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1 Affective and Enjoyment Responses to 12 weeks of High Intensity Interval Training and Moderate
2 Continuous Training in Adults with Crohn's Disease

3 Short title: Enjoyment Responses to Exercise Training in Adults with Crohn's Disease

4

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30

31 Abstract

32

33 The aim was to undertake secondary data analysis from a three-arm randomised feasibility trial of
34 high intensity interval training (HIIT), moderate intensity continuous training (MICT), and usual care
35 control in adults with Crohn's disease (CD; n=36), with a primary focus on exploring affective and
36 enjoyment responses. Twenty-five participants with quiescent or mildly-active CD were randomised
37 to one of the two exercise groups: HIIT (n=13) and MICT (n=12). Both groups were offered thrice
38 weekly sessions for 12 weeks. MICT consisted of cycling for 30 minutes at 35% peak power (W_{peak}),
39 whereas HIIT involved ten 1-minute bouts at 90% W_{peak} , interspersed with 1-minute bouts at 15%
40 W_{peak} . Heart rate (HR), differentiated ratings of perceived exertion for legs (RPE-L) and central
41 (RPE-C), along with feeling state (Feeling Scale; FS) were measured at 92.5% of each session.
42 Enjoyment was measured at the end of training using the Physical Activity Enjoyment Scale (PACES).
43 Post-hoc exploratory analysis involved a mixed-model two-way ANOVA to compare HR, RPE-L, RPE-C
44 and FS for the exercise sessions in weeks 1, 6 and 12 between groups. Overall, HR was greater ($p <$
45 0.01) during HIIT (173 ± 8 bpm) compared with MICT (128 ± 6 bpm). Similarly, RPE-L and RPE-C
46 responses were greater overall ($p = 0.03$ and $p = 0.03$, respectively) during HIIT (5.5 ± 1.6 and $5.1 \pm$
47 1.7 , respectively) compared to MICT (3.3 ± 1.5 and 2.9 ± 1.5 , respectively). Overall, FS was 2.2 ± 1.9
48 for HIIT and 2.1 ± 1.4 for MICT with no effect of treatment group ($p = 0.25$) or time ($p = 0.94$). There
49 was also no significant difference in PACES scores between HIIT (99.4 ± 12.9) and MICT (101.3 ± 17.4 ;
50 $p = 0.78$). The findings suggest HIIT and MICT protocols elicited similar enjoyment and affect in
51 adults with quiescent or mildly-active CD.

52

53

54 **Introduction**

55

56 Crohn's Disease (CD) is a type of inflammatory bowel disease which can affect a patient anywhere
57 from the mouth to the anus. Patients often suffer with symptoms of fatigue, pain and diarrhoea (1).
58 Due to the inflammation of the gut wall it can also lead to malabsorption and this can lead to side
59 effects such as low bone mineral density and loss of muscle mass (1). Such effects can reduce quality
60 of life in a patient (2, 3). Other extraintestinal manifestations include large joint arthritis, uveitis,
61 iritis, episcleritis, erythema nodosum and pyoderma gangrenosum (4). In 2006, it was observed that
62 treatment for inflammatory bowel disease costs the United Kingdom's National Health Service (NHS)
63 approximately £720 million per annum (5) and with numbers of patients increasing annually the
64 economic burden will have risen and will continue to rise.

65 The main goals of treatment for CD are to achieve mucosal healing and deep remission (4) and
66 prevent the need for surgery. The treatment for CD involves an induction and maintenance regimen
67 (6). The choice of medication is dependent on disease severity and response to previous therapies.
68 The most widely used drugs in CD are corticosteroids, immunosuppressants and biologics (6) with
69 the aim to induce remission and mucosal healing and prevent the need for surgery. As mentioned,
70 there are often extraintestinal manifestations such as fatigue, low bone mineral density and loss of
71 muscle mass which the prescribed medications often do not treat. Therefore, exercise could be a
72 potential adjunct therapy to help reduce these symptoms and improve quality of life, as it has been
73 shown to help in other health conditions (7). It therefore seems a logical progression to investigate
74 exercise efficacy in relation to CD.

75 Most of the information currently known about exercise and CD is based on studies of low-moderate
76 intensity exercise with small sample sizes, which demonstrated an improvement in quality of life
77 without apparent adverse events (8-10). However, results from a UK-based survey indicated that

78 83% of adults with IBD do not engage in levels of activity commensurate with the public health
79 guidelines (17) of 150 minutes of moderate aerobic physical activity a week (11). Health related
80 research in the last decade has started to focus on the benefits of high intensity interval training
81 (HIIT) which consists of repeated, intense exercise bouts separated by passive or active recovery and
82 can be performed in less time for the same energy expenditure (12). Data from 6 to 12 weeks of
83 exercise training demonstrates similar to greater improvements in maximal oxygen uptake ($\dot{V}O_{2max}$)
84 with HIIT (~10-14%) compared to MICT (~7-10%)(13, 14). This could make HIIT appealing to
85 recommend when encouraging sedentary individuals to become more physically active. However,
86 HIIT can produce symptoms of shortness of breath, leg pain and dramatic fatigue in comparison to
87 MICT (15) and may therefore be less enjoyable. Currently, little information is known on HIIT in
88 adults with CD despite it appearing as a time-efficient approach to improve cardiorespiratory fitness
89 and cardio-metabolic health in general populations (16) and other clinical populations (17, 18).
90 Previous authors have suggested high-intensity exercise may potentially be detrimental to health
91 due to possible negative side effects in IBD, such as gastrointestinal distress (8) which could
92 exacerbate symptoms. This might be an old-fashioned reservation about high-intensity exercise and
93 IBD as there are several examples of elite athletes who suffer with IBD such as Sir Steve Redgrave (a
94 5 times Olympic Champion) and Ali Jawad (a Paralympic power lifter) who have still managed to
95 compete at an international standard. A greater understanding of the safety and efficacy of different
96 types of exercise training is needed to support the development of evidence-based exercise
97 guidelines and promotion strategies that are specific to CD.

