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Self-reported tolerance of the intensity of exercise influences affective responses to and intentions to engage with high-intensity interval exercise

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1 **Self-Reported Tolerance of the Intensity of Exercise Influences Affective Responses to**
2 **and Intentions to Engage with High-Intensity Interval Exercise**

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4 Running title: tolerance of exercise intensity, affect, & high-intensity interval exercise

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26 **Abstract**

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28 This study investigated the effect of self-reported tolerance of the intensity of exercise on
29 affective responses to, self-efficacy for and intention to repeat low-volume high-intensity
30 interval exercise (HIIE). Thirty-six healthy participants (mean age 21 ± 2 years) were split into
31 high tolerance (HT; $n = 19$), low tolerance (LT; $n = 9$), and very low tolerance (VLT; $n = 8$) of
32 exercise intensity groups. Participants completed 10 x 6 s cycle sprints with 60 s recovery.
33 Affective valence and perceived activation were measured before exercise, after sprints 2, 4, 6,
34 8, 10, and 20 min post-HIIE. Intention and self-efficacy were assessed 20 min post-HIIE.
35 Affective valence was significantly lower in VLT vs. LT ($P = 0.034$, $d = 1.01-1.14$) and HT (P
36 $= 0.018$, $d = 1.34-1.70$). Circumplex profiles showed a negative affective state in VLT only.
37 The VLT group had lower intentions to repeat HIIE once and three times per week than HT (P
38 < 0.001 , $d = 1.87$ and 1.81 , respectively) and LT ($P = 0.107$, $d = 0.85$; $P = 0.295$, $d = 0.53$,
39 respectively). Self-efficacy was not influenced by tolerance. Self-reported tolerance of
40 exercise intensity influences affective responses to and intentions to engage with HIIE.

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50 **KEYWORDS:** interval training; intermittent training; adherence; psychological responses.

51 **INTRODUCTION**

52

53 Low volume high-intensity interval exercise (HIIE) encompasses a range of protocols that
54 involve brief repeated bouts of relatively intense or all-out exercise separated by rest or low-
55 intensity exercise, with total intense exercise time ≤ 10 min per session and total session
56 time ≤ 30 min (Gillen & Gibala, 2014). Growing evidence supports the physical health
57 benefits of low volume HIIE in clinical (Little et al., 2011) and inactive (Allison et al., 2017;
58 Smith-Ryan, Trexler, Wingfield, & Blue, 2016) groups. These benefits are
59 often comparable to or greater than moderate-intensity continuous exercise (Jelleyman et al.,
60 2015; Weston, Wisloff, & Coombes, 2014), but with the benefit of greatly reduced total
61 training time. Several researchers have argued that the time-efficiency of HIIE may reduce
62 barriers, such as lack of time, which contribute to population inactivity and poor public health
63 (Biddle & Batterham, 2015).

64

65 The public health potential of HIIE has been subject to debate with opponents arguing that
66 its high-intensity nature will likely mean that participants will find it unpleasant and therefore
67 have poor adherence (Biddle & Batterham, 2015; Hardcastle, Ray, Beale, & Hagger,
68 2014). This argument draws from Dual Mode Theory (DMT) (Ekkekakis,
69 2003), which demonstrates that intensity is a key mediator of affective responses to
70 exercise. Dual mode theory postulates that affective responses to exercise are based on the
71 interplay between cognitive parameters (e.g., self-efficacy), and interoceptive (e.g. muscular
72 and respiratory) cues. The role that these factors play on affect during exercise is dependent
73 on exercise intensity, with increased reliance on anaerobic metabolism (often operationalised
74 as ventilatory threshold; VT) identified as a critical tipping point (Ekkekakis, Hall, &
75 Petruzzello, 2008; Ekkekakis, Hall, & Petruzzello, 2005b). According to DMT, cognitive

76 parameters influence affect at intensities $< VT$, and affective responses are consistently
77 positive (Ekkekakis et al., 2008). As exercise intensity approaches VT , there is variation in
78 affective responses with some individuals reporting increases and others decreases (Ekkekakis
79 et al., 2008). As exercise exceeds VT interoceptive cues gain salience and most individuals
80 report reduced affect (Ekkekakis, Parfitt, & Petruzzello, 2011).

