

**The contribution of local authority leisure provision to physical activity in the UK:
evidence from a large population-based cohort**
Running head: Leisure centre use and physical activity levels

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1 The contribution of local authority leisure provision to physical activity in the UK:

2 evidence from a large population-based cohort

3 Abstract

4 **Background:** Physical activity (PA) levels vary across specific population groups,
5 contributing to health inequalities. Little is known about how local authority leisure centres
6 contribute to population PA, and whether this differs by age, sex or socioeconomic group.

7 **Methods:** We calculated weekly leisure centre-based moderate/vigorous PA for 20,904
8 registered adult users of local authority leisure facilities in Northumberland, U.K., between
9 July 2018-June 2019, using administrative data. We categorised activity levels (<30
10 minutes/week, 30-149 minutes/week and 150+ minutes/week) and used ordinal regression to
11 examine predictors for activity category achieved.

12 **Results:** Registered users were mainly female (58.7%), younger (23.9% aged 18-29 years
13 versus 10.1% aged 70+ years) and from the two most affluent socio-economic quintiles
14 (53.7%). Median weekly moderate/vigorous leisure centre-based activity was 55 (IQR 30-
15 99) minutes/week. Being female (OR: 2.09, 95% CI: 1.95-2.35), older (OR: 1.14, 95% CI:
16 1.11-1.16), and using a large facility (OR: 1.21, 95% CI: 1.03-1.42) were positive predictors
17 of leisure centre-based PA.

18 **Conclusion:** Older adults and females were more likely to be active and achieve
19 recommended PA levels through centre usage. Widespread use of this novel measure of
20 leisure centre-based activity would improve understanding of how local authority leisure
21 centres can address physical inactivity and associated inequalities.

22

23 1 Background

24 Physical inactivity causes 9% of premature death globally.¹ Achieving recommended levels
25 of physical activity (PA) is associated with risk reductions of 35% in cardiovascular mortality
26 and 33% in all-cause mortality,² 30% in diabetes,³ 20-40% in breast cancer⁴ and 20-30% in
27 colon cancer.⁵ Additionally, regular PA promotes social interactions and social equity,^{6,7} and
28 is positively associated with mental health.⁸ Therefore, the World Health Organisation
29 identifies increasing population levels of PA as a public health priority.⁹

30 Progress to improve PA has been slow; globally 1 in 4 adults do not currently meet the
31 recommended ≥ 150 minutes of weekly moderate or 75 minutes of vigorous PA, or a
32 combination of both.¹⁰ United Kingdom (UK) PA levels for adults are broadly similar to
33 other European countries such as Sweden and Spain,¹¹ however, in 2019 36.7% of adults
34 aged over 18 years in England failed to meet World Health Organisation recommendations
35 for PA,¹² putting them at a significantly greater risk of cardiovascular disease, and premature
36 mortality.¹³ By 2030, it is estimated that the UK population will be 35% less active if current
37 trends continue.¹⁴ PA levels are strongly influenced by demographics such as age and sex.¹³
38 In England, 63.3% of the population were estimated to be sufficiently active in 2018-19, with
39 men more likely to report being active than women (65% and 61% respectively). Activity
40 levels decrease with age (70% of 16-34 year olds report being physically active compared to
41 40% of those aged 75 and over).¹⁵ Additionally, those people who are in managerial,
42 administrative and professionals occupations are more likely to be active compared to those
43 who are long-term unemployed or have never worked (72% and 54% respectively).¹⁵
44 Occupation is a common indicator of socioeconomic status; therefore it is likely that these
45 data indicate that less affluent people are less active.

46 In more economically developed countries, like the UK, leisure time PA (LTPA) is an
47 important sub-domain of PA, which is associated with significant protection against heart
48 disease,¹⁶ and a reduction in all-cause mortality.^{17,18} For these countries, a greater
49 understanding of LTPA at a local/regional level is important to help plan potential solutions
50 to increase population levels of PA and address inequalities in PA. One potential source of
51 LTPA data is that collected routinely by fitness facilities about service usage, but there are a
52 lack of studies examining these data to investigate whether demographic factors affect
53 attendance, and the contribution of fitness facility usage to population PA levels.