98

99 Acceptability and enjoyment are also important when developing and exploring exercise training for
100 clinical populations. Considering that the affective response may be a predictor for exercise
101 adherence (19), it is important to prescribe exercise sessions which result in positive affective
102 responses. More intensive exercise might result in more negative affective responses which in turn

103 might contribute to poor exercise adherence (19). There is a trade-off between higher intensities
104 generally providing more cardiorespiratory fitness benefit but less favourable affective responses.
105 HIIT becomes a viable exercise programming option because the rest intervals between intense work
106 intervals may contribute to reduced discomfort and inducing a more positive affective response.
107 Studies comparing affective responses of HIIT and MICT have produced mixed results (20-23) and no
108 studies have been published in CD. Therefore, we conducted a feasibility study to determine the
109 acceptability and potential benefits and harms of HIIT and MICT in adults with quiescent or mildly-
110 active CD, and the feasibility of conducting a full-scale trial (see Tew *et al.* (24) for full discussion).
111 However, as enjoyment is a potential barrier for participating in exercise we focus here on secondary
112 analysis to explore differences in affect and enjoyment following 12 weeks of either HIIT or MICT
113 training in CD patients.

114

115 **Materials and Methods**

116 **Experimental Design**

117 This is a secondary analysis of data collected in a three-arm, parallel-group, feasibility randomised
118 controlled trial, which had a 12-week intervention period and follow-up assessments at 13 and 26
119 weeks after randomisation. Following enrolment, all participants underwent a baseline
120 cardiopulmonary exercise test (CPET) on a cycle ergometer and were asked for their preference to a
121 specific group allocation prior to randomisation. After baseline assessments, participants were
122 randomly assigned to HIIT, MICT or control, with each group receiving usual NHS care. Data on affect
123 and enjoyment was not collected in the control group, so the focus here is on data from the HIIT and
124 MICT groups only. Further details on the trial design have been published previously (25). Ethics
125 approval was granted by the Camden and Kings Cross Research Ethics Committee (reference

126 15/LO/1804), and all participants provided written informed consent before enrolment. The trial was
127 registered prospectively (ISRCTN13021107).

128

129 **Participants and Setting**

130 We included male and female patients between 16 and 65 years of age with a clinical diagnosis of
131 CD. Patients had to have a stool calprotectin of <250 µg/g, stable medication (>4 weeks), and
132 quiescent or mildly-active disease, as indicated by a Crohn's Disease Activity Index (CDAI) of <150 or
133 150-219, respectively. Exclusion criteria were: contraindication to exercise testing or training (26),
134 coexistent serious autoimmune disease (e.g. rheumatoid arthritis or systemic sclerosis), pregnant,
135 planned pregnancy or major surgery within the first 3 months after randomisation, poor tolerability
136 of venepuncture or inadequate access for venous blood sampling, and current participation in >90
137 min/week of purposeful exercise (e.g. cycling, swimming or running) or another clinical trial.
138 Recruitment was from three hospital trusts in England: Guy's and St Thomas' NHS Foundation Trust,
139 Barts Health NHS Trust, and Hampshire Hospitals NHS Foundation Trust. The exercise programmes
140 were delivered in the exercise science facilities of the University of East London and the University of
141 Winchester.

142

143 **Exercise Intervention**

144 Participants were invited to complete three supervised exercise sessions per week for 12
145 consecutive weeks, commencing the week following their baseline assessment and randomisation.
146 Reimbursement was provided for travel expenses. All exercise was undertaken on a cycle ergometer
147 (Lode Corival or SRM Ergometer), with each session comprising a 5-minute warm-up at 15% of peak

148 power output (W_{peak} ; determined during the baseline CPET), a main conditioning phase, and then a
149 3-minute cool-down at 15% W_{peak} . For HIIT, the conditioning phase involved ten 1-minute bouts at
150 90% W_{peak} , interspersed with 1-minute bouts at 15% W_{peak} , whereas for MICT it involved 30
151 minutes at 35% W_{peak} . The MICT programme was selected because it has been shown to elicit a
152 similar energy expenditure compared with the HIIT programme (27).