81

82 Empirical research supports tenets of DMT. Continuous exercise $> VT$ typically leads to more
83 unpleasant affective responses than continuous exercise at and $< VT$ (Ekkekakis et al., 2005b;
84 Kilpatrick, Kraemer, Bartholomew, Acevedo, & Jarreau, 2007). However, DMT is based on
85 continuous exercise, and may not be directly applicable to the intermittent nature of HIIE that
86 allows periods of recovery between high-intensity bouts (Jung, Little, & Batterham, 2016).
87 Based on DMT, it may be expected that during intervals $>VT$, interoceptive cues would
88 dominate and participants would experience negative affect. However studies that have
89 examined affective response to HIIE compared with moderate-intensity continuous exercise,
90 have reported mixed findings (Stork, Banfield, Gibala, & Ginis, 2017). Some studies reported
91 affect was more negative during HIIE compared to moderate-intensity continuous exercise
92 (Decker & Ekkekakis, 2017; Greene, Greenlee, & Petruzzello, 2018; Jung, Bourne, & Little,
93 2014; Niven, Thow, Holroyd, Turner, & Phillips, 2018), and others reported no difference
94 between conditions (Astorino & Thum, 2016; Little, Jung, Wright, Wright, & Manders,
95 2014). The lack of consistency in findings may partly be due to the influence of individual
96 differences in affective responses to a given exercise challenge. Several studies
97 report wide variation in the affective response of participants, particularly to high-intensity
98 continuous exercise and HIIE (Decker & Ekkekakis, 2017; Greene et al., 2018).

99

100 Drawing from personality theories that highlight variation in individuals' arousability and
101 sensory modulation, Ekkekakis, Hall, and Petruzzello (2005a) introduced the concepts of
102 exercise preference and tolerance to examine variations in affective responses to interoceptive
103 stimuli during exercise. In a series of studies, the researchers demonstrated the validity and
104 reliability of the Preference for and Tolerance of the Intensity of Exercise Questionnaire
105 (PRETIE-Q) to assess these constructs (Ekkekakis, et al., 2005a). The researchers reported
106 that the preference and tolerance scales significantly predicted affective responses at VT, but
107 only the tolerance scale predicted affective responses > VT. That is, a higher tolerance was
108 associated with more positive affective responses > VT. More recently, Tempest and Parfitt
109 (2016) and Tempest and Parfitt (2017) demonstrated a biological basis for the influence of
110 tolerance of the intensity of exercise on affective responses to continuous exercise at VT.

111
112 The finding that individual differences in tolerance of the intensity of exercise may influence
113 affective responses has implications for understanding the relationship between HIIE and
114 affect. Although this relationship has been alluded to in the growing literature (Frazao et al.,
115 2016), to date no study has investigated the influence of tolerance of the intensity of exercise
116 on affective responses to HIIE. Additionally, no HIIE research has considered the influence
117 of tolerance of the intensity of exercise on self-efficacy and intention, which are cognitive
118 antecedents of physical activity and may provide insight into the likelihood of future
119 engagement in HIIE (Rhodes & Kates, 2015).

120
121 The aim of this study was to examine the influence of self-reported tolerance of the intensity
122 of exercise on affective responses to low volume HIIE, and also consider how tolerance may
123 influence self-efficacy for and intention to engage in future HIIE. We hypothesised that self-
124 reported tolerance of the intensity of exercise would significantly influence A) the affective

125 responses to low volume HIIE, and B) self-efficacy for and intentions to repeat low-volume
126 HIIE.

