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Does providing everyone with free-of-charge organised exercise opportunities work in public health?

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ABSTRACT

Background and purpose: Population-level initiatives of free-of-charge organised exercise have been implemented to encourage residents to take up regular physical activity. However, there exists a paucity of evidence on the ability of these interventions to attract and engage residents, especially targeted subgroups. Seeking to contribute to this evidence base, we evaluated a proportionate universal programme providing free exercise sessions, Leeds Let's Get Active.
Methods: Descriptive statistics were used to summarise the programme data and participants. Time to event, count and logistic regression models examined how different population subgroups engaged with the programme in terms of number of entries, weekly participation rates and drop-off patterns.
Results: 51,874 adult residents registered to the programme and provided baseline data (2013–2016). A small proportion (1.6%) attended the free sessions on a weekly basis. Higher participation rates were estimated for the groups of males, retired and non-inactive participants. A neighbourhood-level deprivation status was found to have no marginal effect on the level and frequency of participation, but to be negatively associated with participation drop-off (HR 0.93, 95% CI 0.89–0.97, $p = 0.001$).
Conclusions: Providing everyone with free-of-charge organised exercise opportunities in public leisure centres located in deprived areas can attract large volumes of residents, but may not sufficiently encourage adults, especially inactive residents and those living in disadvantaged neighbourhoods, to take up regular exercise.

1. Introduction

Physical inactivity is a primary contributor to chronic disease, accounting for 9% of all premature mortality worldwide [1]. Lack of regular physical activity (PA) has been estimated to cost $53.8 billion a year to society [2], impacting on several domains including health and social care and productivity [3]. National and international recommendations on minimum PA levels for adults have been developed, which include engaging in at least 150 min of at least moderate PA per week [4–6]. However, evidence has consistently shown that large sections of the population do not currently meet these recommendations, particularly in Western countries [7]. Furthermore, there is a steep socio-economic gradient, with individuals from disadvantaged backgrounds being less likely to engage in habitual leisure-time PA [8,9].

Covid-19 has further exacerbated this issue. The lockdown restrictions have adversely impacted PA levels [10,11], especially individuals from disadvantaged backgrounds [12]. In England, unprecedented decreases have been observed between mid-March and mid-May 2020, compared to the same two-month period 12 months earlier, with around three and a half million more adults being physically inactive and a 1.6% proportional increase within lower socio-economic groups [13]. However, the imposed restrictions have also led to a renewed appreciation for the value of leisure time physical activity, as a way to boost and maintain mental wellbeing [14].

Community-wide initiatives to enhance exercise participation can play an important role in tackling physical inactivity in the general population [15,16]. Over the last two decades, these initiatives have taken different forms in many countries around the world. For example, they have included mass-media campaigns

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[17], built environment-based interventions such as urban regeneration projects, building cycle trails and walkways in the US [18], and free-of-charge organised exercise programmes such as and free centre-based classes in the UK [19–22] or park-based activities in the US [23].

Unlike mass-media campaigns [24] and built environment strategies, for which evidence exists for increasing walking behaviours [25], there have been inconsistent findings on the effectiveness of free-of-charge organised exercise programmes. Specifically, a recent Cochrane review identified a limited evidence base of generally low-quality studies in support of the ability of these interventions to increase PA at a population level [26]. Methodological limitations of these studies have been also highlighted in several reviews [27–30]. In particular, data collection strategies relying on convenience sampling and self-reported survey methods which typify these settings and with consequent risks of selection and recall bias being induced in the analysis.

While policy makers are increasingly interested in the evaluation of these programmes to inform decision making [31], evaluations are not regularly conducted and can be challenging [32–34], not least because data are rarely collected for research purposes and studies tend to be poorly designed [35]. In addition, a primary aim of public health is to reduce the existing inequality across population subgroups [36,37]. However, these studies do not often provide evidence for the impact of these interventions by equity-relevant dimensions (e.g., socio-economic status) [26]. tDue to constraints to intervention design, these programmes are often made available to all residents in the community (i.e., universal approaches), hence potentially widening the existing inequalities in PA participation [38], and consequently health outcomes.

To strike a balance between the universal and targeted paradigms, blended approaches have been suggested, most notably proportionate universalism [37,39]. An example of a proportionate universal approach in PA promotion is the universal offer of access to open green spaces (e.g., public parks) located in deprived neighbourhoods, where geographical / logistical proximity represents the proportioning factor. However, to date, only a handful of studies have examined the ability of these interventions to attract and engage residents and to reduce the inequality gap in PA participation between the targeted subgroups and the rest of the population [40].

Capitalising on an opportunity to analyse objectively measured data on one of these initiatives, we evaluated the Leeds Let's Get Active (LLGA) programme, which was implemented in the North of England (UK) between October 2013 and December 2016. The aim of the LLGA was to encourage exercise participation in the adult population, especially from adult residents who were physically inactive and from disadvantaged socio-economic backgrounds. In two previous analyses of this programme, we assessed the cost-effectiveness [41] and wider economic implications of implementing LLGA in terms of health inequality impact and opportunity cost from a local authority perspective [42]. In the present paper, we focus on evaluating LLGA programme in terms of reach and efficacy [43], and how these varied across population subgroups.

2. Methods

2.1. Intervention

LLGA was a city-wide programme developed by the local authority and funded in collaboration with Sport England and Public Health England, which offered free universal access to off-peak exercise classes (mostly gym and swimming sessions) to all city residents. LLGA was a proportionate universal offer in that the free sessions were available to all city residents but were provided in 17 local City Council-managed leisure centres located in the most deprived areas of the city (i.e., geographical proximity to the leisure centres as the proportioning factor). A marketing campaign targeting population subgroups was conducted by the programme administrators in the six months prior the launch of the programme [44].

2.2. Data collection

Any resident could sign up either in person at the leisure centres or on-line [45]throughout the 39 months of programme duration. On registration, all participants were asked to report basic demographics and their current number of active days per week based on a single-item question derived from the short-form IPAQ questionnaire [46]. Participants were grouped into four PA categories: inactive=zero, insufficiently active=1 or 2, moderately active=3 or 4, active=5 to 7 active days a week [47].

Participants were assigned an electronic card which enabled them to access the free exercise sessions and the administrators to objectively monitor session participation (card swipes). After 18 months from the start of the programme (cohort 2 participants), the survey questionnaire was extended to include additional socio-demographic variables. Participants could attend any of the available sessions at any time with no restrictions. Appendix I Table A details the variables identified for analysis of the LLGA programme.