54 In 2018 in the UK, the fitness industry consisted of 7,239 facilities, of which 4,510 (62.3%)
55 were privately owned and 2,729 (37.7%) are publically owned.¹⁹ In this study, privately
56 owned refers to privately owned facilities with a gym and/or fitness class studio. Publically
57 owned refers to any leisure centres/facilities owned by local authorities with a gym and/or
58 fitness class studio. Both private and publically owned sites may also offer additional
59 facilities such as a swimming pool and/or sports facilities such as indoor sports halls or tennis
60 courts. All facilities offer monthly paid membership options, but local authority owned sites
61 more likely to offer pay-as-you-go options, where participants pay for an activity at the point
62 of booking. Typically, they also offer reduced cost options to those for whom cost may be a
63 barrier to access (e.g. those living in areas of deprivation, those with disabilities etc.). Studies
64 have demonstrated that the provision of free local authority owned leisure centre usage is
65 associated with increased usage both for the whole population,²⁰ and those living in areas of
66 deprivation,^{20 21} but have not attempted to objectively measure the amount of LTPA
67 undertaken. This study aimed to estimate the contribution of local authority owned leisure
68 centre usage to population levels of LTPA by using a large anonymised routine service-use
69 dataset.

70 2 Methods

71 This study examined the contribution of local authority leisure centre provision to PA in a
72 large population-based cohort in Northumberland, UK. Edinburgh Napier University School
73 of Health and Social Care Integrity Committee gave ethical approval for the secondary
74 analysis of these anonymised data (REF: SHSC19023).

75 *2.1 Context*

76 Northumberland is the largest unitary authority by area (5,013km²) and the least densely
77 populated (62 people per km²) county in England. The population is 319,030 and is 98.4%
78 white.²² Compared to the rest of England, health in the county is mixed. Life expectancy for
79 women is lower than the national average. Male life expectancy varies by 10.2 years and
80 female by 8.8 years between the most and least deprived areas of the county.²³ The 2019
81 Sport England Active Lives Survey indicates that 67.7% (95% CI 62.3%-72.6%) of
82 Northumberland adults achieve the UK physical activity guidelines compared to 63.3%
83 nationally, while 20.9% (95% CI 16.9%-25.6%) are inactive (doing less than 30 minutes of
84 PA per week).¹⁵

85 *2.2 Study setting and dataset*

86 We performed a retrospective analysis of leisure centre usage by extracting anonymised data
87 from Active Northumberland, a charitable leisure trust that has operated local authority
88 leisure facilities and delivered associated services to all residents on behalf of
89 Northumberland local authority since 2013. The trust managed 17 leisure sites across
90 Northumberland, nine large leisure centres with swimming pools and eight smaller sites; four
91 school shared used sites (one with a pool) one leisure centre without a pool and three
92 community sites. No leading UK private fitness industry provider with multiple facilities (e.g.

93 Pure Gym, The Gym Group, Anytime fitness) operated in the county, although we identified
94 28 independent fitness facilities (one site businesses) and 3 hotel-based gyms via internet
95 searching.

96 Leisure centre usage data such as the date, type and length of activity were tracked via the
97 front desk system (FDS), Gladstone MRM (Gladstone Ltd, Oxford, U.K.), which provided
98 objective, detailed user information about who used the facilities and what/how much LTPA
99 they undertook. Customers could choose whether to register socio-demographic details (age,
100 sex, and postcode) during first use. Ethnicity and disability data were not recorded.
101 Registered users had each activity recorded via a swipe card or an online booking. They
102 could either take out a pre-paid/monthly membership (fees paid annually or 6-monthly in
103 advance, or by a monthly direct debit) allowing unlimited use of gym, fitness class and
104 swimming pools, or access the centres on a pay-as-you-go basis (activity fees paid
105 individually at the time of booking). To ensure anonymity for the study, the trust used look-
106 up tables²⁴ to classify customer postcodes by index of multiple deprivation (IMD) quintile
107 (representing social economic status at area level, with quintile group 5 being the least
108 deprived group and quintile group 1 the most deprived groups).²⁵ Additionally, the trust
109 replaced customer identification numbers with anonymous study ID numbers prior to data
110 transfer.

