

Are Exercise Referral Schemes Associated With an Increase in Physical Activity? Observational Findings Using Individual Patient Data Meta-Analysis From the National Referral Database

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29 **Abstract**

30 **Objectives:** Examine if exercise referral schemes (ERSs) are associated with meaningful
31 changes in physical activity (PA) in a large cohort of individuals throughout England,
32 Scotland and Wales from The National Referral Database.

33 **Methods:** Data were obtained from 5,246 participants from 12 different ERSs lasting 12
34 weeks. Pre-exercise referral scheme, and changes from pre- to post-exercise referral scheme
35 in self-reported International Physical Activity Questionnaire scores were examined. Two-
36 stage individual patient data meta-analysis was used to generate effect estimates.

37 **Results:** For pre-ERS MET-minutes/week the estimate [95% CI] was 676 MET-
38 minutes/week [539, 812 minutes]. For change in MET-minutes/week the estimate [95% CI]
39 was an increase of 540 MET-minutes/week [396, 684]. Changes in total PA levels occurred
40 as a result of increases in vigorous activity of 17 minutes [95% CI 9, 24], increases in
41 moderate activity of 29 minutes [95% CI 22, 36], and reductions in sitting of -61 minutes
42 [95% CI -78, -43], though little change in walking (-5 minutes [95% CI -14, 5]).

43 **Conclusions:** Most participants undergoing ERSs are already ‘moderately active’. Changes
44 in PA behaviour associated with participation are through increased moderate-to-vigorous PA
45 and reduced sitting. However, this was insufficient to change IPAQ category and participants
46 where still ‘moderately active’.

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55 **What is already known on this topic?**

- 56 • Physical activity is widely considered to be effective in the prevention, management, and
57 treatment of many chronic health disorders, yet population physical activity levels are
58 relatively low and have changed little in recent years.
- 59 • Sufficient physical activity levels for health and wellbeing often do not arise as result of
60 typical activities of daily living and thus, specific exercise has been argued to be necessary for
61 many, and one approach to providing this has been through exercise referral schemes.
- 62 • Exercise referral schemes are aimed at increasing physical activity levels in sedentary
63 individuals with chronic disease, however, despite evidence of the benefits of physical
64 activity, the evidence base regarding whether these are an effective approach to increase
65 physical activity is currently limited.

66

67 **What this study adds**

- 68 • Our findings suggest that, exercise referral schemes may not be targeting the population for
69 which they are aimed as participants are typically classified as ‘moderately active’ prior to
70 beginning their exercise referral scheme, or that participants are overestimating their levels of
71 physical activity.
- 72 • Exercise referral schemes are associated with a statistically significant change in total
73 physical activity with most of this accounted for by increases in moderate-vigorous physical
74 activity (increasing 17 minutes and 29 minutes per week respectively), in addition to
75 reductions in sitting time (reducing by 61 minutes per week); however, the size of the changes
76 was not sufficient for participants to move from the ‘moderately active’ category to ‘highly
77 active’ category.
- 78 • These findings suggest the need to consider exercise referral schemes and their
79 implementation more critically. It would seem that they may not be targeting those who are
80 most inactive, or that participants are overestimating their physical activity levels at baseline,
81 and this may perhaps explain why changes were not sufficient to change activity category.

82 **Introduction**

83 Physical activity (PA) is widely considered an effective prevention and management tool for
84 a wide range of chronic health disorders.¹⁻³ PA is considered as any bodily movement created by
85 skeletal muscles that results in greater demand of energy expenditure than would normally be
86 required.⁴ PA can be conducted in many ways, including unstructured activities as part of an
87 individual's daily living, leisure activities, or occupation, and is often performed without the explicitly
88 desired goal of improving fitness. Improving health and fitness can be a by-product of these
89 unstructured activities, although unstructured physical activity is decreasing within the modern era.⁵