2.3. Data analysis

Residents aged 16 years old or over, for whom basic demographic data were available (age, gender, Index of Multiple Deprivation, IMD, and PA level) were defined as participants. The IMD is a neighbourhood-level measure composite of seven weighted domains of deprivation (income, employment, education, health, crime, barriers to housing and services and living environment), which provides a nationally consistent metric that has been extensively used by local public health authorities in England [48].

Reach was measured as the proportion of total number of adult residents who signed up to the programme (i.e., participants), and their characteristics in comparison to the general population. Efficacy was assessed based on the following outcomes, which were defined considering the characteristics of an open cohort study design [49]:

- Participation volume and rates, measured as the number of entries and weekly rates. Participation rates were calculated as ratios between the total number of LLGA sessions attended over the participant's individual access period (i.e., from first entry to end of the programme);
- Drop-off patterns, time from participant's first to last entry (i.e., participation period); how likely the different participants are to attend the free sessions for at least one time a week; for how long a weekly participation rate of at least one session a week was sustained.

For continuous variables, means and standard deviations (SDs), and for categorical variables proportions were computed. Differences in personal characteristics were tested between sub-samples using analysis of variance (ANOVA) or independent sample t-tests for continuous variables, as appropriate, and $\chi 2$ tests for categorical variables. An informal analysis of residuals followed for significant estimates of categorical variables with more than two levels. Cox, Poisson and logistic regression models were estimated to identify independent factors affecting the different components of participation [50], as appropriate. Missing values were excluded from the analyses and statistical significance was set at a 0.05 threshold. Data were analysed using STATA software version SE 15 [51].

Table 1
Socio-demographic characteristics of the LLGA participants (N = 51,874).

Characteristic	Reference	Total	Cohort 1 n = 32,436	Cohort 2 n = 19,438	p-value
Age group	16–40 y	61.5%	58.7%	66.1%	<0.001
	41–64 y	31.5%	33.1%	28.8%	
	>64 y	7.0%	8.2%	5.1%	
Gender	Female	62.4%	62.5%	62.2%	0.460
	Male	37.6%	37.5%	37.8%	
Index of Multiple Deprivation	Bottom 80% score	80.5%	79.7%	81.8%	<0.001
	Top 20% score	19.5%	20.3%	18.2%	
Physical activity category	Inactive	29.0%	28.6%	29.7%	<0.001
	Insufficiently active	37.0%	35.3%	39.9%	
	Moderately active	21.4%	22.1%	20.2%	
	Active	12.6%	14.0%	10.2%	
Body Mass Index* (n = 6455)	Healthy weight	44.3%			
	Overweight	31.6%			
	With obesity	24.1%			
Ethnicity* (n = 13,142)	White	81.5%			
	Asian	4.8%			
	Black	4.1%			
	Mixed / Other	9.7%			
Education* (n = 13,141)	Higher education	39.3%			
	No higher education	60.7%			
Employment* (n = 13,142)	Full-time	48.0%			
	Part-time	27.7%			
	Unemployed	24.3%			
Relationship* (n = 13,142)	Living alone	41.4%			
	Not living alone	58.6%			

*only survey amongst cohort 2 participants; y=years.

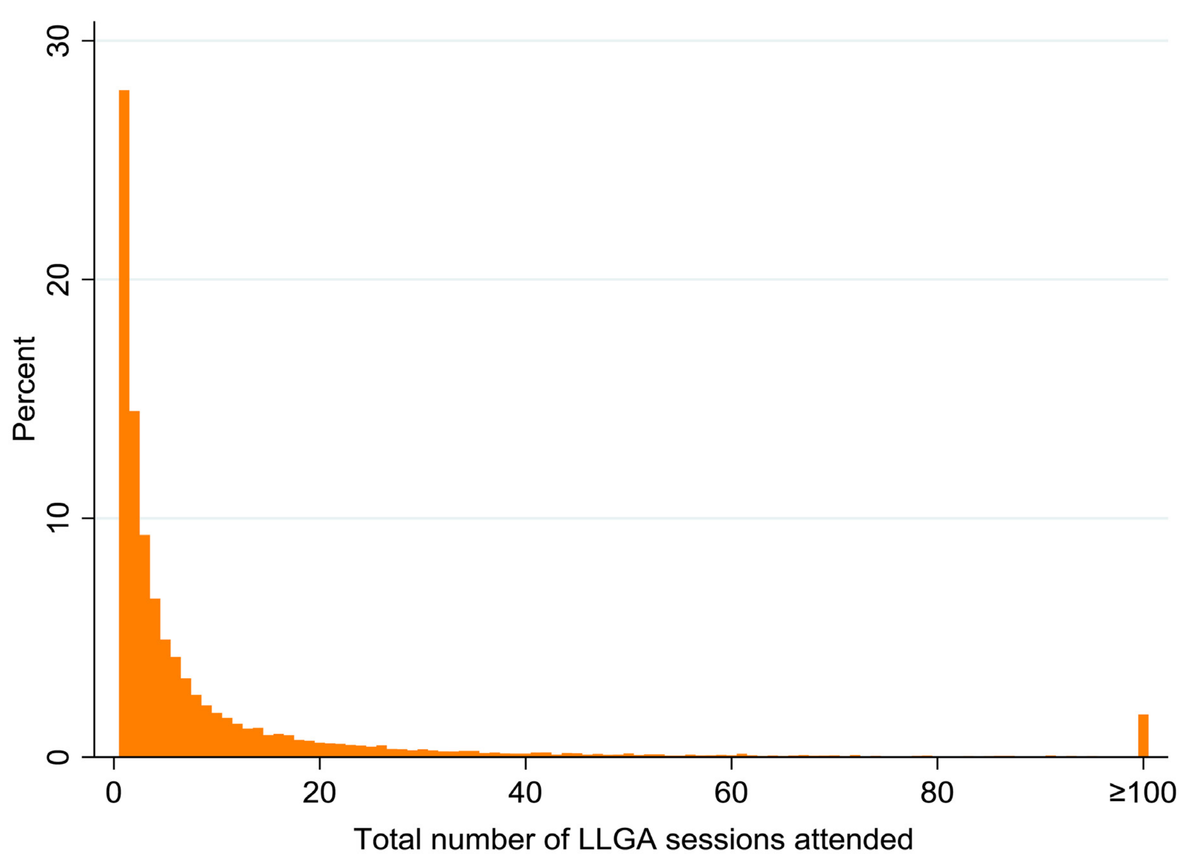

Fig. 1. Distribution of engaged participants by number of LLGA sessions attended.

3. Results

3.1. Reach

Over 39 months, 51,874 adult residents registered to the programme and provided basic demographic data. Sixty-two percent ($n = 32{,}436$) registered in the first 18 months of the programme (cohort 1). Table 1 shows the socio-demographic characteristics of the participants.