111 Not registering socio-demographic details did not prevent leisure centre use. Non-registered
112 users could access the leisure centres on a pay-as-you-go basis by paying for activities at
113 leisure centre receptions. For this group, payments were not linked to an individual user but
114 recorded as one generic 'non-member' user in the FDS. Price level settings ensured that only
115 adult non-registered pay-as-you-go usage was extracted.

116 2.3 *Physical activity classification*

117 Prior to extraction, we conducted 2 scoping workshops with 4 leisure trust staff (chief
118 executive, health and fitness lead, a centre-based fitness manager and an IT specialist) to
119 establish the type and duration of activities available for adults. Further clarification of details
120 took place via email and telephone with the fitness manager and the IT specialist over a 2-
121 week period. We allocated each activity a Metabolic Equivalent of Task (MET) level using
122 the Compendium of Physical Activities.²⁶ Individual activities were classed as either light (<
123 3 METs), moderate (3.0-5.9 METs) or vigorous (\geq 6 METs) intensity.²⁷ For example, we
124 allocated studio cycling a MET value of 8.5 METs and classified it as vigorous activity. We
125 determined activity duration based on timetabled duration of the activity, with the exception
126 of gym and swimming. One leisure site utilised the Technogym MyWellness System
127 (Technogym S.p.A, Cesena, Italy) and reported that 321 individuals had used the system to
128 record their gym-based activity in a 30-day period (01/04/2019-30/04/2019). Leisure trust
129 staff randomly selected and analysed the records of 160 (50%) of these users. The
130 MyWellness system recorded the total amount of time spent using cardiovascular and
131 strength machines (an objective measure of workout time). Median workout time for the
132 group examined was 33.5 (IQR 20-48.75) minutes. We therefore estimated gym activity
133 duration to be a conservative 30 minutes. It was not possible to measure swimming duration
134 objectively; but we applied the same 30-minute workout time, based upon estimates from
135 trust staff. The leisure trust integrated METs values, intensity classification and duration for
136 each activity at the point of data extraction.

137 2.4 *Variables*

138 Our analysis included data for all users that were 18+ years of age between 01/07/2018 and
139 30/06/2019. The final extract contained membership type (pre-paid/monthly member and

140 registered pay-as-you-go user, non-registered pay-as-you-go user), 10 year age group, sex
141 (male, female), IMD quintile and leisure centre classification (small [limited opening times,
142 e.g. only open after school hours, limited facilities e.g. with one of pool or gym or fitness
143 studio] and large [all day opening, pool, gym, fitness classes]). It also included individual
144 usage data: date, duration, intensity level and type of activity undertaken for every indoor
145 leisure centre attendance. Individual activities were grouped into 5 main activity areas (gym,
146 fitness classes, swimming, health referral and other activities).

147 We calculated the total number of attendances at light, moderate and vigorous activities, and
148 the total duration of activities in each intensity category during the data extract period. Using
149 the first and last usage dates for each user, we created a data field for the maximum number
150 of weeks usage in the 1-year data period. We defined a new measure of leisure centre based
151 LTPA based on the domain defined by Samitz, Egger and Zwaheln (2011) '*leisure time PA*
152 '*recreational activities including callisthenics, dancing, walking, hiking, golf, bicycling,*
153 '*swimming, games, exercise and sports*',¹⁷ but limited to LTPA that took place in the leisure
154 centres studied. The total weekly moderate/vigorous leisure centre-based LTPA per user was
155 calculated using:

$$\frac{\text{Total duration of moderate activities} + 2(\text{total duration of vigorous activities})}{\text{Max number of weeks' usage in 1-year data period}}$$

