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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Key words: Exercise referral schemes; physical activity; individual patient data meta-analysis; health database.

Abstract

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

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

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

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

What is already known on this topic?

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

What this study adds

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

Introduction

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

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

Considering this, interventions to increase PA in primary care might present a solution to reduce the heavy burden that inactivity related NCDs place upon the National Health Service (NHS),[12] which at present has risen to £1.2 billion per year.[7] Exercise referral schemes (ERSs) are exercise interventions aimed at increasing the number of sedentary individuals becoming active, along with aiding the rehabilitation and management of chronic health disorders.[1,13,14] Schemes were first introduced in the 1990s in primary care settings across England to facilitate PA participation for individuals referred with chronic health disorders.[15] Professionals in primary care (usually physicians/general practitioners (GPs), but also nurses, physiotherapists and condition-specific specialists) typically refer individuals to third party service providers, usually in leisure centres and gyms, who then prescribe an exercise programme and monitor progress accordingly.

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

Methods

Study Design

Anonymised data were extracted from the The National Referral Database uploaded from ERSs across England, Wales and Scotland. Referrals from primary care to ERSs were made between

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

Outcome Measures

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

Continuous Analysis of IPAQ

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

Categorical Analysis of IPAQ

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

Statistical Analyses

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

Two stage individual patient data meta-analysis was performed on the both the median pre-ERS, and median change scores, (i.e. post- minus pre-ERS scores) for MET-minutes. Analysis was also performed on the breakdown of vigorous and moderate intensity activity, walking, and sitting minutes for pre-ERS, as well as change scores. For stage one, both median pre-ERS for MET-minutes/week and mean pre-ERS for activity breakdowns, and median change scores for MET-minutes/week and mean for activity breakdowns, and their standard errors were derived for each scheme. The second stage involved performing a random effects meta-analysis using the 'metafor' package in R (version 3.5.0; R Core Development Team, https://www.r-project.org/) across all schemes to derive a final point estimate and precision of estimate (95% confidence intervals [CI]). A random effects model was used as our aim was to estimate the PA levels and changes in PA levels for individuals undergoing *any* ERS. We assumed that, due to there being considerable uncertainty in the manner in which each individual ERS scheme was delivered, it was not a reasonable assumption to treat them all as providing estimates of a fixed or common effect. That is to say, the variation in effect sizes estimated for each scheme was assumed not due to solely sampling variation. Estimates were weighted by inverse sampling variance and restricted maximal likelihood estimation was used in all models. Schemes without sufficient participants ($n < 4$) were excluded from analysis. Robustness of main effects were considered through sensitivity analyses by removal of individual schemes and re-analysis of the random effects model. Where significant estimates became non-significant and vice versa, in addition to where there were considerable changes in the magnitude and/or precision of those estimates, the results of sensitivity analyses are reported.

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

Results

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

Categorical IPAQ Classification

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

Pre-ERS MET-minutes

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

Pre-ERS Breakdown of Activity Minutes

Forest plots are shown for pre-ERS breakdown of activity minutes in figure 3. For pre-ERS vigorous activity the estimate from random effects model was 25 minutes [16 to 34 minutes], $p < .0001$). Significant heterogeneity was evident among the schemes ($Q_{(10)} = 128.54$, $p < .0001$; $I^2 = 87.52\%$), however, sensitivity analysis did not reveal any influential schemes. For pre-ERS moderate activity the estimate from random effects model was 45 minutes [38 to 51 minutes], $p < .0001$). Significant heterogeneity was evident among the schemes ($Q_{(11)} = 84.15$, $p < .0001$; $I^2 = 87.52\%$), however, sensitivity analysis did not reveal any influential schemes. For pre-ERS walking the estimate from random effects model was 59 minutes [48 to 69 minutes], $p < .0001$). Significant heterogeneity was evident among the schemes ($Q_{(11)} = 167.73$, $p < .0001$; $I^2 = 96.66\%$), however, sensitivity analysis did not reveal any influential schemes. For pre-ERS sitting the estimate from random effects model was 384 minutes [352 to 415 minutes], $p < .0001$). Significant heterogeneity was evident among the schemes ($Q_{(11)} = 365.00$, $p < .0001$; $I^2 = 97.20\%$), however, sensitivity analysis did not reveal any influential schemes.