90 Worldwide, one in four adults do not meet the current global recommendations for PA, which
91 suggest that adults should undertake 150 minutes of moderate-intensity activity per week.⁴
92 Approximately 20 million adults in the UK are not physically active,⁶ a figure that has remained
93 relatively unchanged in the recent years.⁷ Physical inactivity is a public health dilemma in that it is
94 associated with increased risk of non-communicable diseases (NCDs) including obesity,
95 cardiovascular diseases, diabetes, and premature death.⁷ Physical inactivity has reportedly increased
96 globally, having serious consequences on health and wellbeing.⁷⁻⁹ In contrast to inactivity which is
97 associated with a range of negative health outcomes, physical activity is associated with a range of
98 positive health outcomes.^{2,5} Indeed, network meta-analyses have shown PA interventions, including
99 structured bouts of PA (i.e. exercise), are similarly, and in some cases, more effective than drug
100 treatments for secondary prevention.^{10,11}

101 Considering this, interventions to increase PA in primary care might present a solution to
102 reduce the heavy burden that inactivity related NCDs place upon the National Health Service
103 (NHS),¹² which at present has risen to £1.2 billion per year.⁷ Exercise referral schemes (ERSs) are
104 exercise interventions aimed at increasing the number of sedentary individuals becoming active, along
105 with aiding the rehabilitation and management of chronic health disorders.^{1,13,14} Schemes were first
106 introduced in the 1990s in primary care settings across England to facilitate PA participation for
107 individuals referred with chronic health disorders.¹⁵ Professionals in primary care (usually
108 physicians/general practitioners (GPs), but also nurses, physiotherapists and condition-specific

109 specialists) typically refer individuals to third party service providers, usually in leisure centres and
110 gyms, who then prescribe an exercise programme and monitor progress accordingly.

111 Guidance for ERSs in England, published by The National Institute for Health and Care
112 Excellence (NICE), ‘PH54: Physical Activity: Exercise Referral Schemes’,¹³ are vague in the details
113 regarding what exercise providers should base their schemes upon. However, they do suggest that
114 schemes should typically consist of a 12 weeks’ exercise prescription and should target inactive
115 individuals with chronic health disorders. Yet, the evidence available for inactive but presently
116 healthy individuals specifically, was considered weak at the time of the 2014 guidelines, which in
117 recent consultation have remained the same.¹⁶ The NICE guidelines do not provide any details of the
118 specific exercise prescriptions used within schemes. In addition, ERSs have been described as ‘wild
119 and woolly’, with a lack of agreement between stakeholders on how to determine impact.¹⁷ Although
120 increasing PA levels, both during the intervention and resultant from it, is a primary aim of ERSs,
121 there has been little research documenting change in PA levels after scheme completion; and what has
122 been conducted appears conflicting.^{1,18-20} This is of particular relevance as recent observational
123 findings reported from ERSs in The National Referral Database, suggest that changes in health and
124 wellbeing outcomes may not reach meaningful levels.²¹ It is important to provide an update of
125 evidence of whether ERSs do impact PA across England, Scotland and Wales, to meet the
126 recommendations from NICE, and in order to understand whether a possible explanation for the lack
127 of health and wellbeing outcomes may be due to insufficient changes in PA levels. Documenting
128 change in PA levels was also a recommendation for further research from NICE.¹³ The aim of this
129 study was therefore to examine whether ERSs are effective in providing change in PA in participants
130 who had completed an ERS, using observational data from The National Referral Database, to meet
131 recommendations for further research from NICE, and to review data from the first national database
132 in the United Kingdom (UK).