158 We then classified all weekly moderate/vigorous leisure centre-based LTPA user scores by
159 World Health Organisation PA category (<30 minutes/week, 30-149 minutes/week and 150+
160 minutes/week).²⁸

161 2.5 *Outcomes*

162 We examined descriptive participant characteristics for all registered users and compared
163 registered user demographics with 2018 population estimates provided by Northumberland
164 County Council intelligence team.²⁹ First, examined total usage/usage by main activity type
165 for prepaid/monthly members, registered pay-as-you-go members and non-registered pay-as-
166 you-go users. Where demographics were available, we also examined usage by gender. In the
167 absence of any data about user numbers, we assumed that non-registered pay-as-you-go
168 usage mirrored registered pay-as-you-go usage in terms of number of visits per person. We
169 therefore calculated the mean number of attendances for registered pay-as-you-go users and
170 divided the number of non-registered pay-as-you-go visits to give an estimate to number of
171 non-registered pay-as-you-go users.

172 We examined average number of attendances, average length of usage (based on the
173 maximum number of weeks usage data field), weekly moderate/vigorous leisure centre-based
174 LTPA user scores, and categories of PA. Finally, we examined associations of demographic
175 variables with PA categories achieved.

176 2.6 *Statistical analysis*

177 Descriptive analyses of baseline characteristics for registered users were performed using the
178 Pearson χ^2 test for categorical variables (summarized as frequencies/percentages) and
179 compared to adult Northumberland population estimates, 2018.²⁹ We examined data
180 distribution for total attendance, participants' maximum usage period and weekly
181 moderate/vigorous leisure centre-based LTPA scores using the Kolmogorov-Smirnov test and
182 calculated median usage periods and LTPA scores for pre-paid/monthly and registered pay-
183 as-you-go members. Ordinal regression models were utilized to evaluate the association

184 between demographic variables (sex, age groups, IMD quintiles, locations) and categorical
185 weekly leisure-centre based PA (<30 minutes/week, 30-149 minutes/week and 150+
186 minutes/week) for pre-paid/monthly members by using PA less than 30 minutes /week as the
187 reference group. Subgroup analyses were stratified by sex. We chose ordinal regression
188 models because PA categories were ranked from low to high, which is a natural ordering
189 class. The proportional odds assumption for ordinal regression models were tested and not
190 violated. Odds ratios (ORs) with 95% confidence intervals were reported. Two-sided P values
191 for all tests were calculated with $p < 0.05$ considered significant. All statistical analyses were
192 performed using R version 3.5.1 (Free Software Foundation, Boston, USA).

193 **3 Results**

194 *3.1 Registered participant characteristics*

195 In total, 20,904 registered users attended the leisure facility centres between 01/07/2018 and
196 30/06/2019, representing 8.1% of the Northumberland adult population. Registered users
197 were more likely to be female (58.7%), younger (23.9% of users were aged 18-29 years
198 compared to 10.1% of those aged 70+ years) and from the two most affluent IMD quintiles
199 (53.7%) (Table 1).

200 **INSERT** Table 1

201 *3.2 Attendance and type of activity choices*

202 Users attended 1,085,037 activity sessions in the data period, with the most popular types
203 being the gym (n=387,133, 35.7% of activities) and fitness classes (n=367,812, 33.9% of
204 activities). The number of activities undertaken is not an indicator of the number of visits, as
205 some users took part in multiple activities during visits, (e.g. used the gym and then went
206 swimming). The majority of usage was by pre-paid/monthly members (75.8%) (Table 2).