Change in MET-minutes

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

Breakdown of Change Activity Minutes

Forest plots are shown for pre-ERS breakdown of activity minutes in figure 5. For change in vigorous activity the estimate from random effects model was 17 minutes [9 to 24 minutes], $p < .0001$). Significant heterogeneity was evident among the schemes ($Q_{(11)} = 480.16$, $p < .0001$; $I^2 = 97.87\%$), however, sensitivity analysis did not reveal any influential schemes. For change in moderate activity the estimate from random effects model was 29 minutes [22 to 36 minutes], $p < .0001$). Significant heterogeneity was evident among the schemes ($Q_{(11)} = 133.55$, $p < .0001$; $I^2 = 92.14\%$), however, sensitivity analysis did not reveal any influential schemes. For change in walking the estimate from random effects model was -5 minutes [-14 to 5 minutes], $p = 0.3687$). Significant heterogeneity was evident among the schemes ($Q_{(11)} = 94.79$, $p < .0001$; $I^2 = 95.91\%$), however, sensitivity analysis did not reveal any influential schemes. For change in sitting the estimate from random effects model was -61 minutes [-78 to -43 minutes], $p < .0001$). Significant heterogeneity was evident among the schemes ($Q_{(11)} = 88.51$, $p < .0001$; $I^2 = 90.63\%$), however, sensitivity analysis did not reveal any influential schemes.

Exploratory Meta-Regression

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

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

DISCUSSION

The aim of the present study was to examine changes in PA in participants who had completed an ERS. This study utilised data from the UK's first National Referral Database.[22] Categorical data revealed that roughly half of the participants entering the ERSs examined were classified as having 'moderate' or 'high' levels of PA. Effect estimates from meta-analysis showed that pre-ERS participants total PA fell in the 'moderate' category, completing a median 676 MET-minutes/week [539 to 812 minutes], comprising of 25 minutes [16 to 34 minutes] vigorous activity, 45 minutes [38 to 51 minutes] moderate activity, 59 minutes [48 to 69 minutes] walking, and 384 minutes [352 to 415 minutes] sitting. Significant increases of 540 MET-minutes/week [396 to 684 minutes] occurred in participants undergoing ERSs, and this change occurred as a result of increases in vigorous activity of 17 minutes [9 to 24 minutes], increases in moderate activity of 29 minutes [22 to 36 minutes], and reductions in sitting time of -61 minutes [-78 to -43 minutes]. Little change was reported in weekly walking minutes (-5 minutes [-14 to 5 minutes]). Overall changes were primarily facilitated by increased moderate-to-vigorous physical activity (MVPA) and reduced sitting. Though, categorical data showed at the group level positive changes in the proportions of participants within each IPAQ category (i.e. fewer in the 'low' and more in the 'moderate' and 'high' categories), visualisation of individual data from pre- to post-ERS showed that changes occurred in both directions with some participants moving to higher, and lower, categories. Consideration of the meta-analytic effect estimate for change would suggest that this was not sufficient to result in categorical change within the population and participants where on average still classed as 'moderately active'.

Research suggests that a dose-response relationship occurs between physical activity and health benefits if individuals can improve MET-minutes/week by 500-1000 MET/min/week.[26] Here, participants change, though statistically significant, barely achieved this threshold, which may explain the small changes observed in health and wellbeing outcomes in persons undergoing ERSs.[21] It is also thought that the dose-response curve for PA is steepest at the lowest end of the curve,[27] i.e. moving from a 'no' or 'low' to a 'moderate' PA level. Though, the meta-analytic estimate suggested participants in this study tended to be already moderately active at the beginning of their ERSs. Indeed, in previous studies some proportion of participants undergoing ERSs have reported themselves as being 'moderately inactive' (15.3% [19]). Chalder et al [18] also reported that ~25-28% of their participants were already achieving at least 1000 MET-minutes/week of PA at baseline. This is perhaps a cause for concern as the NICE guidelines [13,16] suggest ERSs should be targeted towards inactive individuals. The observational data presented here would suggest that this recommendation is not being followed. However, it should be considered that some participants may be overestimating their levels of PA, and not accurately recording their activity.