On overage, LLGA participants were aged 39 years, the majority were female (62.4%), two thirds were inactive or insufficiently active and a fifth reported to live in a top IMD quintile area of the city (i.e., most deprived). The majority of cohort 2 participants, on whom additional information was available, were in majority of White ethnicity (81.5%), at a healthy weight or overweight (75.9%), not living alone (58.6%), at least part-time employed (75.7%) and without a higher education degree (60.7%).

Those living in the top 20% most deprived areas were significantly more inactive than the rest of the population (32.8% vs 28.1%, $p < 0.001$). Comparing means and standard deviations (in brackets) of age and active days per week between the two cohorts, cohort 2 participants were younger [*cohort 1,* 39.4 (15.2) vs *cohort 2,* 36.9 (14.1), years], slightly more inactive [*cohort 1,* 2.08 (1.98) vs *cohort 2,* 1.86 (1.83) active days]. Cohort 2 participants were also 2.1% less likely to live in the most deprived areas of the city.

Over the 39 months the LLGA programme was able to attract 8.3% of the total number of residents aged 16 years old or above (51874/623698 [52]). Comparing this subset of residents with the characteristics of the respective population, the LLGA participants were slightly younger (Leeds: 16–40 years, 47%; 41–64 years, 34% and over 64 years, 19% [52]), female in a greater proportion (Leeds: 51% [*52*]), less physically active (Leeds: inactive 18%, fairly active 25%, active 57% [52]) and living in the top 20% most deprived areas in a smaller proportion (Leeds: 33.61% [53]).

3.2. Volumes of entries

Heterogeneity was found in terms of number of LLGA sessions attended by residents who registered to the programme and attended at least one LLGA session ($n = 23{,}481$, hereinafter referred to as “engaged participants”). Twenty-eight percent attended only one session ($n = 6559$), while the top decile was distributed between 25 and 780 sessions (Fig. 1).

The group of over 65 years old (IRR 2.74, 95% CI 2.71–2.77, $p < 0.001$) and male participants (IRR 1.35, 95% CI 1.34–1.36, $p < 0.001$) were expected to attend a greater number of sessions, compared to the youngest group and female, respectively, after adjusting other factors including access period. Higher baseline number of active days was monotonically associated with higher session counts, which were expected to increase by a factor ranging between 1.07 and 1.22. Conversely, the rate ratio of entries was expected to decrease by a 0.98 factor for participants living in a top 20% IMD score area of the city was, compared to the rest of the population (Appendix II Table B).

Results from a fully adjusted model focussing on cohort 2 participants indicated that not having a higher education degree (IRR 0.91, 95% CI 0.88–0.95, $p < 0.001$) was associated with lower counts, while for being a student or part-time employed (IRR 1.12, 95% CI 1.07–1.17, $p < 0.001$), retired or unemployed (IRR 1.37, 95% CI 1.31–1.44, $p < 0.001$), and belonging to an ethnic minority (Asian: IRR 1.21, 95% CI 1.12–1.31, $p < 0.001$, Black: IRR 1.34, 95% CI 1.21–1.48, $p < 0.001$, mixed race: 1.43, 95% CI 1.35–1.52, $p < 0.001$), total number of entries was expected to increase, compared to the respective reference categories (Appendix II Table C).

3.3. Weekly participation rates

An analysis of the participation rates indicated that most engaged participants (98.4%) attended the free exercise sessions at a rate lower than one time a week (Appendix III Fig. I). Odds of higher participation rates were found to be monotonically and independently associated with an older age (age 40–64 years: OR 1.46 1.38–1.53, $p < 0.001$; age >64 years: OR 2.52 2.30–2.76, $p < 0.001$), being male (OR 1.15 1.09–1.20, $p < 0.001$) and active at baseline (OR 1.10 1.02–1.19, $p = 0.019$, Appendix III Table D), compared to the respective reference categories. These factors were identified as being independently and also more markedly associated with greater odds of engaging with the programme at a rate of at least one session a week (age 40–64 years: OR 3.76, 2.92–4.86, $p < 0.001$; age >64 years: OR 8.17, 6.10–10.95, $p < 0.001$; male: OR 2.32, 1.87–2.88, $p < 0.001$; active: OR 1.66 1.20–2.29, $p = 0.002$, Appendix III Table E).

Results from a fully adjusted model focussing on cohort 2 participants estimated that the odds of attending the session at higher weekly rates were predicted to decrease with not having a higher education degree (OR 0.84, 0.72–0.99, $p = 0.038$), while to increase with a retired or unemployed status (OR 1.40, 1.13–1.73, $p = 0.002$) and being of a mixed race (OR 1.39, 1.04–1.86, $p = 0.028$), given the other variables are held constant (Appendix III Table F). No evidence for this category of predictors was found in terms of odds of at least one session a week participation rate (Appendix III Table G). IMD status was not identified as a factor influencing participation rate in any of these models.

3.4. Drop-off patterns

As mentioned above, no restrictions were imposed on participants in terms of their ability to attend as many of the provided exercise sessions they wished and at any point in time, after registration.

Following their first entry, 72% of the engaged participants ($n = 16{,}922$) continued attending the free exercise sessions for at least one more time during a subsequent week within a 6-month time period (Appendix IV Fig. II).

This analysis also showed that some groups of LLGA participants attended the programme sessions over longer periods of time than others. This was estimated by comparing participation periods. This was the number of weeks between the participant's first and their last entry to the LLGA sessions, which was found to increase with an older age (40–64 years: HR 0.87, 95% CI 0.84–0.90, $p < 0.001$; age>64 years: HR 0.74, 95% CI 0.70–0.79, $p < 0.001$), being male (HR 0.92, 95% CI 0.89–0.95, $p < 0.001$), non-inactive at the time of registration (insufficiently active: HR 0.95, 95% CI 0.91–0.98, $p = 0.007$; moderately active: HR 0.91, 95% CI 0.87–0.95, $p < 0.001$; active: HR 0.90, 95% CI 0.86–0.95, $p < 0.001$, Fig. 2) and living in the top 20% most deprived areas of the city (HR 0.93, 95% CI 0.89–0.97, $p = 0.001$), compared to the respective categories (Appendix IV Table H).

Among the subsample of cohort 2 participants with complete data ($n = 2427$, median: 2, mean 4.3, SD 6.8), having obesity (HR 1.29, 95% CI 1.12–1.48, $p < 0.001$) and being without a higher education degree) was negatively associated (HR 1.14, 95% CI 1.02–1.28, $p = 0.025$, while living with other people was positively associated (HR 0.88, 95% CI 0.78–0.98, $p = 0.027$) with participation period (Appendix IV Table I).

