Medline, embase, cinahl, and adapted for remaining databases:

http://www.sign.ac.uk/search-filters.html

Medline

exp exercise/ or exp walking/ or exp physical fitness/ or exp running/ or exp physical exertion/ or exp bicycling/ or exp swimming/ or exp yoga/ or exp sports/ or exp dancing/ or exp leisure activities/ or exp activities of daily living/ or ((physic* adj3 activ*) or exercis* or walk* or run* or fitness* or (physical adj (fit* or exert*)) or swim* or yoga* or cycling* or bicyc* or pilates* or (energy expenditure) or sport* or danc* or (activ* adj lifestyle) or (leisure activ*) or (activities of daily living)).mp.

and

((accept* adj5 commit*) or (act)).mp. or exp "acceptance and commitment therapy"/

AND

(Randomized Controlled Trials as Topic/ or randomized controlled trial/ or Random Allocation/ or Double Blind Method/ or Single Blind Method/ or clinical trial/ or clinical trial, phase i.pt or clinical trial, phase ii.pt or clinical trial, phase iii.pt or clinical trial, phase iv.pt or controlled clinical trial.pt or randomized controlled trial.pt or multicenter study.pt or clinical trial.pt or exp Clinical Trials as topic/ or (clinical adj trial$).tw or ((singl$ or doubl$ or treb$ or tripl$) adj (blind$3 or mask$3)).tw or PLACEBOS/ or placebo$.tw or randomly allocated.tw or (allocated adj2 random$).tw) NOT (case report.tw or letter/ or historical article/)

Limits : 1980 to present

Embase

1 (Clinical Trial/ or Randomized Controlled Trial/ or controlled clinical trial/ or multicenter study/ or Phase 3 clinical trial/ or Phase 4 clinical trial/ or RANDOMIZATION/ or Single Blind Procedure/ or Double Blind Procedure/ or Crossover Procedure/ or PLACEBO/ or randomi?ed controlled trial$.tw. or rct.tw. or (random$ adj2 allocat$).tw. or single blind$.tw. or double blind$.tw. or ((treble or triple) adj blind$).tw. or placebo$.tw. or Prospective Study/) not (Case Study/ or case report.tw. or abstract

report/ or letter/ or Conference proceeding.pt. or Conference abstract.pt. or Editorial.pt. or Letter.pt. or Note.pt.) (1550528)

2   ((physic* adj3 activ*) or exercis* or walk* or run* or fitness* or (physical adj (fit* or exert*)) or swim* or yoga* or cycling* or bicyc* or pilates* or energy expenditure or sport* or danc* or (activ* adj lifestyle) or leisure activ* or activities of daily living).ti,ab. (1003036)

3   exp *exercise/ (131738)

4   exp *sport/ (65674)

5   exp *physical activity/ (107892)

6   exp *walking/ (31215)

7   exp *running/ (9236)

8   exp *fitness/ (15066)

9   exp *swimming/ (6667)

10   exp *yoga/ (2799)

11   exp *cycling/ (3068)

12   exp *dancing/ (1823)

13   exp *leisure/ (8585)

14   exp *daily life activity/ (12195)

15   or/2-14 (1092874)

16   ((accept* adj5 commit*) or act).ti,ab. (291098)

17   exp *"acceptance and commitment therapy"/ (444)

18   16 or 17 (291138)

19   1 and 15 and 18 (622)

20   limit 19 to yr="1980 -Current" (614)

CINAHL

#	Query
S8	S1 AND S4 AND S7
S7	S5 OR S6
S6	(MH "Physical Fitness+") OR (MH "Exercise+") OR (MH "Walking+") OR (MH "Running+") OR (MH "Exertion+") OR (MH "Cycling") OR (MH "Swimming") OR (MH "Yoga+") OR (MH "Dancing+") OR (MH "Leisure Activities+") OR (MH "Activities of Daily Living+") OR (MH "Sports+")
S5	((physic* n3 activ*) or exercis* or walk* or run* or fitness* or (physical n1 (fit* or exert*)) or swim* or yoga* or cycling* or bicyc* or pilates* or (energy expenditure) or sport* or danc* or (activ* n1 lifestyle) or (leisure activ*) or (activities of daily living))
S4	S2 OR S3
S3	(MH "Acceptance and Commitment Therapy")
S2	(accept* n5 commit*)
S1	(MH "Clinical Trials+") OR PT Clinical trial OR (TX ((singl* n1 blind*) or (singl* n1 mask*)) or TX ((doubl* n1 blind*) or (doubl* n1 mask*)) or TX ((tripl* n1 blind*) or (tripl* n1 mask*)) or TX ((trebl* n1 blind*) or (trebl* n1 mask*))) OR TX randomi* control* trial* OR (MH "Random Assignment") OR TX random* allocat* OR TX placebo* OR (MH "Placebos") OR (MH "Quantitative Studies") OR TX allocat* random*