127

128 **METHODS**

129

130 **Participant screening**

131

132 The research was approved by the University of Edinburgh, Moray House School of Education
133 Ethics Committee. To identify high and low tolerance participants, we screened a sample
134 (n=114) of healthy (confirmed via Physical Activity Readiness Questionnaire) participants
135 aged 18-35 and unfamiliar with HIIE (confirmed via self-report of unfamiliarity with
136 undertaking HIIE as defined by Gillen & Gibala (2014)). Participants were recruited through
137 University social media platforms to complete the PRETIE-Q (Ekkekakis et al., 2005a). This
138 16-item questionnaire focuses on an individual's interpretation of interoceptive stimuli during
139 exercise in order to separately quantify their preference for and tolerance of the intensity of
140 exercise (Ekkekakis et al., 2005a). Each item comprises a five-point response scale (1 = I
141 totally disagree to 5 = I strongly agree). The eight items relating to tolerance of the intensity
142 of exercise were used in the current study, as the tolerance scale of the PRETIE-Q has been
143 shown to predict affective responses > VT (Ekkekakis et al., 2005a). Participants received a
144 tolerance score ranging from 8 (lowest tolerance) to 40 (highest tolerance). The PRETIE-Q
145 has a test-retest reliability coefficient of 0.85 (Ekkekakis et al., 2005a), and in the current study
146 had an internal consistency (Cronbach's alpha) of 0.72. Participants' responses to the PRETIE-
147 Q were ranked and the highest 25 and lowest 25 scoring participants were invited to participate
148 in the HIIE protocol. Splitting the sample in this way allowed the production of two distinct
149 groups: high tolerance (HT, $n = 25$) and low tolerance (LT, $n = 25$) (Tempest & Parfitt, 2016)

150 and provided the study with the power to detect a moderate effect ($\eta^2 = 0.5$) with $\alpha = 0.05$ and
151 $\beta = 0.20$ (Tempest & Parfitt, 2016). Participants were blinded to their grouping, and those who
152 were not invited for the second phase were fully debriefed.

153

154 **Participants**

155

156 Of the 50 participants invited to complete the HIIE protocol, six from the HT and eight from
157 the LT group did not complete the study, leaving $n = 19$ and $n = 17$ for HT and LT, respectively
158 (Figure 1; descriptive statistics in Table 1).

159

160 ****INSERT FIGURE 1 HERE****

161

162 ****INSERT TABLE 1 HERE****

163

164 **Predicted maximal oxygen uptake**

165

166 Participants completed the Perceived Functional Ability (PFA) questionnaire, which quantifies
167 participants' perceived ability to sustain an exercise intensity considered 'not too easy and not
168 too hard' (George, Stone, & Burkett, 1997). An incremental submaximal cycle ergometer
169 (Ergomedic 874E, Monark, Sweden) test was then performed (Nielson, George, Vehrs, Hager,
170 & Webb, 2010). Participants began the test against a 1 kg resistance for 3 min. Each 3 min
171 stage increased in resistance by 0.5 kg. Stages were completed until participants achieved an
172 end-stage heart rate (HR) $\geq 70\%$ but $< 85\%$ of age-predicted maximum. Cadence was
173 maintained at 70 rev.min⁻¹. Heart rate, PFA, end-exercise power output, age, gender and body
174 mass (BM) were used in the following $\dot{V}O_{2\max}$ prediction equation:

175

176 $\dot{V}O_{2\max} = 54.513 + 9.752(\text{gender, } 1 = \text{male, } 0 = \text{female}) - 0.297(\text{BM, kg}) + 0.739(\text{PFA}) + 0.077$
177 $(\text{power output, W}) - 0.071(\text{HR})$

178

179 This equation reported a standard error of the estimate of 3.36 ml.kg⁻¹.min⁻¹ in a similar sample
180 to that of the current study (Nielson et al., 2010). This prediction equation was used as it
181 employed multiple key influencers of $\dot{V}O_{2\max}$ (gender, BMI, habitual physical activity) as well
182 as a self-reported measure of an individual's PFA, which meaningfully contributed to the
183 accuracy of the equation (George et al., 1997).