133

134 **Methods**

135 *Study Design*

136 Anonymised data were extracted from the The National Referral Database uploaded from
137 ERSs across England, Wales and Scotland. Referrals from primary care to ERSs were made between
138 September 2011 and October 2017. At the time of the data cut in October 2017, data were exported
139 from The National Referral Database into an Excel Spreadsheet where it went through a process of
140 data cleaning ready for analysis. The database has been described elsewhere including database
141 formation, data cleaning, and structure in detail.²² The study uses a retrospective cohort longitudinal
142 study design following individuals entering and exiting ERS following referral from a range of
143 organisations and referrer types (GPs, nurses, physiotherapists, condition-specific specialists) across
144 the UK. Due to the inclusion of various schemes within the database, in order to account for scheme
145 level variance, a multilevel modelling approach was employed involving, an individual patient data
146 random effects meta-analysis with a two-stage approach was used (see statistical analysis).

147

148 Outcome Measures

149 The National Referral Database used the self-reported International Physical Activity
150 Questionnaire (IPAQ)-short form to measure physical activity levels of participants. This was the PA
151 questionnaire which was used by exercise providers who uploaded data onto the National Referral
152 Database throughout the UK, therefore this was used to measure PA within this study. This
153 questionnaire was used to determine weekly physical activity, in Metabolic Equivalent (MET)-
154 minutes/week (described below), which was the primary outcome measure. Change in MET-
155 minutes/week of self-reported PA pre- and post- scheme, was used to examine the impact ERSs had
156 on the participant's physical activity levels. The IPAQ-short form contains seven open-ended items
157 surrounding the participants' last seven day recall of PA and sitting behaviours. Items were structured
158 to provide scoring on walking, moderate-intensity and vigorous-intensity activity, in addition to
159 sitting. The IPAQ has been designed for observational research and its test-retest reliability indicates
160 good stability and high reliability ($\alpha >.80$), along with concurrent validity.^{23,24} Both continuous and
161 categorical indicators of PA come from IPAQ.

162

163 *Continuous Analysis of IPAQ*

164 Due to the non-normal distribution of energy expenditure in participants, it has been
165 suggested that continuous indicators be presented as median MET-minutes/week.²⁵ A MET is the ratio
166 of the rate of energy expended during an activity to the rate of energy expended at rest.²⁶ A MET is a
167 unit of energy expenditure and by calculating MET-minutes, can be used to track the amount of PA an
168 individual is doing per week.²⁵

169

170 *Categorical Analysis of IPAQ*

171 There are three categorical levels of PA scoring to classify populations through the IPAQ:
172 'low', 'moderate' and 'high'. Criteria set for each of the levels consider each question asked on the
173 IPAQ form.²³ The 'high' category describes high levels of PA participation; either >1500 MET-
174 minutes/week (consisting of vigorous activity on at least three days), or >3000 MET-minutes/week
175 (consisting of any combination of activities across seven days). This provides a higher threshold of
176 measures of total PA and is useful to examine population variation. The 'moderate' category defines
177 an individual to be participating in some activity, more than those in the 'low' category (600 to 1499
178 MET-minutes/week). Those in the 'low' category do not engage in at least half an hour moderate-
179 intensity physical activity most days (0 to 599 MET-minutes/week). Individuals in the 'low' category
180 do not meet any criteria from the high or moderate categories, and are not participating in any regular
181 PA.

182

183 *Statistical Analyses*

184 Analyses performed were with the intention of reporting broadly; do we observe a meaningful
185 change in PA levels in individuals who are undergoing ERSs?

186 Two stage individual patient data meta-analysis was performed on the both the median pre-
187 ERS, and median change scores, (i.e. post- minus pre-ERS scores) for MET-minutes. Analysis was
188 also performed on the breakdown of vigorous and moderate intensity activity, walking, and sitting
189 minutes for pre-ERS, as well as change scores. For stage one, both median pre-ERS for MET-
190 minutes/week and mean pre-ERS for activity breakdowns, and median change scores for MET-
191 minutes/week and mean for activity breakdowns, and their standard errors were derived for each

