

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).

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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.

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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 than 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 through 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.

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Methods

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This systematic review followed a protocol registered with PROSPERO (registration number: CRD42018115730) (Pears, Sutton, & Griffin, 2018) and used the PRISMA checklist (provided in Supplementary Document 2) for reporting systematic reviews (Moher, Liberati, Tetzlaff, & Altman, 2009).

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Inclusion and Exclusion Criteria

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Studies were required to meet the following criteria: (i) Randomized controlled trials (RCTs) or pre-post designs; (ii) the intervention was designed to increase physical activity (interventions targeting multiple health behaviours were excluded); (iii) the study must report a physical activity behaviour outcome (either objective or subjective /self-report); (iv) the study must include an intervention based on ACT (delivered individually or in a group; via single or multiple sessions; by any provider, including fully-digitized interventions; in any setting); (v) the study must target adult participants (≥ 18 years); (vi) the study must be available in English language.

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Search Strategy

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Seven electronic databases were searched from 1980 up to June 26th 2018: MEDLINE, EMBASE, PsycINFO, Web of Science, Scopus, CINAHL, and the Cochrane Library. Searches were restricted to 1980 or later, as acceptance and commitment therapy was not developed before 1982. The search strategy was designed and conducted with the help of a university librarian (IK). The search terms were “acceptance and commitment 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 I₂ 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 $\geq 79\%$ 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)).

BCTs in the intervention condition: additional components.

407
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).

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 ($\chi^2=104.39$, $p<0.00001$) 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 ($\chi^2=4.79$, $p=0.31$; $I^2=17\%$), 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

462 **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.

624 **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	Participant s 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] (<i>Month 1 only</i>) 2. Total mins of exercise over 30 days (daily exercise journal) [SR] (<i>Month 1 only</i>) 3. Self-reported exercise, min/week [SR] 4. PAR exercise min/week in past week (Stanford 7-day physical activity recall. PAR) [SR] (<i>baseline and Month 1 only</i>) 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
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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. 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)
		<u>8 weeks</u>	<u>ACT= 1.50 (15.56); ED= 0.89 (1.48)</u>	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)	
		<u>3 months</u>	<u>ACT= 3956.4 (261.60); Ctrl = 2332.9 (246.00)</u>	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)	
		<u>6 months</u>	<u>ACT =23.59 (21.42); II=18.18 (12.71)</u>	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)
		<u>6 months</u>	<u>ACT+FB =29.5 (17.6); FB=26.6 (16.8)</u>	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 test) [O]	Baseline	ACT=24.43 (6.71)	
		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)
		<u>12 weeks</u>	<u>ACT+WP = 42.68 (33.28); WP =20.04 (17.23)</u>	<u>0.82 (0.29 to 1.36)</u>
Stevens; 2017	1. Total mins of exercise over 30 days (Heart rate monitor, HRM, data) [O]	<u>1 month</u>	<u>ACT+EP =659.64 (496.85); EP= 517.15 (361.759)</u>	<u>0.32 (-0.13 to 0.77)</u>
	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; IL, 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.