184

185 We chose a submaximal $\dot{V}O_{2\max}$ prediction test because 1) participants with low tolerance of
186 the intensity of exercise may have terminated a maximal test prior to attaining $\dot{V}O_{2\max}$
187 (Ekkekakis, Lind, Hall, & Petruzzello, 2007; Hall, Petruzzello, Ekkekakis, Miller, & Bixby,
188 2014), which would have reduced test validity and presented an ethical concern regarding the
189 use of such a test in this sample, and 2) the $\dot{V}O_{2\max}$ data was used as a comparative measure of
190 fitness and not as a measure on which methodological decisions were made, precluding
191 requirement for the potentially greater precision of a maximal test.

192

193 **Low-volume high-intensity interval exercise**

194

195 Participants visited the climate-controlled laboratory (~21°C, 50% relative humidity) having
196 abstained from alcohol and strenuous exercise for ≥ 24 h. The investigator gave a detailed
197 explanation of the HIIE protocol, which included the requirement to complete each sprint
198 maximally, and standardised explanations of the psychometric scales according to the original
199 publications.

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Anthropometric measures were recorded (BM: model 708; Seca, Hamburg, Germany; standing height: model 245; Seca, Hamburg, Germany). The cycle ergometer (Ergomedic 874E, Monark, Sweden) was then adjusted to fit the participant, followed by a 5 min warm-up at a self-selected cadence with 1 kg resistance. Participants then completed 3 x 6 sec familiarisation sprints against their individualised target resistance, interspersed with 60 sec recovery. Following a 10 min seated recovery, the HIIE protocol began. Participants completed 10 x 6 sec all-out efforts against 7.5% BM (males) or 6.5% BM (females) (Froese & Houston, 1987), interspersed with 60 sec recovery. The first 50 sec of recovery was passive. From 50-59 sec, participants cycled unloaded at 60 rev·min⁻¹. At 59 sec, participants cycled maximally for 1 sec unloaded, after which the resistance was added to the flywheel and the 6 sec sprint began. This low volume HIIE protocol has been shown to substantially improve $\dot{V}O_{2max}$ and metabolic health in untrained populations (Adamson, Lorimer, Cobley, & Babraj, 2014). The researcher was present throughout to add and remove weight to the flywheel, however no encouragement was provided.

Measures

Heart rate was recorded throughout at 5 sec intervals (Polar Team 2, Finland). The Borg CR-10 scale assessed ratings of perceived exertion (RPE) (Borg & Kaijser, 2006; Oliveira, Slama, Deslandes, Furtado, & Santos, 2013). Affective valence (pleasure/displeasure) was assessed using the Feeling Scale (FS), ranging from -5 (very bad) to +5 (very good) (Hardy & Rejeski, 1989). Perceived activation was measured using the Felt Arousal Scale (FAS) (Svebak & Murgatroyd, 1985), ranging from 1 (low arousal) to 6 (high arousal). Scales were administered at rest immediately prior to HIIE (except RPE), immediately after sprints 2, 4, 6, 8 and 10, and

225 20 min post-HIIE (except RPE). Scales were taken immediately following sprints due to the
226 problem of collecting this information during an all-out cycling effort.

227

228 Data from the FS and FAS were represented in the circumplex model, describing a combined
229 affective state (Russell, 1980) with associated qualitative descriptors (calmness; energy;
230 tension; tiredness) (Oliveira et al., 2013). Ekkekakis et al. (2008) suggested that the circumplex
231 model is particularly appropriate for assessing affect before, during, and after exercise.