192 scheme. The second stage involved performing a random effects meta-analysis using the ‘metafor’
193 package in R (version 3.5.0; R Core Development Team, <https://www.r-project.org/>) across all
194 schemes to derive a final point estimate and precision of estimate (95% confidence intervals [CI]). A
195 random effects model was used as our aim was to estimate the PA levels and changes in PA levels for
196 individuals undergoing *any* ERS. We assumed that, due to there being considerable uncertainty in the
197 manner in which each individual ERS scheme was delivered, it was not a reasonable assumption to
198 treat them all as providing estimates of a fixed or common effect. That is to say, the variation in effect
199 sizes estimated for each scheme was assumed not due to solely sampling variation. Estimates were
200 weighted by inverse sampling variance and restricted maximal likelihood estimation was used in all
201 models. Schemes without sufficient participants ($n < 4$) were excluded from analysis. Robustness of
202 main effects were considered through sensitivity analyses by removal of individual schemes and re-
203 analysis of the random effects model. Where significant estimates became non-significant and vice
204 versa, in addition to where there were considerable changes in the magnitude and/or precision of those
205 estimates, the results of sensitivity analyses are reported.

206 An α level of 0.05 was used to determine statistical significance, however results were not
207 interpreted dichotomously based purely on this, or whether the 95% CI crossed zero. Instead, the
208 point estimate and its precision were considered in light of the physical activity guidelines and
209 interpreted with respect to how meaningful the change was. In this sense, progressively greater
210 increases in MET-minutes/week are required as starting PA levels increase to move into a higher
211 category. This was based upon the IPAQ ‘low’, ‘moderate’, and ‘high’ categories. For high we
212 considered the lower threshold of 1500 MET-minutes/week. Categorical IPAQ data was also
213 examined and the descriptive proportions both pre- and post-ERS considered across schemes in
214 addition to longitudinal plotting across the entire sample to examine changes between IPAQ
215 categories.

216

217 **Results**

218 A total of 12 schemes were included in the final analysis, which included a total of 5246
219 participant’s data with an average age of 53 ± 15 years and 68% of whom were female.

220

221 Categorical IPAQ Classification

222 Examination of categorical data revealed that roughly half of participants who began an ERS
223 were not classified as having 'low' levels of PA. There were shifts from pre-ERS to post-ERS in the
224 proportions of participants in each category with decreases in the proportion of those in the 'low'
225 categories and increases in both 'moderate' and 'high'. Table 1 shows the proportions across schemes.
226 Tracking of the entire sample visually (figure 1) showed that participants within the 'low' categories
227 tended to shift into the 'moderate' and 'high' categories. Some participants within the 'moderate'
228 category also shifted into the 'high' category. However, a number of participants in the 'low' category
229 remained in this category, some in the 'moderate' category dropped into the 'low' category, and some
230 in the 'high' category dropped into both the 'moderate' and 'low' categories.

231

232 Pre-ERS MET-minutes

233 For pre-ERS MET-minutes/week the estimate from random effects model was 676 MET-
234 minutes/week [539 to 812 minutes], $p < .0001$). Figure 2 shows the forest plot for pre-ERS MET-
235 minutes. Significant heterogeneity was evident among the schemes ($Q_{(11)} = 84.31$, $p < .0001$; $I^2 =$
236 90.41%), however, sensitivity analysis did not reveal any influential schemes.

237

238 Pre-ERS Breakdown of Activity Minutes

239 Forest plots are shown for pre-ERS breakdown of activity minutes in figure 3. For pre-ERS
240 vigorous activity the estimate from random effects model was 25 minutes [16 to 34 minutes], $p <$
241 $.0001$). Significant heterogeneity was evident among the schemes ($Q_{(10)} = 128.54$, $p < .0001$; $I^2 =$
242 87.52%), however, sensitivity analysis did not reveal any influential schemes. For pre-ERS moderate
243 activity the estimate from random effects model was 45 minutes [38 to 51 minutes], $p < .0001$).
244 Significant heterogeneity was evident among the schemes ($Q_{(11)} = 84.15$, $p < .0001$; $I^2 = 87.52\%$),
245 however, sensitivity analysis did not reveal any influential schemes. For pre-ERS walking the
246 estimate from random effects model was 59 minutes [48 to 69 minutes], $p < .0001$). Significant
247 heterogeneity was evident among the schemes ($Q_{(11)} = 167.73$, $p < .0001$; $I^2 = 96.66\%$), however,