With a median value of three weeks (mean 8.16, SD 15.8), being older, male, non-inactive and living in the most deprived areas of the city were independently and positively associated

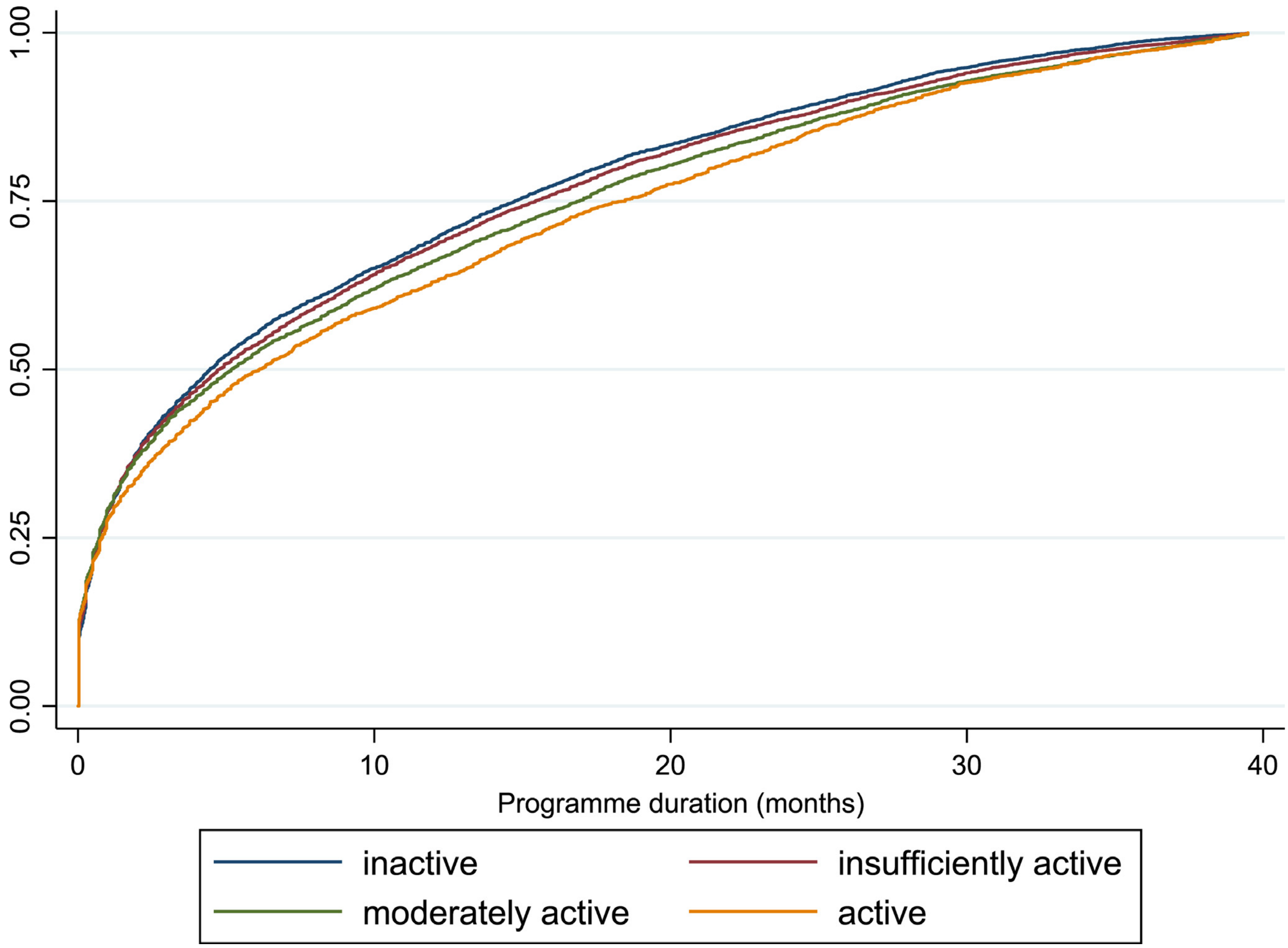

Fig. 2. Participation drop-off rate by baseline physical activity category.

with the number of active weeks of active participation (at least one session attended, Appendix IV Table J). A subgroup analysis also indicated that having obesity (IRR 0.94, 95% CI 0.90–0.99, $p = 0.025$) and being without an higher education (IRR 0.92, 95% CI 0.88–0.96, $p < 0.001$) were associated with lower number of weeks of active participation, which were expected to decrease by a 6% to 8%, respectively, relative to their respective categories. Conversely, being part-time (IRR 1.10, 95% CI 1.04–1.15, $p < 0.001$), unemployed (IRR 1.27, 95% CI 1.21–1.34, $p < 0.001$), of Black (IRR 1.14, 95% CI 1.01–1.28, $p = 0.030$) or mixed race ethnicity (IRR 1.37, 95% CI 1.29–1.47, $p < 0.001$), were identified as being independent predictors of higher counts (Appendix IV Table K).

Following the first week of session participation, 9% of the engaged participants ($n = 2129$) attended the programme sessions for at least one time in the subsequent week, 2.4% ($n = 554$) continued in the third week, while 0.3% ($n = 81$) sustained regular participation for the first month since registration. Regular session participation was found to be monotonically and independently predicted by an older age (40–64 years: HR 0.96, 95% CI 0.93–0.99, $p = 0.005$; >64 years: HR 0.91, 95% CI 0.87–0.96, $p < 0.001$) and being male (HR 0.97, 95% CI 0.94–0.99, $p = 0.021$). Conversely, living in the most deprived areas was found to be negatively associated (HR 1.05, 95% CI 1.01–1.08, $p = 0.008$). Neither a higher PA level at the time of registration nor any other factors were found to significantly affect regular session participation (Appendix IV Table L and Table M).

4. Discussion

4.1. Main findings

This study explored whether providing free-of-charge organised exercise opportunities in deprived areas of the city can achieve the desired participation outcomes, i.e., attract and engage residents, particularly from targeted subgroups. To answer this question, we evaluated the LLGA programme in England. Survey and card swipe data from the programme were analysed to assess reach and participation by the adult population.

The intervention attracted large volumes of residents, in part from targeted subgroups of physically inactive and residents living in disadvantaged neighbourhoods. Applying the diffusion of innovation model [54], innovators and early adopters (earlier registrations) were more likely to be of an older age, male, already physically active and subsequently attend more of the free exercise sessions, hence having longer periods of access for engaging actively with the programme.