232

233 Task self-efficacy was assessed using a two-item measure (Jung et al., 2014). Question one
234 asked: “How confident are you that you can perform one bout of exercise a week for the next
235 four weeks that is just like the one you completed today?” Question two was identical, except
236 the number of exercise bouts increased to three per week (Jung et al., 2014). Responses were
237 scored on a scale of 0% (not at all) to 100% (extremely confident) in 10% increments. This
238 measure has demonstrated good internal consistency (Cronbach’s $\alpha \geq 0.95$) (Jung et al.,
239 2014). Intention to engage in the HIIE just completed over the next month was assessed using
240 a two-item measure (Jung et al., 2014), and consistent with other measures of intention
241 (Fishbein & Ajzen, 2010). Participants were asked to rate the extent to which they agreed with
242 the statement “I intend to engage in the type of exercise I performed today at least once per
243 week during the next month”, and the same statement but with a frequency of at least three
244 times per week. Responses were scored on a 7-point scale ranging from 1 (very unlikely) to 7
245 (very likely). Task self-efficacy and intentions to repeat were measured 20 min post-exercise,
246 which falls within the window of any affective rebound (Hall, Ekkekakis, & Petruzzello, 2002;
247 Jung et al., 2014; Oliveira et al., 2013).

248

249

250 **Statistical Analyses**

251

252 *Descriptive statistics*

253

254 Initial observation of the data identified a larger range of PRETIE-Q scores in LT (range = 10)
255 compared to HT (range = 5), as well as a greater variability in affective responses across
256 participants in LT compared to HT. Therefore, the LT group was further subdivided using its
257 median PRETIE-Q score into LT ($n = 9$; age 22.3 ± 2.2 years, height 1.68 ± 0.05 m, BM 67.3
258 ± 14.8 kg) and very low tolerance (VLT, $n = 8$; age 21.4 ± 1.7 years, height 1.72 ± 0.10 m, BM
259 72.7 ± 7.9 kg) groups.

260

261 *Inferential analysis*

262

263 The Shapiro-Wilk test assessed normality of distribution for all data sets. Exercise tolerance
264 scores were assessed using the Mann-Whitney U test. Mean $\dot{V}O_{2max}$, mean power output and
265 mean peak HR during HIIE was compared using one-way independent groups ANOVA. Post-
266 hoc analysis used the Games-Howell test for pairwise comparisons, to account for uneven
267 sample sizes across the tolerance groups (Games & Howell, 1976; Games, Keselman, & Rogan,
268 1981). Rating of perceived exertion, affective valence, and perceived activation were analysed
269 using a mixed-method two-way (group x time) ANOVA, with Games-Howell post hoc
270 analysis. Intentions to repeat and self-efficacy were assessed using Kruskal-Wallis tests with
271 Mann Whitney-U post hoc tests for between-group differences. The Bonferroni correction was
272 applied to the alpha level for post hoc tests. For all other tests, an alpha level of $P < 0.05$ was
273 used. Partial eta² (η^2) effect size (ES) quantified the magnitude of main ANOVA effects. For
274 select comparisons, Cohen's d ES for between-participants and within-participants designs

275 (Lakens, 2013) was used and defined as trivial (< 0.20), small ($\geq 0.2 - < 0.5$), medium ($\geq 0.5 -$
276 < 0.8), and large (≥ 0.8) (Cohen, 1992).

277

278 **RESULTS**

279

280 **Tolerance of the intensity of exercise, and predicted $\dot{V}O_{2\max}$**

281

282 By design, tolerance of the intensity of exercise in VLT (Mdn = 17.0, range 12-19) was
283 significantly lower than LT (Mdn = 21.0, range 20 to 22; $U = 0.0$, $z = 3.5$, $P < 0.001$) and HT
284 (Mdn = 32.0, range 31 to 36; $U = 0.0$, $z = 4.1$, $P < 0.001$), and was significantly lower in LT
285 vs. HT ($U = 0.0$, $z = 4.3$, $P < 0.001$).