248 sensitivity analysis did not reveal any influential schemes. For pre-ERS sitting the estimate from
 249 random effects model was 384 minutes [352 to 415 minutes], $p < .0001$). Significant heterogeneity
 250 was evident among the schemes ($Q_{(11)} = 365.00$, $p < .0001$; $I^2 = 97.20\%$), however, sensitivity
 251 analysis did not reveal any influential schemes.

252

253 Change in MET-minutes

254 For change in MET-minutes/week the estimate from random effects model for was 540 MET-
 255 minutes/week [396 to 684 minutes], $p < .0001$). Figure 4 shows the forest plot for change in MET-
 256 minutes. Significant heterogeneity was evident among the schemes ($Q_{(11)} = 47.44$, $p < .0001$; $I^2 =$
 257 84.90%), however, sensitivity analysis did not reveal any influential schemes. Considering the
 258 estimate for pre-ERS MET-minutes/week (676 MET-minutes) it would seem that the estimate for
 259 change in MET-minutes/week resulted in participants beginning as moderately active and, though
 260 their activity levels increased and categorical analysis showed changes, the effect estimate for change
 261 in activity levels were insufficient to result in a change in IPAQ category with them remaining
 262 moderately active.

263

264 Breakdown of Change Activity Minutes

265 Forest plots are shown for pre-ERS breakdown of activity minutes in figure 5. For change in
 266 vigorous activity the estimate from random effects model was 17 minutes [9 to 24 minutes], $p <$
 267 $.0001$). Significant heterogeneity was evident among the schemes ($Q_{(11)} = 480.16$, $p < .0001$; $I^2 =$
 268 97.87%), however, sensitivity analysis did not reveal any influential schemes. For change in moderate
 269 activity the estimate from random effects model was 29 minutes [22 to 36 minutes], $p < .0001$).
 270 Significant heterogeneity was evident among the schemes ($Q_{(11)} = 133.55$, $p < .0001$; $I^2 = 92.14\%$),
 271 however, sensitivity analysis did not reveal any influential schemes. For change in walking the
 272 estimate from random effects model was -5 minutes [-14 to 5 minutes], $p = 0.3687$). Significant
 273 heterogeneity was evident among the schemes ($Q_{(11)} = 94.79$, $p < .0001$; $I^2 = 95.91\%$), however,
 274 sensitivity analysis did not reveal any influential schemes. For change in sitting the estimate from
 275 random effects model was -61 minutes [-78 to -43 minutes], $p < .0001$). Significant heterogeneity was

276 evident among the schemes ($Q_{(11)} = 88.51, p < .0001; I^2 = 90.63\%$), however, sensitivity analysis did
 277 not reveal any influential schemes.

278

279 Exploratory Meta-Regression

280 Due to the finding that ERS schemes appear to be attracting those who are categorised as
 281 having either ‘moderate’ or ‘high’ PA levels despite guidance suggesting they should be aimed at
 282 those who have ‘low’ PA levels, exploratory analysis was performed using mixed effects meta-
 283 regression to examine the relationship between proportion of participants (%) in each scheme
 284 categorised as having ‘low’ PA levels, and changes in PA levels. The coefficient for change in total
 285 MET-minutes was not significant (-5.7 MET-minutes [-17.3 to 5.9], $p = 0.3347$) with a significant
 286 residual heterogeneity ($QE_{(10)} = 39.91, p < 0.0001$) and $R^2 = 0.00\%$. Figure 6 shows the meta-analytic
 287 scatterplot for change in total MET-minutes and proportion of participants categorised as ‘low’
 288 physical activity.