Limited to 1980 onwards

PsycINFO

#	Query
S13	S3 AND S6 AND S12
S12	S7 OR S8 OR S9 OR S10 OR S11
S11	trial* or placebo* or random* or control* or quantitative*
S10	(((DE "Clinical Trials") OR (DE "Placebo")) OR (DE "Quantitative Methods")) OR (DE "Random Sampling")

S9   TX allocat* random*

S8   (TX ((singl* n1 blind*) or (singl* n1 mask*)) or TX ((doubl* n1 blind*) or (doubl* n1 mask*)) or TX ((tripl* n1 blind*) or (tripl* n1 mask*)) or TX ((trebl* n1 blind*) or (trebl* n1 mask*))) OR TX randomi* control* trial* OR (MH "Random Assignment") OR TX random* allocat* OR TX placebo*

S7   ((doubl* n1 blind*) or (doubl* n1 mask*)) or ((tripl* n1 blind*) or (tripl* n1 mask*))

S6   S4 OR S5

S5   DE "Acceptance and Commitment Therapy"

S4   (accept* n5 commit*)

S3   S1 OR S2

S2   (((((((DE "Exercise" OR DE "Aerobic Exercise" OR DE "Weightlifting" OR DE "Yoga") OR (DE "Physical Activity" OR DE "Actigraphy" OR DE "Exercise")) OR (DE "Physical Fitness")) OR (DE "Walking")) OR (DE "Swimming")) OR (DE "Yoga")) OR (DE "Energy Expenditure")) OR (DE "Activities of Daily Living")

S1   ((physic* n3 activ*) or exercis* or walk* or run* or fitness* or (physical n1 (fit* or exert*)) or swim* or yoga* or cycling* or bicyc* or pilates* or (energy expenditure) or sport* or danc* or (activ* n1 lifestyle) or (leisure activ*) or (activities of daily living))

Limited to 1980 onwards

Cochrane Central Register of Controlled Trials
ID

#1   accept near/5 commit*:ti,ab,kw (Word variations have been searched)

#2   MeSH descriptor: [Acceptance and Commitment Therapy] explode all trees

#3   #1 or #2

#4   ((physic* near/3 activ*) or exercis* or walk* or run* or fitness* or (physical near/1 (fit* or exert*)) or swim* or yoga* or cycling* or bicyc* or pilates* or (energy expenditure) or sport* or danc* or (activ* near/1 lifestyle) or (leisure activ*) or (activities of daily living))

#5   MeSH descriptor: [Exercise] explode all trees

#6   MeSH descriptor: [Walking] explode all trees

#7   MeSH descriptor: [Physical Fitness] explode all trees

#8   MeSH descriptor: [Physical Exertion] explode all trees

#9   MeSH descriptor: [Bicycling] explode all trees

#10   MeSH descriptor: [Swimming] explode all trees

#11   MeSH descriptor: [Yoga] explode all trees

#12   MeSH descriptor: [Sports] explode all trees

#13   MeSH descriptor: [Dancing] explode all trees

#14   MeSH descriptor: [Leisure Activities] explode all trees

#15   MeSH descriptor: [Activities of Daily Living] explode all trees

#16   #4 or #5 or #6 or #7 or #8 or #9 or #10 or #11 or #12 or #13 or #14 or #15

#17   #3 and #16

Web of Science

((physic* NEAR/3 activ*) or exercis* or walk* or run* or fitness* or (physical NEAR/1 (fit* or exert*)) or swim* or yoga* or cycling* or bicyc* or pilates* or (energy expenditure) or sport* or danc* or (activ* NEAR/1 lifestyle) or (leisure activ*) or (activities of daily living))

AND

((accept* NEAR/5 commit*)

AND

Random* or trial* or placebo* or blind* or control*

Limited to 1980 to current

SCOPUS

TITLE-ABS-KEY (((*PHYSIC** W/3 *ACTIV**) OR *EXERCIS** OR *WALK** OR *RUN** OR *FITNESS** OR (*PHYSICAL* W/1 (*FIT** OR *EXERT**)) OR *SWIM** OR *YOGA** OR *CYCLING** OR *BICYC** OR *PILATES** OR (*ENERGY* W/1 *EXPENDITURE*) OR *SPORT** OR *DANC** OR (*ACTIV** W/1 *LIFESTYLE*) OR (*LEISURE* W/1 *ACTIV**) OR (*ACTIVITIES* W/1 *OF* W/1 *DAILY* W/1 *LIVING*))) AND TITLE-ABS-KEY (*ACCEPT** W/5 *COMMIT**) AND TITLE-ABS-KEY (*RANDOM** OR *TRIAL** OR *PLACEBO** OR *BLIND** OR *CONTROL**)

-