207 **INSERT** Table 2

208 Overall, 24.2% of usage was on a pay-as-you-go basis. Non-registered pay-as-you-go usage
209 (those with no details registered who paid for activities at the point of attendance) was an
210 important component of this (16.9% of overall usage), being 2.3x higher than registered pay-
211 as-you-go member usage (those with details registered who paid for activities at the time of
212 booking) (7.3% of overall usage). For the non-registered group, the most popular activity was
213 swimming (n=155,065, 84.5% of activities). The mean number of attendances per registered
214 pay-as-you-go user was 10.6 (SD \pm 17.8). We presumed that non-registered pay-as-you-go
215 users attended a similar number of times to registered pay-as-you-go members. As the total
216 non-registered pay-as-you-go usage attendance of 183,440, we estimated there were 17,305
217 (183,440/10.6) non-registered pay-as-you-go participants who used the leisure centres during
218 the 1-year period, giving an estimated 38,159 adult leisure centre users (14.7% of the
219 Northumberland population).

220 *3.3 Attendance and activity choices of registered users by sex*

221 Females accounted for 57.4% of all registered usage, with the most popular female activity
222 being fitness classes (59.3% of female visits). This was consistent for both pre-paid/monthly
223 members (58.6% of female visits) and registered pay-as-you-go users (66.3% of female
224 visits). The most popular male activity was the gym (65.7% of visits). For male pre-
225 paid/monthly members, the most popular activity was the gym (69.5% of male visits), while
226 for registered pay-as-you-go users, other activities (5-a-side football, badminton, squash,
227 table tennis) were the most popular choice (36.5% of male visits) (Table 3).

228 **INSERT** Table 3

229 *3.4 Overall attendance and maximum weeks usage for registered users*

230 The median number of attendances for registered users in the 1-year data period was 20 (IQR
231 4.0-59.8) and the median number of weeks that participants used the leisure centres was 29
232 (IQR 5.0-4.9). Pre-paid/monthly members attended more often (median 41.0 attendances,
233 IQR 15.0-84.0) ($p < 0.001$), over a longer period of time (median 44.0, weeks IQR 15.0-51.0
234 weeks) (Table 4).

235 **INSERT** Table 4

236 As the median attendance and number of weeks usage for registered pay-as-you-go members
237 was so short (4.0 weeks, IQR 1.0-25.0), in the following results we present a more detailed
238 analysis for pre-paid/monthly members only.

239 *3.5 Weekly moderate/vigorous leisure centre-based LTPA for pre-paid/monthly members*

240 Median weekly moderate/vigorous leisure centre-based LTPA was 55 (IQR 30-99)
241 minutes/week for pre-paid/monthly members. This equated to approximately 1/3 of the
242 recommended 150 minutes of moderate/vigorous weekly PA. Some pre-paid/monthly
243 members ($n=1,729$, 12.9%) achieved the World Health Organisation recommended levels of
244 PA through leisure centre use alone. Females were more likely to achieve 150 minutes of
245 moderate/vigorous PA by leisure centre use than males (18.9% vs 5.8%) (Table 5).

246 **INSERT** Table 5

247 Being female, older and attending a large leisure significantly increased the odds of achieving
248 a higher category of PA (30-149 minutes and ≥ 150 minutes) compared with undertaking < 30
249 minutes of activity per week through leisure centre based activity. In the sex-stratified
250 analysis, for both sexes being older and attending a large leisure centre significantly increased
251 the odds of achieving a higher category of PA compared to undertaking < 30 minutes of PA.
252 Women living in deprived areas had increased odds of higher activity categories compared to

253 those in more affluent areas, but conversely, for men, living in a more affluent area decreased
254 had decreased odds of achieving higher physical activity categories (Table 6).

255 **INSERT Table 6**

256 **4 Discussion**

257 *4.1 Main finding of this study*

258 In this large population-based study, our results demonstrated that the provision of local
259 authority leisure centres contributed a median of 55 minutes (IQR 30-99) of
260 moderate/vigorous LTPA per week to the recommended ≥ 150 minutes of moderate/vigorous
261 PA per week. This means that local authority leisure centre members achieve approximately
262 1/3 of the World Health Organisation recommended 150 minutes of moderate/vigorous
263 weekly PA¹² through leisure centre use. This is an important contribution, which should be
264 combined with encouragement for users to be active in other environments to achieve the
265 recommended levels of PA. Importantly, our findings identified that being female, being
266 older and attending a large leisure centre significantly increased the odds of achieving a
267 higher category of physical activity (30-149 minutes and ≥ 150 minutes) compared with
268 undertaking < 30 minutes of activity per week through leisure centre based activity.