289 The coefficient for change in total vigorous minutes was not significant (-0.3 minutes [-0.9 to
 290 0.3], $p = 0.3204$) with a significant residual heterogeneity ($QE_{(10)} = 443.79, p < 0.0001$) and $R^2 =$
 291 0.00% . The coefficient for change in moderate minutes was not significant (0.2 minutes [-0.3 to 0.7],
 292 $p = 0.4684$) with a significant residual heterogeneity ($QE_{(10)} = 132.00, p < 0.0001$) and $R^2 = 0.00\%$.
 293 The coefficient for change in walking minutes was not significant (0.3 minutes [-0.4 to 1.1], $p =$
 294 0.3788) with a significant residual heterogeneity ($QE_{(10)} = 93.03, p < 0.0001$) and $R^2 = 0.00\%$. The
 295 coefficient for change in sitting minutes was not significant (0.4 minutes [-0.8 to 1.7], $p = 0.5230$)
 296 with a significant residual heterogeneity ($QE_{(10)} = 75.60, p < 0.0001$) and $R^2 = 0.00\%$. Figure 7 shows
 297 the meta-analytic scatterplots for change in breakdown of activity minutes and proportion of
 298 participants categorised as ‘low’ physical activity.

299

300 **DISCUSSION**

301 The aim of the present study was to examine changes in PA in participants who had
 302 completed an ERS. This study utilised data from the UK’s first National Referral Database.²²
 303 Categorical data revealed that roughly half of the participants entering the ERSs examined were

304 classified as having 'moderate' or 'high' levels of PA. Effect estimates from meta-analysis showed
305 that pre-ERS participants total PA fell in the 'moderate' category, completing a median 676 MET-
306 minutes/week [539 to 812 minutes], comprising of 25 minutes [16 to 34 minutes] vigorous activity,
307 45 minutes [38 to 51 minutes] moderate activity, 59 minutes [48 to 69 minutes] walking, and 384
308 minutes [352 to 415 minutes] sitting. Significant increases of 540 MET-minutes/week [396 to 684
309 minutes] occurred in participants undergoing ERSs, and this change occurred as a result of increases
310 in vigorous activity of 17 minutes [9 to 24 minutes], increases in moderate activity of 29 minutes [22
311 to 36 minutes], and reductions in sitting time of -61 minutes [-78 to -43 minutes]. Little change was
312 reported in weekly walking minutes (-5 minutes [-14 to 5 minutes]). Overall changes were primarily
313 facilitated by increased moderate-to-vigorous physical activity (MVPA) and reduced sitting. Though,
314 categorical data showed at the group level positive changes in the proportions of participants within
315 each IPAQ category (i.e. fewer in the 'low' and more in the 'moderate' and 'high' categories),
316 visualisation of individual data from pre- to post-ERS showed that changes occurred in both
317 directions with some participants moving to higher, and lower, categories. Consideration of the meta-
318 analytic effect estimate for change would suggest that this was not sufficient to result in categorical
319 change within the population and participants where on average still classed as 'moderately active'.

320 Research suggests that a dose-response relationship occurs between physical activity and
321 health benefits if individuals can improve MET-minutes/week by 500-1000 MET/min/week.²⁶ Here,
322 participants change, though statistically significant, barely achieved this threshold, which may explain
323 the small changes observed in health and wellbeing outcomes in persons undergoing ERSs.²¹ It is also
324 thought that the dose-response curve for PA is steepest at the lowest end of the curve,²⁷ i.e. moving
325 from a 'no' or 'low' to a 'moderate' PA level. Though, the meta-analytic estimate suggested
326 participants in this study tended to be already moderately active at the beginning of their ERSs.
327 Indeed, in previous studies some proportion of participants undergoing ERSs have reported
328 themselves as being 'moderately inactive' (15.3%¹⁹). Chalder et al¹⁸ also reported that ~25-28% of
329 their participants were already achieving at least 1000 MET-minutes/week of PA at baseline. This is
330 perhaps a cause for concern as the NICE guidelines^{13,16} suggest ERSs should be targeted towards
331 inactive individuals. The observational data presented here would suggest that this recommendation is

332 not being followed. However, it should be considered that some participants may be overestimating
333 their levels of PA, and not accurately recording their activity.