286

287 Predicted $\dot{V}O_{2\max}$ in the HT, LT, and VLT groups was 54.8 ± 1.8 , 49.9 ± 2.1 , and 47.3 ± 2.0
288 $\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$, respectively ($F_{2,33} = 10.266$, $P < 0.001$). In HT, $\dot{V}O_{2\max}$ was significantly greater
289 than LT ($P = 0.006$, $d = 0.64$) and VLT ($P < 0.001$, $d = 1.05$). There was no significant
290 difference between LT and VLT ($P = 0.478$, $d = 0.42$).

291

292 **Physiological demand**

293

294 Mean power output during HIIE was 8.7 ± 1.9 , 7.8 ± 1.9 , and $6.3 \pm 2.3 \text{ W}\cdot\text{kg}^{-1}$ for the HT, LT
295 and VLT groups, respectively ($F_{2,31} = 3.913$, $P = 0.031$). There was a large ES for mean power
296 output between HT and VLT ($P = 0.062$, $d = 1.26$), and a medium ES between HT and LT (P
297 $= 0.526$, $d = 0.56$) and between LT and VLT ($P = 0.385$, $d = 0.68$). Mean peak HR during HIIE
298 was 163 ± 13 , 157 ± 7 , and $157 \pm 12 \text{ b}\cdot\text{min}^{-1}$ for HT, LT, and VLT, respectively ($F_{2,27} = 1.067$,

299 $P = 0.358$). There was a medium ES for mean peak HR between HT and both LT and VLT (d
300 $= 0.50 - 0.52$), and a trivial ES for LT and VLT ($d = 0.05$).

301

302 **Rating of Perceived Exertion**

303

304 Figure 2 shows RPE for the three tolerance groups. There was a significant main effect of time
305 on RPE ($F_{2,9,95.0} = 140.118$, $P < 0.001$, $\eta^2 = 0.805$), with RPE at each time point significantly
306 different to the previous time point ($P < 0.001$, $d = 0.72 - 2.61$). There was no statistically
307 significant effect of tolerance ($F_{2,33} = 0.210$, $P = 0.812$, $\eta^2 = 0.013$) or tolerance x time
308 interaction ($F_{5,8,95.0} = 0.833$, $P = 0.543$, $\eta^2 = 0.048$).

309

310 ***Figure 2 near here***

311

312 **Affective valence**

313

314 Figure 3A shows affective valence for the three tolerance groups. There was a significant main
315 effect of tolerance on affective valence ($F_{2,33} = 9.771$, $P < 0.001$, $\eta^2 = 0.372$). Affective
316 valence was significantly lower in VLT vs. LT ($P = 0.034$, $d = 1.01 - 1.14$) and HT ($P = 0.018$,
317 $d = 1.34 - 1.70$) at all time points during and post-exercise. There were no significant
318 differences between LT and HT ($P = 0.862$, $d = 0.07 - 0.19$). There was also a significant main
319 effect of time on affective valence ($F_{2,4,77.9} = 4.581$, $P = 0.009$, $\eta^2 = 0.122$). There was no
320 significant tolerance x time interaction ($F_{4,7,6.4} = 1.329$, $P = 0.262$, $\eta^2 = 0.075$).

321

322 ***Figure 3 near here***

323

324 **Perceived Activation**

325

326 There was no significant effect of tolerance on perceived activation ($F_{2,33} = 1.573, P = 0.223,$
327 $\eta^2=0.372$; Figure 3B). However, there was a significant effect of time ($F_{3,7,121.9} = 26.11, P <$
328 $0.001, \eta^2=0.442$), with perceived activation increasing significantly between baseline and
329 sprint 2 ($P < 0.001, d = 1.20$) and decreasing significantly from sprint 10 to 20 min post-
330 exercise ($P = 0.014, d = 0.83$). There was no tolerance x time interaction ($F_{7,4,121.9} = 26.11, P$
331 $= 0.723, \eta^2=0.038$).

332

333 **Circumplex**

334

335 All groups began with a sense of calmness pre-HIIE (Figure 4). The VLT group progressed to
336 a state of negative affect and low arousal by sprints 8 and 10, associated with tiredness. The
337 LT group generated a similar pattern to the HT group, progressing to a state of energy from
338 sprints 4-10. The VLT and LT groups returned to calmness post-HIIE, whereas the HT group
339 remained in a state of energy.