Around half of participants attended the exercise sessions at least once, the majority of which for only a handful of entries, while only a very small proportion engaged frequently and on a regular basis. We found that programme participation was highest among residents aged 65 years or over – who are likely to be retired in most cases - and male, consistently across all the analysed indicators (number of entries, weekly participation rate and participation patterns), and particularly in terms of sustained participation over time.

Those who were previously physically inactive engaged with the programme sessions to a lesser degree, attended less regularly, and dropped off the programme earlier than more active residents did. No difference was found between residents living in the most deprived areas and the rest of the population, both in terms of total number of entries and weekly participation rates. However, lower drop-off rates for the former group meant that they attended the sessions more sporadically over longer periods of times than those in the less deprived IMD score areas. We also found that the provided off-peak sessions were more likely and frequently attended by residents with a higher education degree, of a minority ethnic group and part-time employed or unemployed.

4.2. Comparison with previous studies

This study contributes to the limited evidence base on the ability of universal programmes of free-of-charge organised exercise to attract and engage the residing population, especially targeted subgroups. A recent analysis of the "Re:fresh" scheme provides some measure of comparison with the results of the present study [20]. Compared to the LLGA, this scheme provided free access to exercise sessions, at most times of the day, in nine City Council-managed leisure centres located close to deprived neighbourhoods in Blackburn with Darwen (northern England) between July 2008 and December 2015. Regression analysis of swipe-card data from that study indicated that the intervention generated an overall increased participation in gym and swimming entries (RR 1.64, 95% CI 1.43 to 1.89, $P < 0.001$) and a positive effect on inequality in terms the proportion of non-inactive adults, favouring disadvantaged socioeconomic groups the most (4.7%, 95% CI 4.4 to 5.0). The latter results of broadly align with those found in the present study for the group of part-time employed or unemployed. and suggest that removing user charges may be particularly appealing to individuals without a full-time job and low-income recipients.

Similarly, a comparative regression discontinuity study examining the impact of free access to swimming pools during the summer holidays in children living in a disadvantaged area in England found that the programme was associated with an additional 6% (95% CI 4% to 9%) increase in the number of swimmers and 33 swims per 100 children per year (95% CI 21 to 44) [55]. This study also found that this population-level increase was more pronounced in children from moderately deprived areas compared to the rest of the population. Another comparable initiative implemented in California (US), the "100 Citizens" [23] which delivered park-based free exercise classes targeting minorities and physically inactive adults in low-income neighbourhoods, was found to successfully attract individuals from the targeted population subgroup (85% Latinos) and increase the number of park users. However, this comparative analysis relied on a simple pre-post measurement design and data from a sub-sample of observer-based counts of park users. Furthermore, both these two studies focused on increases in facility use, and no inference could be drawn from these studies in terms of ability of the intervention to change overall PA levels in the targeted subgroups.

4.3. Strengths and limitations

To the best of our knowledge, this is the first study providing a comprehensive assessment of the reach and participation to this type of programmes at a population level. Unlike previous evaluations that were constrained to rely on convenience samples [18,19,21], we had the opportunity to access individual level information on the entirety of residents who participated. Furthermore, participation was objectively measured from swipe-card entries at the leisure centres, eliminating the risk of report bias which is a common challenge of these types of evaluations [35].

We used the IMD to assess the inequality implications of implementing the programme and we did not find any differential effect. The IMD is a neighbourhood-level metric which was used as a proxy measure of individual-level socio-economic deprivation [56]. While the IMD provides a nationally consistent measure, it may not have been sensitive enough to capture individual-level differences in socio-economic deprivation [57]. Furthermore, we had only information on whether a participant resided in a top quintile IMD area or not. This limited our ability both to analyse participation across the entire social gradient and to formally assess how proximity played a role - for which the full postcode would be required.

While entries were electronically recorded, participants' PA levels were not monitored in the leisure centres. The plausibility of assuming that an entry would correspond to at least 30 min of at least moderate PA (i.e., active day) may be questionable. Testing the concurrent validity of an entry against an objective measure on a random subset of participants, such as using accelerometers [58], would have increased confidence in the results, but this was not feasible in practice due to resource constraints. Moreover, the free sessions were offered at off-peak times, likely affecting the proportion of residents that could attend them and therefore reducing the generalisability of the findings accordingly.

Furthermore, the paucity of the data available on covariates, particularly on PA levels in other domains (e.g., occupational), changes in health-related behaviours and events that may have influenced the observed behaviours (e.g., relocating to another city) limited the extent of statistical analysis. While we were able to assess uptake of the intervention in a real-life setting, the effect that the LLGA programme had on changing overall PA, and consequently health outcomes and inequalities, could not be reliably quantified. In addition, the LLGA offer was made available to current leisure centre members as well and we could not control for potential substitution effects with existing gym memberships. These effects would cancel out any with participation effects induced by the programme and potentially represent a waste of public resources on which the disadvantaged groups rely more heavily than the rest of the population).

5. Conclusions

Providing everyone with free-of-charge organised exercise opportunities can attract large volumes of adult residents but are likely to encourage only a selective minority to take up regular exercise. While removing user charges can be a tempting strategy, it alone is not sufficient to promote sustained participation at a population level. Universal policies do not achieve the desired outcome of supporting already inactive adults, hence alternative approaches should be considered. Unstructured involvements of research professionals limit the ability to adequately design, conduct and evaluate these interventions and their impact on health outcomes and inequalities. With increasing pressure to local government budgets, established collaborations with academic institutions would help support an efficient allocation of public health resources by adequately informing policy decision-making.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.healthpol.2022.01.001.

Appendix I. Variables

Table A

Table A
Variables selected for analysis.

Variable	Description	Notes
Physical activity	4 ordinal categories, defined according to the number of active days over previous seven days: Inactive= 0, Insufficiently active= 1–2, Moderately active= 3–4, Active= 5–6–7.	For descriptive purposes, considered also as an interval (0–7), as well as a continuous variable
Survey questionnaires		
Age group	3 ordinal categories (years): 1= younger adults: 16–40, 2= middle-aged: 41–64, 3= older adults:>= 65	Considered also as a continuous variable
Gender	Female or male	Reference category=female
Index of multiple deprivation (IMD)	Binary, 0= bottom 80% IMD score, 1= top 20% IMD score	Reference category=Non-deprived
Cohort status	Time period of registration to LLGA, before (cohort 1) or after 31.03.15 (cohort 2)	Different survey questionnaires
Body mass index status*	3 ordinal categories: 0= if 18–25 healthy, 1= if<30 &>=25 overweight, 2= if>30 obese*	Reference category=healthy
Ethnic background*	Nominal variable, White, Asian, Black, mixed race / other	Reference category= White
Education status*	Binary, 0= higher education (diploma/ BSc/ MSc/ PhD) or 1=not	Reference category= higher education
Employment status*	3 categories, 0= full-time; 1= part-time employed, student or volunteer; 2=unemployed, retired or unable to work	Reference category= full-time
Relationship status*	Binary, 0=living alone or 1= not	Reference category= alone

* available only for cohort 2 participants, NAD=number of active days; World Health Organisation classification of obesity in adults.