334 A number of participants moved from the 'low' category to both the 'moderate' and 'high'
335 categories and, considering the dose-response nature of PA changes, it may be that the more
336 meaningful PA, health and wellness changes primarily occur in those who begin an ERS categorised
337 as inactive. However, exploratory meta-regression analysis examining whether there was an
338 association between the proportion of participants in schemes classified as having 'low' PA levels did
339 not demonstrate this. Further, supplementary analysis performed by Wade et al.²¹ did not show
340 particularly strong relationships between changes in PA levels and health and wellbeing outcomes in
341 ERS participants from analysis conducted using The National Referral Database.

342 ERS can and do increase PA levels, however the value of this to a participant's health
343 outcomes is less clear. In their systematic review and meta-analysis, Pavey, et al.¹ reported that,
344 compared with usual care, ERSs have a slightly greater impact on the number of participants
345 achieving between 90-150 minutes of moderate activity per week. However, they noted that at the
346 time evidence was weak. Using seven-day PA recall, Murphy, et al.¹⁹ found that ERS group
347 participants at 12 months' post intervention achieved a median of 200 minutes of exercise compared
348 with 165 for the control group. Chalder, et al.¹⁸ found increases post intervention, though no
349 significant differences, in proportion of participants meeting at least 1000 MET-minutes/week
350 between ERS or usual care in depressed adults, though descriptively they noted slight differences
351 (ERS = 52% at four months, 63% at eight months, and 58% at twelve months; Usual care = 43% at
352 four months, 49% at eight months, and 40% at twelve months). Our results show changes likely do
353 occur, although not of considerable magnitude.

354 It is also worth considering the nature of the change in PA levels. The increases in total PA
355 were primarily driven by increases in MVPA and decreased sitting. Participants increased MVPA
356 per week by ~46 minutes (17 minutes vigorous and 29 minutes' moderate), yet walking did not
357 change much in participants undergoing ERSs. Therefore, it could be recommended that schemes
358 should encourage walking outside of an ERS attendance, as there was no change reported in walking
359 post-completion. Though walking and light activities are associated with improvements in all-cause

360 mortality, these seem to be greatest again at the lower end of the dose-response curve²⁸ and, at an
361 equal volume, MVPA is associated with greater benefits.²⁹ It could therefore be viewed as positive
362 that MVPA increased in patients undergoing ERSs. Increases in MVPA even in small amounts have
363 been shown to be associated with reductions in all-cause mortality.³⁰ Jefferis, et al.³⁰ reported each
364 10-minute increase in MVPA per day resulted in a 10% reduction in all-cause mortality risk.
365 O'Donovan, et al.³¹ have recently reported that inclusion of vigorous activity has an even stronger
366 impact upon cardiovascular disease mortality risk, and participants in this present study showed
367 increases in vigorous activity, which may still yield significant health benefits beyond the scope of
368 our timeframe. Further, there was ~1-hour reduction in sitting time *per week* across participants.
369 However, recent data shows that reducing sitting time point estimates of ~30 minutes *per day* are be
370 considered clinically meaningful.³²

371 There are several limitations with the current database²² that are worthy of note and these
372 partially extend to the data analysis here. Length of scheme is a factor that could influence changes in
373 PA. However, in this study only schemes of 12 weeks in length were included. In a recent systematic
374 review,³³ it was reported that longer length schemes (20+ weeks) improved adherence to PA
375 prescribed over the course of the scheme. This research emphasises the importance of increasing
376 length of schemes. Indeed, it may be that if longer schemes were present in the database for analysis
377 these may reveal greater PA increases compared with shorter schemes. Although other research by
378 Webb, et al.²⁰ suggests shorter schemes can be effective as it was found that after completing an 8-
379 week ERS, categorical IPAQ scores significantly increased.