153 Differential ratings for breathlessness (RPE-C) and leg exertion (RPE-L) were assessed using Borg's
154 CR-10 scale (28) before exercise, immediately post, and 10-minutes post-exercise. In addition,
155 participants were asked to rate their breathlessness and leg exertion at 2.5%, 7.5%, 42.5%, 47.5%,
156 92.5% and 97.5% of exercise completed. These time points were chosen to incorporate both interval
157 and recovery periods during the HIIT protocol (21). Participants' heart rate was also recorded using
158 Polar heart-rate monitors at 2.5%, 42.5%, and 92.5% of exercise completed. The one item Feeling
159 Scale (FS; (29)) was used to measure general affective valence (i.e., pleasure and displeasure).

160 Participants were prompted at the beginning of each exercise visit with the following instructions:
161 *"While participating in exercise, it is common to experience changes in mood. Some individuals find*
162 *exercise pleasurable, whereas others find it to be unpleasant. Additionally, feeling may fluctuate*
163 *across time. That is, one might feel good and bad a number of times during exercise. When asked*
164 *please tell me how you feel at that current moment using the scale below"*. The feeling scale is
165 scored on an 11-point bipolar scale ranging from -5 (very bad) to +5 (very good). The FS was
166 administered pre-, immediately post and 10-minutes post-exercise. To assess in-task affect, the FS
167 was also administered at 2.5%, 42.5%, and 92.5% of exercise completed. In addition, enjoyment was
168 measured during the follow up assessment in week 13 using the Physical Activity Enjoyment Scale
169 (PACES). Incremental cycle exercise testing to maximum volitional exertion was performed in the
170 final sessions of weeks 4 and 8 to re-calculate W_{peak} and determine if the power output of the
171 upcoming exercise sessions needed to be changed.

172

173 **Statistical Analysis**

174 Statistical analyses were performed using SPSS v25.0 (IBM, Chicago, USA). Data are presented as
175 means \pm standard deviation (SD) and, where appropriate, individual responses are presented in a dot
176 plot graph. Post-hoc exploratory analysis involved a mixed-factorial two-way ANOVA to compare
177 exercise training data for RPE-C, RPE-L and FS on data averaged across the 3 weekly sessions at
178 92.5% of exercise completed (at the end of the 10th interval for HIIT and 27th minute for MICT) for
179 weeks 1, 6 and 12 (time) and between groups (condition). In addition, a mixed-factorial two-way
180 ANOVA to compare exercise testing data for peak power and HR at baseline and weeks 4, 8 and 12
181 (time) and between groups (condition). Main effects for time, main effects for condition and the
182 interaction between time and condition were calculated and where appropriate Bonferonni post-
183 hoc corrections for multiple comparisons were conducted. Mean differences are presented with
184 standard error when comparisons are made. Data normality was checked using a Shapiro-Wilk test;
185 upon moderate violation of the normality assumption, analysis of variance (ANOVA) was still
186 conducted as the model is sufficiently robust to detect statistically significant differences between
187 means, in terms of type 1 error (30). There was homogeneity of variances, as assessed by Levene's
188 test of homogeneity of variance ($p > 0.05$). There was homogeneity of covariances, as assessed by
189 Box's test of equality of covariance matrices ($p > 0.05$). Greenhouse-Geisser correction was applied
190 upon violation of Mauchly's test of sphericity for ANOVAs. An independent t-test was used to assess
191 between-group differences in PACES scores. Significance was determined by a p value of <0.05 .
192 Effect sizes were calculated using partial eta squared (η_p^2) and defined as trivial (<0.10), small (0.10-
193 0.29), moderate (0.30-0.49), or large (≥ 0.50) (31).

194

195 Results

196 Participant Characteristics at Baseline

197 A total of 13 participants, of which 7 (54%) were male (mean \pm SD age: 37.0 \pm 11.1 yrs; body mass:
198 76.2 \pm 13.5 kg; CDAI: 74 \pm 48), were randomised to HIIT and 12 were randomised to MICT (male:
199 n=3, 25%; mean \pm SD age: 38.5 \pm 13.0 yrs; body mass: 63.8 \pm 12.5 kg; CDAI: 55 \pm 47). The mean
200 baseline peak oxygen consumption ($\dot{V}O_{2peak}$) were 27.3 \pm 7.7 and 28.7 \pm 8.6 ml/kg/min for HIIT and
201 MICT, respectively. Mean recorded baseline peak power output on the CPET was 169 \pm 25 W for
202 HIIT and 153 \pm 11 W for MICT. When participants were asked for their preference to a specific group
203 allocation prior to randomisation 74% preferred HIIT, 22% MICT, and 4% control.

204

205 Exercise Testing Data

206 Table 1 depicts the exercise testing data during the exercise tests at baseline and weeks 4, 8 and 12
207 for both HIIT and MICT. There was a significant interaction between time and condition for peak
208 power ($F_{(3,60)}=5.27$; $p < 0.01$; $\eta_p^2=0.21$). There was a significant effect of time on peak power for HIIT
209 ($F_{(3,27)}=27.81$; $p < 0.01$; $\eta_p^2=0.76$). For HIIT peak power significantly increased from baseline to week 4
210 (mean \pm SD, 20.5 \pm 10.8W, $p = 0.03$). Peak power was not significantly different between weeks 4
211 and 8 (mean difference \pm SE; 10.00 \pm 8.94W, $p = 0.31$), but power was significantly greater in week 12
212 compared to 4 (mean difference \pm SE; 12.30 \pm 6.32, $p = 0.02$). There was no significant difference
213 between weeks 8 and 12 (mean difference \pm SE; 2.30 \pm 7.16W, $p = 1.00$). There was no significant
214 effect of time on peak power for MICT ($F_{(1.69,18.56)}=3.62$; $p = 0.05$; $\eta_p^2=0.25$). There were no
215 statistically significant differences between HIIT and MICT for peak power at baseline, weeks 4, 8 and
216 12 ($p > 0.05$). Peak HR was similar between conditions throughout the training with no main effect