Appendix II. Session participation Appendix II Session participation

Table B; Table C

Table B
Predictors of number of LLGA entries, n = 23,481.

Variable	Unadjusted IRR (95% CI)	p value	Adjusted IRR (95% CI)[a]	p value
age 16–40 y	Reference			
age 40–65 y	1.925 (1.909–1.941)	<0.001	1.789 (1.774–1.804)	<0.001
age >65 y	3.735 (3.697–3.774)	<0.001	2.745 (2.716–2.775)	<0.001
female	Reference			
male	1.502 (1.490–1.513)	0.108	1.353 (1.343–1.364)	<0.001
IMD bottom 80%	Reference			
IMD top 20%	1.075 (1.064–1.086)	<0.001	0.980 (0.970–0.990)	<0.001
inactive	Reference			
insufficiently active	1.056 (1.045–1.067)	0.016	1.068 (1.057–1.079)	<0.001
moderately active	1.130 (1.282–1.310)	<0.001	1.162 (1.149–1.175)	<0.001
active	1.140 (1.393–1.428)	<0.001	1.224 (1.209–1.239)	<0.001
N. of observations	23,481			
Pseudo R2	0.218			
Prob > chi2	<0.001			

Note: IMD=Index of Multiple Deprivation score, y=years.
[a] Poisson regression model adjusted by listed covariates, access period, type of activity and cohort status.

Table C
Predictors of number of LLGA entries, n = 2427.

Variable	Adjusted IRR (95% CI)[a]	p value
age 16–40 y	Reference	
age 40–65 y	1.789 (1.774–1.804)	<0.001
age >65 y	2.745 (2.716–2.775)	<0.001
female	Reference	
male	1.353 (1.343–1.364)	<0.001
IMD bottom 80%	Reference	
IMD top 20%	0.980 (0.970–0.990)	<0.001
inactive	Reference	
insufficiently active	1.068 (1.057–1.079)	<0.001
moderately active	1.162 (1.149–1.175)	<0.001
active	1.224 (1.209–1.239)	<0.001
healthy weight	Reference	
overweight	0.949 (0.910–0.990)	0.014
obese	1.006 (0.959–1.053)	0.813
Living alone	Reference	
Living with others	0.963 (0.926–1.001)	0.058
full-time employed	Reference	
part-time / student	1.122 (1.070–1.175)	<0.001
retired/unemployed	1.369 (1.306–1.436)	<0.001
Higher education	Reference	
No higher education	0.912 (0.879–0.947)	<0.001
White	Reference	
Asian	1.214 (1.123–1.312)	<0.001
Black	1.337 (1.209–1.478)	<0.001
Mixed-other	1.432 (1.351–1.519)	<0.001
	N. of observations	2427
	Pseudo R2	0.149
	Prob > chi2	<0.001

Note: IMD=Index of Multiple Deprivation score, y=years.
[a] Poisson regression model adjusted by listed covariates, access period, type of activity and cohort status.

Appendix III. Participation rates Appendix III Participation rates

Fig. I;Table D; Table E; Table F; Table G

Table D
Predictors of higher quartile of participation rate, n = 23,481.

Variable	Unadjusted OR (95% CI)	p value	Adjusted OR (95% CI)[a]	p value
age 16–40 y	Reference			
age 40–65 y	1.391 (1.322–1.463)	<0.001	1.456 (1.383–1.533)	<0.001
age >65 y	2.232 (2.042–2.440)	<0.001	2.523 (2.302–2.765)	<0.001
female	Reference			
male	1.229 (1.173–1.288)	<0.001	1.148 (1.094–1.204)	<0.001
IMD bottom 80%	Reference			
IMD top 20%	1.031 (0.972–1.093)	0.122	0.954 (0.898–1.013)	0.122
inactive	Reference			
insufficiently active	1.039 (0.980–1.101)	0.195	1.064 (1.003–1.128)	0.039
moderately active	1.031 (0.966–1.101)	0.355	1.048 (0.981–1.119)	0.166
active	1.063 (0.984–1.148)	0.123	1.098 (1.016–1.188)	0.019
N. of observations	23,481			
Pseudo R2	0.026			
Prob > chi2	<0.001			

Note: IMD=Index of Multiple Deprivation score, *y*=years.
[a] Ordered logistic regression model adjusted by listed covariates, access period, type of activity and cohort status.

Table E
Predictors of participation rate of at least one session a week, n = 23,481.

.Variable	Unadjusted OR (95% CI)	p value	Adjusted OR (95% CI)[a]	p value
age 16–40 y	Reference			
age 40–65 y	3.605 (2.803–4.637)	<0.001	3.763 (2.917–4.856)	<0.001
age >65 y	8.594 (6.479–11.398)	<0.001	8.174 (6.100–10.954)	<0.001
female	Reference			
male	2.798 (2.262–3.462)	<0.001	2.320 (1.867–2.884)	<0.001
IMD bottom 80%	Reference			
IMD top 20%	1.269 (0.955–1.685)	0.101	1.012 (0.756–1.356)	0.935
inactive	Reference			
insufficiently active	0.972 (0.734–1.287)	0.843	1.057 (0.795–1.406)	0.702
moderately active	1.309 (0.976–1.754)	0.072	1.279 (0.946–1.721)	0.11
active	1.668 (1.125–2.290)	0.002	1.658 (1.198–2.295)	0.002
N. of observations	23,481			
Pseudo R2	0.119			
Prob > chi2	<0.001			

Note: IMD=Index of Multiple Deprivation score, *y*=years.
[a] Logistic regression model adjusted by listed covariates, access period, type of activity and cohort status.

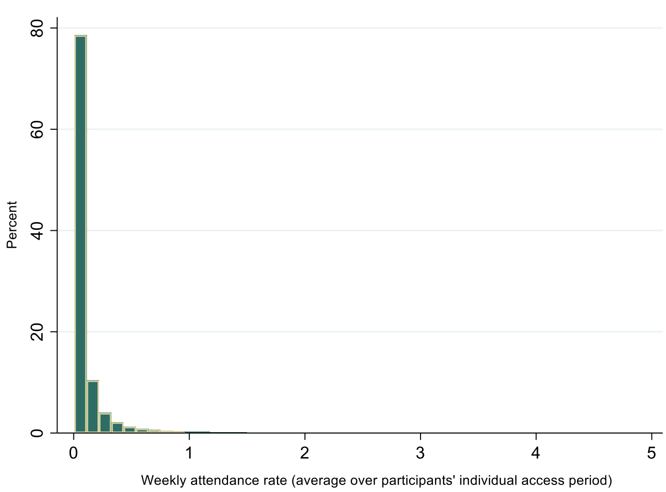

Fig. I. Distribution of participants by weekly participation rate, n = 23,481.