380 Another limitation, considering PA levels specifically, use of self-reported outcomes, is a
381 potential issue. IPAQ is of course a subjective measure and was not designed for examination of
382 change in physical activity levels and this could mean it does not well reflect participants' objective
383 changes in physical activity,^{24,34} however, this was the only measure used within the database
384 reviewing PA levels of participants. Although, a recent study has suggested that participants'
385 perceptions of their PA levels relative to others, even when independent of the actual PA conducted
386 (whether self-reported or device measured), are strong predictors of all-cause mortality.³⁵ Although
387 this study reviewed the effects of ERSs on change in PA, it does not consider the reasons why

388 participants chose to attend an ERS. Indeed, many factors influence uptake³⁶ and it seems likely
389 would influence engagement throughout also. Some participants may have attended due to their own
390 motivation to improve their health conditions, whereas, other participants may have only attended
391 because their GP advised them to. A future study could review the reasoning behind individuals'
392 uptake in schemes, along with recorded adherence to PA or self-report PA through IPAQ. This could
393 also be captured by schemes within the database as it is developed. Lastly, similarly to the health and
394 wellbeing outcomes, there was considerable heterogeneity across schemes with respect to the changes
395 observed.

396

397 **Conclusion**

398 These results represent the initial findings from first analysis of the National Referral
399 Database considering PA levels. The analyses performed here were with the intention of considering
400 broadly “do we observe a change in physical activity in individuals who are undergoing ERSs?” and
401 the findings suggest that significant changes in total MET-minutes/week do occur. Participants in the
402 ERSs assessed here were however predominantly ‘moderately active’ at baseline and remained so
403 post-ERS. Thus, it is not clear the degree to which the changes observed are meaningful or not.
404 Considering the heterogeneity of results across schemes also, future work, including that afforded by
405 this database, should be focused upon determining where best practice exists (i.e. what works best for
406 which population).

407

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411

412 **Patient and Public Involvement**

413 There was no patient or public involvement in the production of this research.

414

415 **Data Sharing**

416 All data is available upon request from the corresponding author and we would encourage researchers
417 to consider broader questions that might be answered with this dataset and to contact us in this regard.

418

419 **Ethics Statement**

420 As per the Health Research Authority and Research Ethics Committee section 11 of Standard
421 Operating Procedures, ethical approval is not required for research involving patient data that is not
422 identifiable. However, as this work was conducted as part of a PhD project local ethics approval was
423 obtained from Coventry University (P46119).

424

425 **Transparency Statement**

426 The guarantor affirms that the manuscript is an honest, accurate, and transparent account of the study
427 being reported; that no important aspects of the study have been omitted; and that any discrepancies
428 from the study as originally planned (and, if relevant, registered) have been explained.

429

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432

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542 **Figure titles**

543 Figure 1. Pre- and post-ERS changes in categorical IPAQ classification across participants.

544 Figure 2. Forest plot of pre-ERS MET-minutes/week across schemes .

545 Figure 3. Forest plot of pre-ERS (A) vigorous, (B) moderate, (C) walking, and (D) sitting minutes
546 across schemes.

547 Figure 4. Forest plot of change in MET-minutes/week across schemes.

548 Figure 5. Forest plot of change in (A) vigorous, (B) moderate, (C) walking, and (D) sitting minutes
549 across schemes.

550 Figure 6. Meta-analytic scatterplot for change in total MET-minutes and proportion of participants
551 (%) categorised as 'low' physical activity.

552 Figure 7. Meta-analytic scatterplots for change in (A) vigorous, (B) moderate, (C) walking, and (D)
553 sitting minutes and proportion of participants categorised as 'low' physical activity

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