217 for condition ($F_{(1,19)}=0.09$; $p =0.77$; $\eta_p^2=0.01$) and no main effect for time ($F_{(3,57)}=0.35$; $p =0.79$;
 218 $\eta_p^2=0.02$) nor an interaction between time and training ($F_{(3,57)}=1.16$; $p =0.33$; $\eta_p^2=0.06$).

219

220 Table 1. Mean \pm SD peak power and HR during the exercise tests at baseline and weeks 4, 8 and 12
 221 for HIIT and MICT

	HIIT*				MICT			
	Baseline	4	8	12	Baseline	4	8	12
Peak Power (W)	169 \pm 25	190 \pm 35 [#]	203 \pm 29 [#]	203 \pm 35 [#] [§]	153 \pm 11	163 \pm 36	165 \pm 37	165 \pm 30
HR (bpm)	181 \pm 12	181 \pm 10	183 \pm 11	179 \pm 13	173 \pm 11	177 \pm 11	176 \pm 9	177 \pm 9

222 *significant difference from MICT ($p <0.05$). [#]significant difference from baseline. [§]significant
 223 difference from 4 weeks.

224

225 Exercise Training Data

226 Attendance:

227

228 Participants attended 62% of HIIT sessions offered and 75% of MICT sessions. The median (range)
 229 number of sessions attended was 25 (0–36) and 25 (18–34) for the HIIT and MICT groups,
 230 respectively. Eight (62%) of the HIIT participants and eight (67%) of the MICT participants achieved
 231 the pre-specified minimum attendance criterion of at least 24 sessions. Two HIIT participants did not
 232 attend a single exercise session: one due to illness, and the other due to work and holiday
 233 commitments. Another HIIT participant withdrew from the intervention after completing 5 sessions

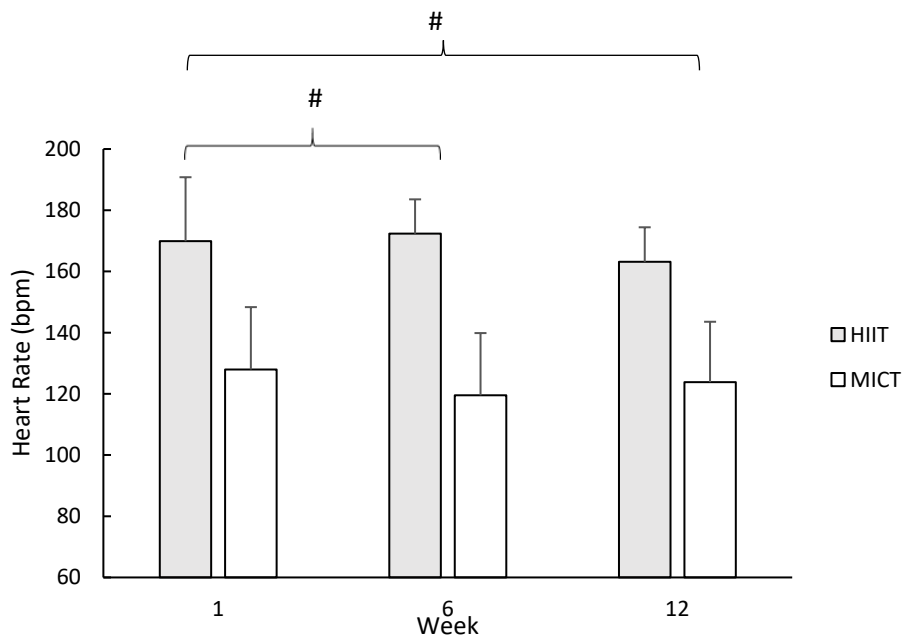
234 due to moving abroad. The main reasons for sessions being missed were work commitments (25%,
235 72/286), illness (25%, 71/286 [only two of which were CD-related]) and holiday (14%, 40/286) (data
236 from both exercise groups combined).

237

238 Heart rate responses

239

240 There was no significant interaction between time and condition for HR during training ($F_{(2,26)}=0.12$;
241 $p=0.89$; $\eta_p^2=0.01$; Fig 1). There was a main effect of time ($F_{(2,26)}=9.60$; $p<0.01$; $\eta_p^2=0.43$) which
242 showed HR to be significantly lower at week 6 (149 ± 6 bpm) and week 12 (148 ± 6 bpm) compared
243 to 1 (155 ± 8 bpm; $p=0.03$ and $p<0.01$, respectively). However, there was no significant difference
244 between weeks 6 and 12 (1 ± 2 bpm, $p=1.00$). There was also a main effect of condition with HR
245 being significantly higher overall during HIIT (173 ± 8 bpm) compared to MICT (128 ± 6 bpm, p
246 <0.001).