Appendix IV. Participation patterns Appendix IV Participation patterns

Table H; Table I; Table J; Table K; Table L; Table M; Fig. II

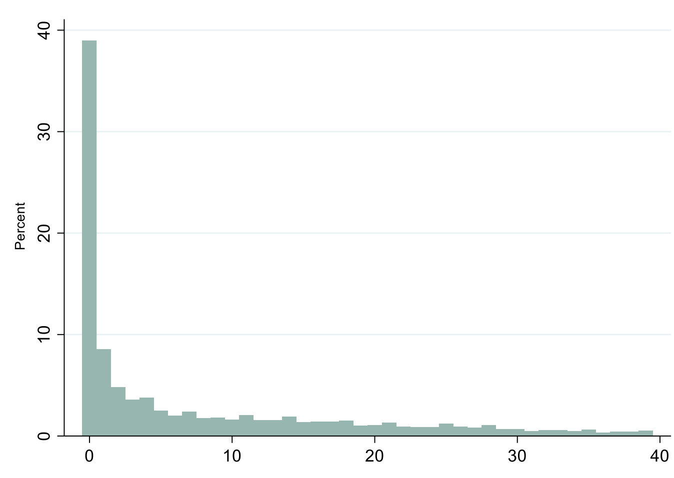

Fig. II. Distribution of participants by participation period, n = 23,481.

Table F
Predictors of higher quartile of participation rate, $n = 2427$.

Variable	Adjusted OR (95% CI)[a]	p value
age 16–40 y	Reference	
age 40–65 y	1.348 (1.131–1.607)	0.001
age >65 y	1.563 (1.095–2.231)	0.014
female	Reference	
male	1.338 (1.138–1.573)	<0.001
IMD bottom 80%	Reference	
IMD top 20%	1.091 (0.884–1.348)	0.416
inactive	Reference	
insufficiently active	1.131 (0.937–1.365)	0.2
moderately active	1.028 (0.83–1.273)	0.8
active	0.931 (0.705–1.228)	0.613
healthy weight	Reference	
overweight	0.882 (0.738–1.054)	0.167
obese	0.921 (0.995–0.995)	0.413
Living alone	Reference	
Living with others	1.055 (0.894–1.246)	0.526
full-time employed	Reference	
part-time / student	1.043 (0.863–1.260)	0.661
retired/unemployed	1.398 (1.126–1.735)	0.002
Higher education	Reference	
No higher education	0.844 (0.719–0.990)	0.038
White	Reference	
Asian	1.310 (0.891–1.924)	0.169
Black	1.230 (0.728–2.077)	0.438
Mixed-other	1.387 (1.036–1.858)	0.028
	N. of observations	2427
	Pseudo R2	0.118
	Prob > chi2	<0.001

Note: IMD=Index of Multiple Deprivation score, y=years.
[a] Ordered logistic regression model adjusted by listed covariates, access period, type of activity and cohort status.

Table G
Predictors of participation rate of at least one session a week, $n = 2427$.

Variable	Adjusted OR (95% CI)[a]	p value
age 16–40 y	Reference	
age 40–65 y	3.083 (1.531–6.205)	0.002
age >65 y	4.927 (1.831–13.260)	0.002
female	Reference	
male	1.821 (1.011–3.282)	0.046
IMD bottom 80%	Reference	
IMD top 20%	0.724 (0.312–1.681)	0.453
inactive	Reference	
insufficiently active	1.046 (0.496–2.206)	0.906
moderately active	0.919 (0.395–2.136)	0.844
active	1.964 (0.769–5.016)	0.158
healthy weight	Reference	
overweight	0.796 (0.403–1.574)	0.512
obese	1.065 (0.492–2.305)	0.873
Living alone	Reference	
Living with others	0.714 (0.372–1.368)	0.310
full-time employed	Reference	
part-time / student	0.785 (0.320–1.924)	0.596
retired/unemployed	1.327 (0.626–2.812)	0.460
No higher education	Reference	
Higher education	0.910 (0.493–1.676)	0.761
White	Reference	
Asian	1.846 (0.391–8.719)	0.439
Black	NA	–
Mixed-other	2.352 (0.958–5.779)	0.062
	N. of observations	2371
	Pseudo R2	0.249
	Prob > chi2	<0.001

Note: IMD=Index of Multiple Deprivation score, y=years.
[a] Logistic regression model adjusted by listed covariates, access period, type of activity and cohort status. NA=not applicable.

Table H
Predictors of participation period, $n = 23{,}481$.

Variable	Unadjusted HR (95% CI)	*p* value	Adjusted HR (95% CI)[a]	*p* value
age 16–40 y	Reference			
age 40–65 y	0.825 (0.798–0.853)]	<0.001	0.874 (0.845–0.904)	<0.001
age >65 y	0.620 (0.587–0.655)	<0.001	0.744 (0.703–0.787)	<0.001
female	Reference			
male	0.959 (0.929–0.990)	0.009	0.921 (0.893–0.951)	<0.001
IMD bottom 80%	Reference			
IMD top 20%	0.903 (0.868–0.939)	<0.001	0.930 (0.894–0.968)	0.001
inactive	Reference			
insufficiently active	0.930 (0.894–0.967)	<0.001	0.948 (0.911–0.985)	0.007
moderately active	0.853 (0.816–0.891)	<0.001	0.908 (0.869–0.949)	<0.001
active	0.820 (0.779–0.863)	<0.001	0.902 (0.856–0.949)	<0.001
N. of observations	168,124			
Time at risk	173,594			
Prob > chi2	<0.001			

Note: IMD=Index of Multiple Deprivation score, *y*=years.
[a] Cox regression model adjusted by listed covariates, access period, type of activity and cohort status.

Table I
Predictors of participation period, $n = 2427$.