340

341 ***Figure 4 near here***

342

343 **Intention to repeat and exercise task self-efficacy**

344

345 Significant between-groups main effects were found for intention to repeat HIIE once ($\chi^2 =$
346 $14.3, P = 0.001$) and three times per week ($\chi^2 = 14.8, P = 0.001$). The VLT group had
347 significantly lower intentions to repeat HIIE at both exercise frequencies than the HT group,
348 and lower intentions to repeat at both frequencies than the LT group, with moderate to large

349 ES (Table 2). Exercise task self-efficacy (Table 2) was not significantly influenced by
350 tolerance of the intensity of exercise once per week ($\chi^2 = 2.3, P = 0.321$) or three times per
351 week ($\chi^2 = 2.8, P = 0.247$).

352

353 ***Table 2 near here***

354

355 **DISCUSSION**

356

357 Research investigating affective responses to HIIE has produced inconsistent findings (Stork
358 et al., 2017). This inconsistency may partly be explained by individual differences in affective
359 responses to HIIE. The aim of this study was to investigate the effect of the individual
360 difference measure self-reported tolerance of the intensity of exercise on affective responses
361 during and after low-volume HIIE. The VLT group reported significantly lower affective
362 valence during and after low-volume HIIE, and more negative circumplex responses, compared
363 to LT and HT. The VLT group also showed lower intentions to repeat low-volume HIIE than
364 the LT and HT groups, and the LT group showed lower intentions to repeat than the HT group.
365 However, there was no effect of tolerance of the intensity of exercise on task self-efficacy.

366

367 The finding that VLT participants showed significantly more negative affect than HT and LT
368 participants during and after low-volume HIIE suggests that self-reported tolerance of the
369 intensity of exercise moderates affective responses to HIIE. An increase in exercise intensity,
370 particularly to beyond VT, exacerbates the influence of interoceptive cues on an individual's
371 perception of exercise demand, which may lead to a decline in affect (Ekkekakis et al., 2011).
372 A logical extension of this tenet is that individuals who are more tolerant to the 'accumulation'
373 of these interoceptive cues will be more able to defend against declines in affect. Evidence

374 supporting this suggestion can be found in steady-state and incremental exercise protocols
375 (Ekkekakis et al., 2007; Hall et al., 2014), with recent research suggesting this tolerance has a
376 biological basis (Tempest & Parfitt, 2016). However, this is the first study to provide support
377 for a potentially discriminatory role of VLT of the intensity of exercise on affective responses
378 during HIIE. Our data also supports assertions previously articulated in the growing HIIE
379 literature that tolerance of the intensity of exercise may explain variance in affective responses
380 (Frazao et al., 2016).

381

382 The LT group did not differ in affective responses compared with HT, which is contrary to
383 continuous exercise studies (Ekkekakis et al., 2007; Tempest & Parfitt, 2016). Affective
384 responses to HIIE are known to be influenced by the number and duration of work bouts and
385 the work/rest ratio (Frazao et al., 2016; Martinez, Kilpatrick, Salomon, Jung, & Little, 2015).
386 Therefore, the lack of difference in affect between HT and LT may be as a consequence of the
387 ‘more palatable’ (Martinez et al., 2015) nature of the low volume HIIE protocol employed in
388 this study, which LT participants were able to tolerate.