247

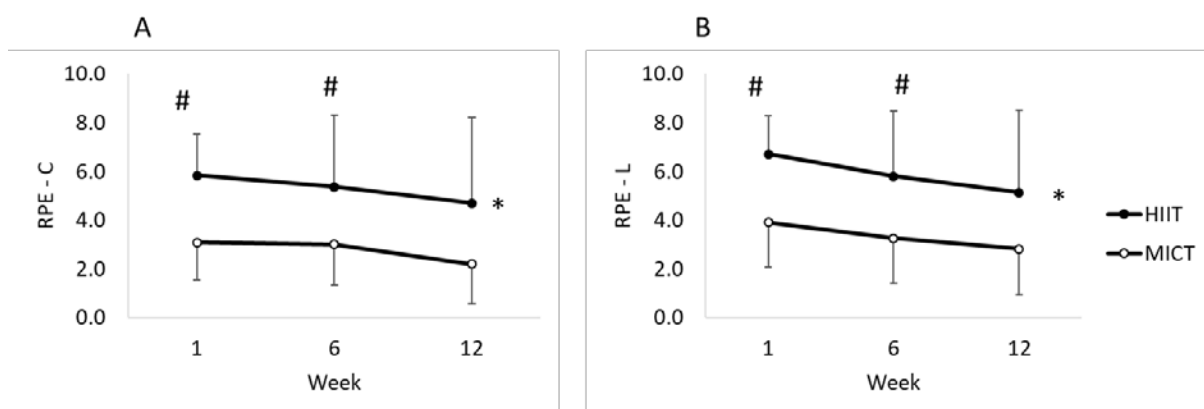
248 Fig 1: Mean (SD) HR at week 1, 6 and 12. * denotes significant difference from week 1 ($p<0.05$).

249

250 RPE and affective responses

251 There was no significant interaction for time and condition for RPE-L ($F_{(2,26)}=0.65$; $p=0.51$; $\eta_p^2=0.05$)
252 or RPE-C ($F_{(2,26)}=0.12$; $p=0.09$; $\eta_p^2=0.01$). There was a main effect of condition for RPE-L
253 ($F_{(1,13)}=6.37$; $p=0.03$; $\eta_p^2=0.33$) and RPE-C ($F_{(1,13)}=5.91$; $p=0.03$; $\eta_p^2=0.31$), with RPE-L and RPE-C
254 being significantly greater during HIIT (5.5 ± 1.6 and 5.1 ± 1.7 i.e. 'hard', respectively) compared to
255 MICT (3.3 ± 1.5 and 2.9 ± 1.5 i.e. 'moderate', respectively; Fig 2). A main effect of time was
256 demonstrated for both RPE-L ($F_{(2,26)}=7.61$; $p<0.01$; $\eta_p^2=0.37$) and RPE-C ($F_{(2,26)}=5.66$; $p=0.01$; $\eta_p^2=$
257 0.30), with values lower at week 12 (3.3 ± 1.7) compared to 1 (4.5 ± 0.76) and 6 (4.1 ± 1.1).

258

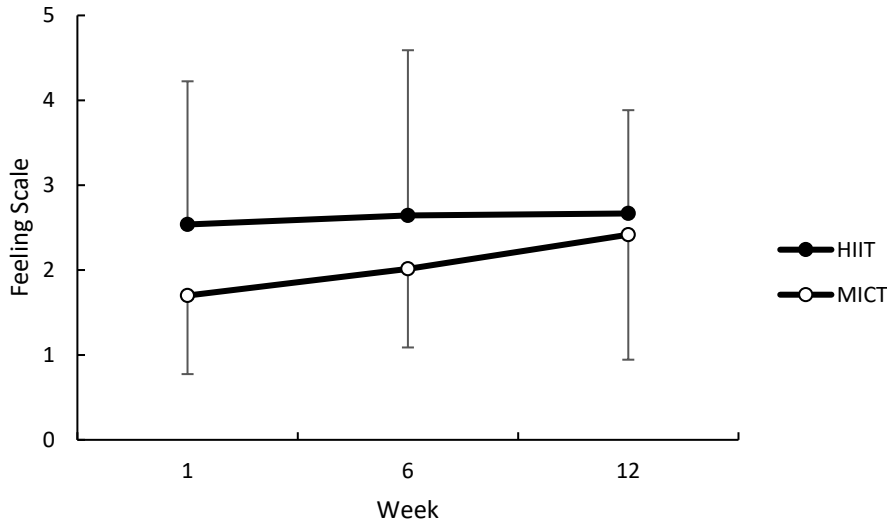


259

260 Fig 2: Mean (SD) RPE for central (RPE-C: panel A) and legs (RPE-L: panel B) at week 1, 6 and 12. *
261 denotes significant difference from MICT ($p<0.05$). # denotes significant difference from week 12 (p
262 <0.05).

263

264 There was no significant interaction between time and condition for FS ($F_{(2,26)}=1.17$; $p=0.32$; $\eta_p^2=$
265 0.08). There was also no main effect of condition ($F_{(1,8)}=1.51$; $p=0.25$; $\eta_p^2=0.03$) with FS being 2.2
266 ± 1.9 (i.e. fairly good) for HIIT and 2.1 ± 1.4 (i.e. fairly good) for MICT (Fig 3). Nor was there a main
267 effect of time ($F_{(3,24)}=0.13$; $p=0.94$; $\eta_p^2=0.04$).