Variable	Adjusted HR (95% CI)[a]	*p* value
age 16–40 y	Reference	
age 40–65 y	0.832 (0.736–0.942)	0.004
age >65 y	0.842 (0.668 1.061)	0.144
female	Reference	
male	0.880 (0.787–0.958)	0.027
IMD bottom 80%	Reference	
IMD top 20%	0.896 (0.773–1.038)	0.144
inactive	Reference	
insufficiently active	0.810 (0.708–0.927)	0.002
moderately active	0.835 (0.718–0.972)	0.020
active	0.843 (0.692–1.026)	0.088
healthy weight	Reference	
overweight	1.070 (0.944–1.213)	0.289
obese	1.291 (1.123–1.485)	<0.001
Living alone	Reference	
Living with others	0.877 (0.781–0.985)	0.027
full-time employed	Reference	
part-time / student	1.026 (0.897–1.175)	0.705
retired/unemployed	0.933 (0.802–1.086)	0.37
Higher education	Reference	
No higher education	1.139 (1.017–1.276)	0.025
White	Reference	
Asian	0.814 (0.627–1.057)	0.123
Black	0.999 (0.717–1.391)	0.995
Mixed-other	0.828 (0.681–1.006)	0.058
N. of observations	7916	
Time at risk =	6807	
Prob > chi2	<0.001	

Note: IMD=Index of Multiple Deprivation score, *y*=years.
[a] Cox regression model adjusted by listed covariates, access period, type of activity and cohort status.

Table J
Predictors of weeks of active participation, $n = 23{,}481$.

Variable	Unadjusted IRR (95% CI)	p value	Adjusted IRR (95% CI)[a]	p value
age 16–40 y	Reference			
age 40–65 y	1.777 (1.760–1.795)	<0.001	1.658 (1.642–1.675)	<0.001
age >65 y	3.338 (3.297–3.380)	<0.001	2.548 (2.516–2.581)	<0.001
female	Reference			
male	1.345 (1.333–1.357)	<0.001	1.242 (1.230–1.253)	<0.001
IMD bottom 80%	Reference			
IMD top 20%	1.156 (1.142–1.170)	<0.001	1.057 (1.044–1.070)	<0.001
inactive	Reference			
insufficiently active	1.108 (1.095–1.121)	<0.001	1.117 (1.104–1.131)	<0.001
moderately active	1.287 (1.271–1.304)	<0.001	1.171 (1.156–1.187)	<0.001
active	1.374 (1.354–1–0.394)	<0.001	1.210 (1.192–1.228)	<0.001
N. of observations	23,481			
Pseudo R2	0.192			
Prob > chi2	<0.001			

Note: IMD=Index of Multiple Deprivation score, *y*=years.
[a] Poisson regression model adjusted by listed covariates, access period, type of activity and cohort status.

Table K
Predictors of weeks of active participation, $n = 2427$.

Variable	Adjusted IRR (95% CI) [a]	p value
age 16–40 y	Reference	
age 40–65 y	1.491 (1.427–1.559)	<0.001
age >65 y	1.615 (1.498–1.740)	<0.001
female	Reference	
male	1.307 (1.256–1.361)	<0.001
IMD bottom 80%	Reference	
IMD top 20%	1.056 (0.999–1.117)	0.054
inactive	Reference	
insufficiently active	1.268 (1.204–1.334)	<0.001
moderately active	1.265 (1.195–1.338)	<0.001
active	1.180 (1.098–1.268)	0.001
healthy weight	Reference	
overweight	0.925 (0.884–0.969)	0.001
obese	0.943 (0.896–0.993)	0.025
Living alone	Reference	
Living with others	0.980 (0.939–1.023)	0.353
full-time employed	Reference	
part-time / student	1.096 (1.041–1.153)	<0.001
retired/unemployed	1.275 (1.210–1.344)	<0.001
No higher education	Reference	
Higher education	0.922 (0.885–0.961)	<0.001
White	Reference	
Asian	1.073 (0.979–1.176)	0.131
Black	1.140 (1.013–1.285)	0.030
Mixed-other	1.374 (1.287–1.466)	<0.001
	N. of observations	2427
	Pseudo R2	0.105
	Prob > chi2	<0.001

Note: IMD=Index of Multiple Deprivation score, *y*=years.
[a] Poisson regression model adjusted by listed covariates, access period, type of activity and cohort status.

Table L
Predictors of regular session participation, $n = 23{,}481$.

Variable	Unadjusted HR (95% CI)	p value	Adjusted HR (95% CI)[a]	p value
age 16–40 y	Reference			
age 40–65 y	0.959 (0.932–0.986)	0.003	0.960 (0.934–0.988)	0.005
age >65 y	0.896 (0.854–0.940)	<0.001	0.914 (0.870–0.960)	<0.001
female	Reference			
male	0.955 (0.930–0.980)	0.001	0.969 (0.944–0.995)	0.021
IMD bottom 80%	Reference			
IMD top 20%	1.048 (1.014–1.083)	0.005	1.046 (1.012–1.082)	0.008
inactive	Reference			
insufficiently active	1.023 (0.990–1.057)	0.176	1.019 (0.987–1.053)	0.246
moderately active	1.015 (0.978–1.052)	0.436	1.023 (0.986–1.061)	0.221
active	0.990 (0.948–1.033)	0.633	1.002 (0.960–1.046)	0.928
N. of observations	26,882			
Time at risk =	26,984			
Prob > chi2	<0.001			

Note: IMD=Index of Multiple Deprivation score, *y*=years.
[a] Cox regression model adjusted by listed covariates, access period, type of activity and cohort status.

Table M
Predictors of regular session participation, $n = 2427$.

Variable	Adjusted HR (95% CI)[a]	p value
age 16–40 y	Reference	
age 40–65 y	0.976 (0.889–1.072)	0.611
age >65 y	0.959 (0.799–1.151)	0.653
female	Reference	
male	0.983 (0.902–1.071)	0.689
IMD bottom 80%	Reference	
IMD top 20%	0.999 (0.892–1.119)	0.988
inactive	Reference	
insufficiently active	1.011 (0.914–1.119)	0.824
moderately active	1.018 (0.907–1.142)	0.765
active	1.012 (0.873–1.173)	0.870
healthy weight	Reference	
overweight	1.008 (0.917–1.109)	0.861
obese	0.991 (0.892–1.102)	0.871
Living alone	Reference	
Living with others	1.006 (0.921–1.099)	0.895
full-time employed	Reference	
part-time / student	1.000 (0.903–1.107)	0.998
retired/unemployed	0.971 (0.867–1.088)	0.613
Higher education	Reference	
No higher education	1.001 (0.919–1.090)	0.985
White	Reference	
Asian	1.000 (0.814–1.227)	0.997
Black	0.907 (0.692–1.189)	0.481
Mixed-other	0.995 (0.854–1.158)	0.945
N. of observations	2601	
Time at risk =	2065	
Prob > chi2	<0.001	

Note: IMD=Index of Multiple Deprivation score, *y*=years.
[a] Cox regression model adjusted by listed covariates, access period, type of activity and cohort status.

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