389

390 It is plausible that the greater aerobic fitness of the HT and LT groups vs. the VLT group may
391 have contributed to the better maintenance of affect, as recovery from work bouts during HIIE
392 is enhanced with better aerobic fitness (Tomlin & Wenger, 2001). Less complete recovery in
393 the VLT group compared to the HT group may have led to a progressively greater homeostatic
394 disturbance as HIIE continued, thereby causing a progressively more negative affective state
395 (figure 3A) (Ekkekakis et al., 2011; Gaitanos, Williams, Boobis, & Brooks, 1993; Martinez et
396 al., 2015). However, the difference in aerobic fitness between LT and VLT was small, and
397 there was no significant difference between the groups in RPE suggesting that participants
398 perceived they were working at an equivalent intensity. These findings indicate that aerobic

399 fitness may have a minor moderating influence on affective responses to HIIE, and should be
400 controlled in order to further isolate the effect of tolerance of the intensity of exercise as a
401 moderator of affective responses to HIIE.

402

403 Several researchers have argued that HIIE does not have public health potential because
404 participants are unlikely to adhere to it (Biddle & Batterham, 2015). In our study intention to,
405 but not self-efficacy for future engagement in HIIE differed across the tolerance groups. It is
406 possible that the more negative affect experienced by the VLT group during HIIE influenced
407 their weaker intention. In a systematic review, Rhodes and Kates (2015) reported a limited
408 relationship between affective responses and intention. It is therefore plausible that there are
409 other explanations for these differences such as past experiences, which may also help explain
410 the difference between HT and LT. The lack of effect of tolerance of the intensity of exercise
411 on self-efficacy for future HIIE could suggest that the different affective responses to HIIE
412 between the groups did not impact on self-efficacy. Rhodes and Kates (2015) reported mixed
413 findings regarding a relationship between affective responses and self-efficacy. Future
414 research would be valuable to examine how individual differences in tolerance of the intensity
415 of exercise, and other variables including exercise preference, moderate the relationship
416 between affective responses to HIIE and intention to engage in and self-efficacy for future HIIE
417 in fully powered studies, whilst controlling for both baseline affect and pre-exercise levels of
418 these variables (Rhodes & Kates, 2015).

419

420 Although future research should aim to replicate the findings of the current study, our data have
421 implications for research and practice. Firstly, future studies comparing the influence of HIIE
422 and continuous exercise on affect should control for self-reported tolerance of the intensity of
423 exercise as a confounding variable. Practitioners may screen potential HIIE participants for

424 tolerance of the intensity of exercise using the PRETIE-Q to assist in the prescription of
425 appropriate activities. Although there is evidence that some individuals have positive
426 motivating experiences participating in HIIE (Burn & Niven, 2018), it is unsurprising that is
427 not likely to be for everyone and very low tolerance of the intensity of exercise could be a key
428 determinant. A limitation of this study is the sample size. We provided a power calculation
429 for a two-group analysis as this was the original methodological intention of the study.
430 However, the subsequent three-group analysis detected a statistical significance, therefore
431 confirming sufficient power for the statistical test to detect the effect. Furthermore, ES and
432 conservative post hoc tests for uneven sample sizes and variances were used. A second
433 limitation is the use of healthy young (albeit untrained) participants. Future research should
434 replicate the study with wider age and fitness ranges, clinical populations and different HIIE
435 protocols.

436

437 Declaration of interest

438

439 The authors have no conflicts of interest related to this paper.

440

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583 FIGURE 1. Schematic detailing the flow of participants through the study (number of
584 participants recruited, excluded based on pre-test screening, allocated to high tolerance and low
585 tolerance groups, and who withdrew from the study).

586

587 FIGURE 2. Ratings of perceived exertion at all time points for all groups.

588 * Significant main effect of time. HT = high tolerance; LT = low tolerance; VLT = very low
589 tolerance.

590

591 FIGURE 3. Affective valence (A) and perceived activation (B) at all time points for all groups.

592 ** Significantly lower in VLT vs. LT and HT at all time points $P = 0.034$.

593 *** Significant difference between time-points, $P < 0.001$ and $P = 0.014$, respectively. HT =
594 high tolerance; LT = low tolerance; VLT = very low tolerance.

595

596 FIGURE 4. Affective circumplex model applied to the all groups. HT = high tolerance; LT
597 = low tolerance; VLT = very low tolerance.

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