A number of participants moved from the 'low' category to both the 'moderate' and 'high' categories and, considering the dose-response nature of PA changes, it may be that the more meaningful PA, health and wellness changes primarily occur in those who begin an ERS categorised as inactive.

However, exploratory meta-regression analysis examining whether there was an association between the proportion of participants in schemes classified as having 'low' PA levels did not demonstrate this. Further, supplementary analysis performed by Wade et al.[21] did not show particularly strong relationships between changes in PA levels and health and wellbeing outcomes in ERS participants from analysis conducted using The National Referral Database.

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

It is also worth considering the nature of the change in PA levels. The increases in total PA where primarily driven by increases in MVPA and decreased sitting. Participants increased MVPA per week by ~46 minutes (17 minutes vigorous and 29 minutes' moderate), yet walking did not change much in participants undergoing ERSs. Therefore, it could be recommended that schemes should encourage walking outside of an ERS attendance, as there was no change reported in walking post-completion. Though walking and light activities are associated with improvements in all-cause mortality, these seem to be greatest again at the lower end of the dose-response curve [28] and, at an equal volume, MVPA is associated with greater benefits.[29] It could therefore be viewed as positive that MVPA increased in patients undergoing ERSs. Increases in MVPA even in small amounts have been shown to be associated with reductions in all-cause mortality.[30] Jefferis, et al. [30] reported each 10-minute increase in MVPA per day resulted in a 10% reduction in all-cause mortality risk. O'Donovan, et al. [31] have recently reported that inclusion of vigorous activity has an even stronger impact upon cardiovascular disease mortality risk, and participants in this present study showed increases in vigorous activity, which may still yield significant health benefits beyond the scope of our timeframe. Further, there was ~1-hour reduction in sitting time *per week* across participants. However, recent data shows that reducing sitting time point estimates of ~30 minutes *per day* are be considered clinically meaningful.[32]

There are several limitations with the current database [22] that are worthy of note and these partially extend to the data analysis here. Length of scheme is a factor that could influence changes in PA. However, in this study only schemes of 12 weeks in length were included. In a recent systematic review,[33] it was reported that longer length schemes (20+ weeks) improved adherence to PA prescribed over the course of the scheme. This research emphasises the importance of increasing length of schemes. Indeed, it may be that if longer schemes where present in the database for analysis these may reveal greater PA increases compared with shorter schemes. Although other research by Webb, et al. [20] suggests shorter schemes can be effective as it was found that after completing an 8-week ERS, categorical IPAQ scores significantly increased.

Another limitation, considering PA levels specifically, use of self-reported outcomes, is a potential issue. IPAQ is of course a subjective measure and was not designed for examination of change in physical activity levels and this could mean it does not well reflect participants' objective changes in physical activity,[24,34] however, this was the only measure used within the database reviewing PA levels of participants. Although, a recent study has suggested that participants' perceptions of their PA levels relative to others, even when independent of the actual PA conducted (whether self-reported or device measured), are strong predictors of all-cause mortality.[35] Although this study reviewed the effects of ERSs on change in PA, it does not consider the reasons why participants chose to attend an ERS. Indeed, many factors influence uptake [36] and it seems likely would influence engagement throughout also. Some participants may have attended due to their own motivation to improve their health conditions, whereas, other participants may have only attended because their GP advised them to. A future study could review the reasoning behind individuals' uptake in schemes, along with recorded adherence to PA or self-report PA through IPAQ. This could also be captured by schemes within the database as it is developed. Lastly, similarly to the health and wellbeing outcomes, there was considerable heterogeneity across schemes with respect to the changes observed.

Conclusion

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

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Patient and Public Involvement

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

Data Sharing

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

Ethics Statement

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

Transparency Statement

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

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Figure titles

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

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

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

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

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

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

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