268

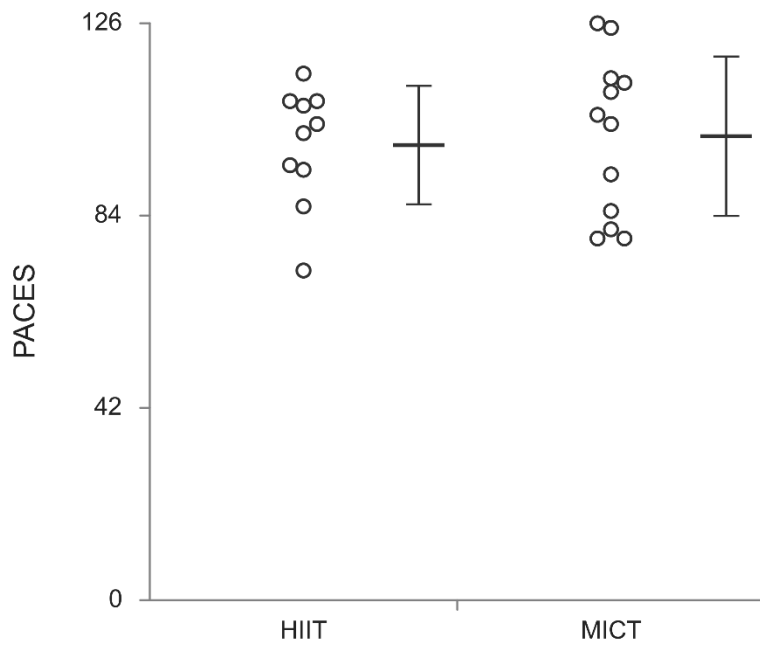
269 Fig 3: Mean (SD) feeling scale at the end of exercise at weeks 1, 6 and 12

270

271 Exercise Enjoyment (PACES)

272 As can be seen in Fig 4 both HIIT and MICT produced high exercise enjoyment scores (mean ± SD
 273 99.4 ± 12.9 and 101.3 ± 17.4, respectively) demonstrating a high level of enjoyment (max score 126),
 274 with no significant differences between conditions ($t_{(20)} = -0.29$; $p = 0.78$; $\delta = 0.06$). When comparing
 275 the single item score on PACES between HIIT and MICT (Fig 5) there was no significant interaction
 276 between question and condition ($F_{(5.5,110.8)} = 0.57$; $p = 0.74$; $\eta_p^2 = 0.03$). There was a main effect of
 277 question ($F_{(5.5,110.8)} = 3.61$; $p < 0.01$; $\eta_p^2 = 0.15$), but there was no main effect of condition ($F_{(1,20)} = 0.08$;
 278 $p = 0.78$; $\eta_p^2 = 0.01$).

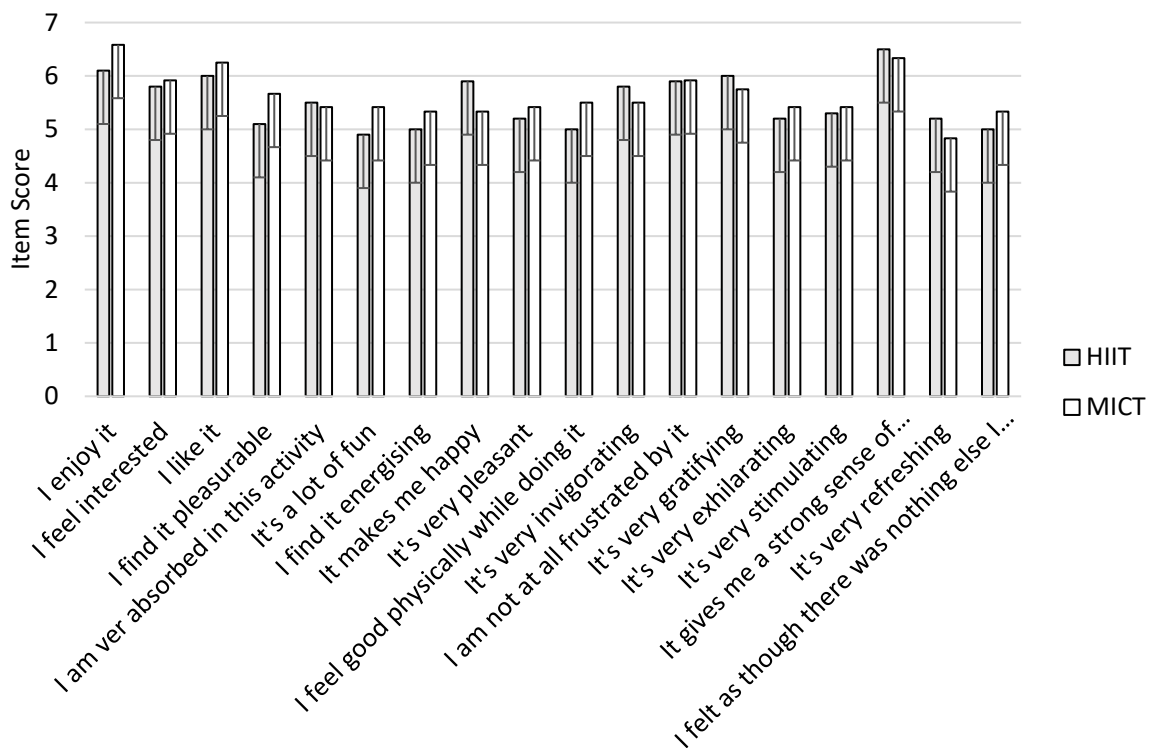
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280