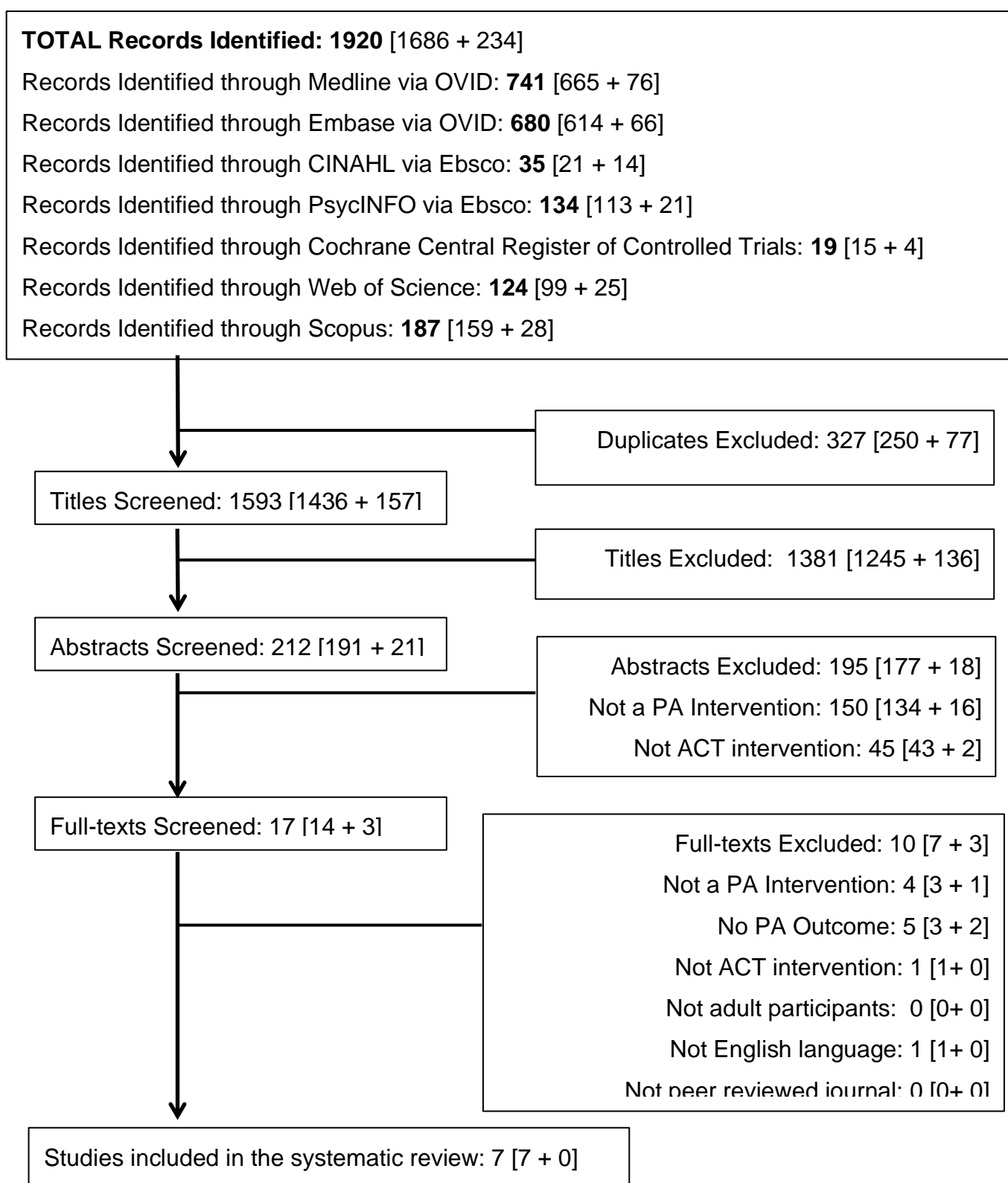


Figure 1. Flow diagram of systematic selection of papers in review. Total numbers are shown in **bold**. Results of the original search (conducted 26th June 2018) plus the results of the updated search (conducted 29th May 2019) are show in [square brackets].

	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).

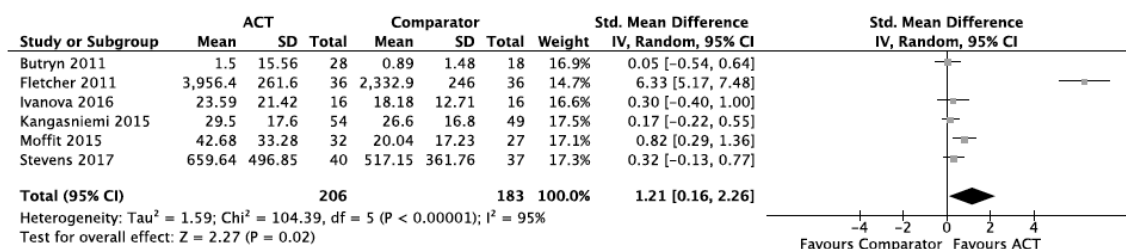


Figure 3: Forest plot of the effect of ACT-based interventions versus Comparators on physical activity behaviour expressed as standardised mean difference.

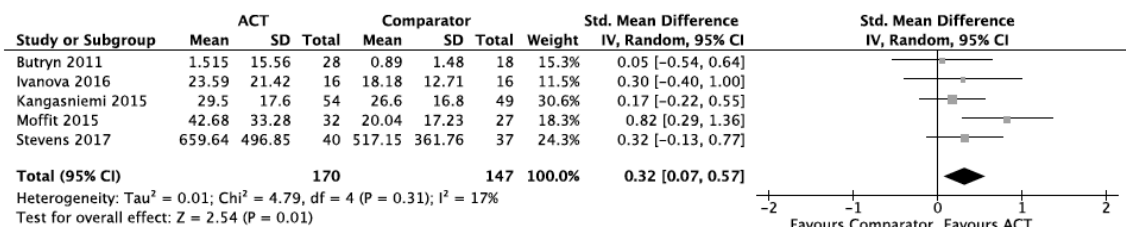


Figure 4: Forest plot of the effect of ACT-based interventions versus Comparators on physical activity behaviour expressed as standardised mean difference, after removing one outlier.

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.

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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

<i>Section/topic</i>	<i>#</i>	<i>Checklist item</i>	<i>Reported on page #</i>
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

<i>Section/topic</i>	<i>#</i>	<i>Checklist item</i>	<i>Reported on page #</i>
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

<i>Section/topic</i>	<i>#</i>	<i>Checklist item</i>	<i>Reported on page #</i>
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
<i>DISCUSSION</i>			
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
<i>FUNDING</i>			

<i>Section/topic</i>	<i>#</i>	<i>Checklist item</i>	<i>Reported on page #</i>
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

OVERVIEW

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 FILTER: 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)

#	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*

(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*

S8

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**)

•