281 Fig 4: Dot plot of individual exercise enjoyment scores (PACES) and mean (\pm SD) PACES score post 12
 282 weeks of training for both HIIT and MICT.

283



284

285 Fig 5: Mean (SD) single item scores (from 1 to 7) for PACES for both HIIT and MICT conditions.

286 Discussion

287 The present study is the first to compare the enjoyment and affective responses to HIIT and MICT in
288 adults with quiescent or mildly active CD. Despite significantly greater HR and RPE responses during
289 HIIT compared to MICT, these methods of training elicited similar enjoyment and affective
290 responses. Attendance rates were also similar between groups. The enjoyment and affective
291 responses were also generally high, suggesting that adults with quiescent or mildly active CD can
292 find both forms of aerobic exercise training to be acceptable and enjoyable.

293 Previous research by Tew *et al.* (32) demonstrated that adults with IBD did not meet the physical
294 activity guidelines of the general population. Often a major barrier for participation in physical
295 activity is lack of enjoyment in particular when considering high intensity exercise (15, 20, 21). As
296 mentioned earlier, high intensity exercise has been suggested to potentially be detrimental to health
297 in adults with IBD due to possible negative side effects, such as gastrointestinal distress (8) which
298 could exacerbate symptoms. Therefore, it was surprising that when participants were asked for
299 their preference to a specific group allocation prior to randomisation 74% preferred HIIT, 22% MICT,
300 and 4% control. This suggests that patients are interested in performing HIIT if they are willing to
301 participate in an exercise clinical trial. As can be seen from the results of this study, not only did
302 participants in both arms of the study enjoy their exercise intervention (either HIIT or MICT) they
303 also felt 'fairly good' towards the end of the exercise sessions. We have previously reported that
304 very few exercise-related adverse events occurred during this trial (24). These results suggest that
305 participants with quiescent or mildly active CD feel 'fairly good' when performing both MICT and
306 HIIT.

307 Along with the barriers to exercise, adhering to an exercise programme can also bring challenges.
308 Demonstrating similar enjoyment between MICT and HIIT suggests both modes of exercise could be
309 employed in a training programme for patients with quiescent or mildly active CD. For participants

310 to maintain a training programme they need to have positive affect responses during exercise as
311 observed in the present study. Mean FS in the present study was 2.2 (SD 1.8; i.e. fairly good) for HIIT
312 and 2.1 (SD 1.3, i.e. fairly good) for MICT at 92.5% of the exercise completed. A meta-analysis by
313 Oliveira *et al.* (19) found that for FS, only six out of 12 comparisons showed beneficial effects for
314 HIIT involving normal weight and overweight-to-obese populations. The authors found no
315 relationship of FS to the fitness characteristics of the participants and therefore suggest that the FS
316 scores were related to the exercise characteristics (19). When comparing the FS scores in the
317 present study with previous research by Oliveira *et al.* (23) who measured FS pre, every 20% of
318 exercise completed and post exercise for both HIIT and MICT it is apparent that CD patients
319 demonstrated a greater positive FS compared to young healthy adults. The mean \pm SD values at the
320 final 20% of exercise in Oliveira *et al.* (23) were -2.7 ± 2.6 for HIIT and 0.8 ± 2.5 for MICT. Differences
321 between our study and Oliveira *et al.* (23) could be a result of the exercise intensity being lower in
322 the present study (90% HRpeak) for 60 seconds compared to 100% VO_{2peak} for 120 seconds. Rhodes
323 and Kates (33) have demonstrated that affective responses during moderate intensity exercise
324 linked positively to future exercise behaviour. Suggesting that participants who feel good during
325 exercise are more likely to continue to perform exercise.

326

327 As mentioned previously, HIIT and MICT were matched for energy expenditure although the HIIT
328 main conditioning phase (i.e. excluding warm-up and cool-down) duration was significantly shorter
329 lasting 20 minutes compared to 30 minutes for MICT. HR and RPE were significantly greater for the
330 HIIT sessions compared to the MICT showing a greater exercise intensity. This resulted in greater
331 increases in peak power in the HIIT group compared to the MICT group, suggesting that HIIT could
332 produce greater cardiovascular improvements and ultimately greater cardiometabolic benefits. The
333 exercise intensity and rest intervals of HIIT is important when considering affective and enjoyment
334 responses. There is no universally accepted approach to HIIT and therefore studies often employ
335 different exercise/rest intervals. Research has demonstrated that exercise intervals at 120 seconds

336 produced significantly lower affective responses compared to 60 second intervals (19). Insufficient
337 rest between intervals can also negatively affect enjoyment and ultimately exercise adherence
338 suggesting a stimulus - recovery ratio of 1:1 produces the best affective responses (19). The HIIT
339 protocol used in the present study employed a 1:1 ratio of 60 seconds, designed to provide positive
340 affect responses based on research with young sedentary adults (34) . As there are many different
341 methods of HIIT, it may not be appropriate to generalise the findings of the present study to
342 different HIIT approaches e.g. sprint interval training or high volume HIIT (4 minute intervals with
343 recovery of a similar duration) (35).

344

345 Mean enjoyment levels based on PACES in the present study were 99.4 (\pm 12.9) and 101.3 (\pm 17.4)
346 for HIIT and MICT, respectively. These results are similar in terms of HIIT to Thum *et al.* (15) who
347 found scores of 103.8 \pm 9.4 for HIIT (8 x 60s at 85% Wmax followed by 60s at 25% Wmax) in
348 recreationally active participants. In the same study by Thum *et al.* (15) their MICT protocol (20
349 minutes at 45% Wmax) produced slightly lower levels of enjoyment compared to the present study
350 (84.2 \pm 19.1). Similarly, Oliveira *et al.* (23) observed values of 97.8 \pm 17.3 for HIIT (6 x 120s at 100%
351 VO₂peak, 120s at 0% for recovery) and 96.2 \pm 16.7 for MICT (20min at 85% VO₂peak) in University
352 students. Vella *et al.* (36) observed PACES scores between 74 and 125 for both HIIT (10 x 1 minute at
353 75-80% of heart rate reserve followed by 1 minute at 35-40%) and MICT (20 minutes at 55-59% of
354 heart rate reserve) in sedentary obese adults. In a clinical population of patients waiting for an
355 elective abdominal aortic aneurysm repair they observed PACES values of 98 (18) with HIIT training
356 (either 8 x 2 minutes or 4 x 4 minutes, 3 x a week for 4 weeks) (37). Therefore, it appears that
357 patients with quiescent or mildly active CD have similar levels of enjoyment towards both HIIT and
358 MICT exercise in comparison to healthy and clinical adult populations (15, 23, 36, 37).

359

360 Previous authors have suggested there is a need to report individual PACES items to signify which
361 items are responsible for high levels of enjoyment (38). There were no differences in scores for any
362 item of PACES. Each item is scored out of 7, with a higher score demonstrating a greater level of
363 enjoyment. There was a mean score of 5 on every item of the scale for both conditions. To the
364 author's knowledge the only published study investigating differences on the individual items of the
365 PACES is Malik *et al.* (39) and they found higher levels in items "I got something out of it", "It's very
366 exciting" and "It gave me a strong feeling of success" with HIIT compared to MICT. In contrast, the
367 authors observed higher levels of "I feel bored" and "It's not at all interesting" in the MICT compared
368 to HIIT. They suggest the differences are due to participants perceiving a greater sense of reward,
369 excitement and success following HIIT compared to MICT. The results of the research by Malik *et al.*
370 (39) may differ to the current study due to the fact their participants were aged 12-15 year olds,
371 whereas our study recruited 16-65 year olds.

372

373 The study did have some limitations, this was a feasibility trial and as such, with a relatively small
374 sample size, is likely underpowered for these exploratory analyses. Being a small study increases the
375 likelihood of a chance imbalance between groups in the responses to HIIT and MICT throughout the
376 training intervention. Other studies have used a crossover design so participants experience the
377 different exercise protocols, but this is difficult to do when using a 12-week intervention. Another
378 limitation was that enjoyment was only measured at one timepoint. In the study of Heisz *et al.* (34),
379 PACES was assessed at the end of every week in a 6-week intervention with PACES scores increasing
380 every week in the HIIT arm. However, as the present study measured one time point these changes
381 were not detectable if they existed.

382

383 In conclusion, both HIIT and MICT produced high levels of enjoyment within this small cohort as well
384 as feeling 'fairly good' suggesting that future exercise trials could include either/both modes as an

385 exercise intervention. One of the major barriers to exercise participation is enjoyment and this
386 study demonstrates that patients with quiescent or mildly active CD appear to enjoy high intensity
387 interval and moderate continuous cycling exercise.

388

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394

395 **Conflict of Interest**

396 We have not identified any competing interests in relation to this trial.

397

398 **Author Contributions**

399 LB was the Chief Investigator, who conceived and designed the trial, and contributed to its
400 management and led the write-up of this paper. DL coordinated the majority of exercise sessions
401 and assessments at the University of East London. RC contributed to the design of the trial and
402 helped coordinate trial activity at the University of East London. SA was the Principal Investigator at
403 Guy's and St Thomas' NHS Foundation Trust, contributing to trial design and patient recruitment. LL

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405 recruitment. JR was the Principal Investigator for Hampshire Hospitals NHS Foundation Trust,
406 contributing the patient recruitment. JF was the Principal Investigator at the University of
407 Winchester, coordinating trial activity at this site. EC contributed to data analysis. CF contributed to
408 the trial design and led the data analysis. MS was the Principal Investigator at the University of East
409 London, designing the blood analysis aspects of this trial. All authors had full access to the data from
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428

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