269 A positive finding of this study was that females were disproportionately more likely to
270 engage in local authority leisure centre activity, reflecting UK public sector insight³⁰ and
271 potentially addressing previously observed sex-based PA inequalities.³¹ This is particularly
272 important since 43% of activity inequality, as identified in a study of mobile telephone step
273 data from 111 countries, was explained by sex.³² Local authority leisure centres are therefore
274 a potentially important intervention to encourage LTPA for women. From the activity data in
275 our study, it is clear that female users preferred to take part in predominantly non-

276 competitive, group-based fitness activities (58.6% of all female member activity). Much
277 research and policy has focused on understanding sex-based inequity in sport and
278 encouraging female sports participation.³³ However, studies indicate that making physical
279 education more enjoyable by increasing choice and offering a wide range of non-competitive
280 activities leads to successful interventions to increase PA in girls.³⁴ Our results indicate that
281 the availability of group fitness classes, which tend to be non-competitive and emphasise the
282 fun element of PA, may be the reason why leisure centre-based LTPA appeals to women.
283 Qualitative research is required to gain insight into female activity preferences in a leisure
284 centre environment in order to develop more suitable activity options. In particular, studies
285 are required to understand why the gym environment lacks appeal to many women and
286 whether it is possible to address low-usage.

287 We identified that 8.1% of the Northumberland population were registered users of the local
288 authority leisure centres and 65% of these (5.2% of Northumberland population) were
289 prepaid/monthly members. We estimated that 14.7% of the adult Northumberland population
290 accessed Northumberland local authority leisure centres in the year studied. The 2019 State
291 of the U.K. Fitness Industry Report revealed that 15.6% of the U.K. adult population are now
292 members of a gym.¹⁹ In Northumberland, the 5.2% level of pre-paid/monthly memberships is
293 similar to the U.K. national average of 5.1% with a membership at a publically owned
294 facility. Unlike many other areas of the U.K., however, Northumberland has no multisite
295 private fitness provider within the county. Nationally, small independent fitness facility
296 operators account for only 20% of fitness memberships (3.1% of the U.K. population),¹⁹
297 indicating that even if independent operators have expanded to fill some of the market
298 occupied elsewhere by large gym chains, there is likely to be latent demand for fitness usage
299 in Northumberland. The ability to ‘pay-as-you-go’ appears to be an important element of

300 local authority leisure provision in the county, accounting for 24.2% of use. This is one of the
301 benefits of public sector provision, but better understanding of these users is required.

302 Registered pay-as-you-go members had a much shorter median usage period (4 weeks [IQR
303 1.0-25.0]), making them a group to target for maintained engagement. There was also a large
304 group of users where data are lacking (non-registered pay-as-you-go users). This group
305 accounts for 16.9% of usage, but we were only able to estimate number of users and had no
306 information about demographics. Due to a lack of comparable studies, we are unable to
307 comment on whether this issue is specific to Northumberland. We encourage other providers
308 to examine these data. Encouraging or incentivising this group to register details would
309 increase understanding.

310 Our analysis indicated that, compared with the Northumberland population those who were
311 older were less likely to use the local authority leisure centres, but where they did engage
312 they were more likely to achieve the recommended PA levels¹² through leisure centre use
313 than younger people. This highlights the potential for local authority leisure centres to
314 increase PA for older populations if they can be encouraged to engage. Since
315 Northumberland population projections indicate that 31% of residents will be over 65 by
316 2031,³⁵ provision must be made appealing and accessible to those who are older. It is unclear
317 why a large proportion of the older population in Northumberland do not currently access the
318 local authority leisure centres, but it is possible that older people do not consider the facilities
319 to be easily accessible, activities to be appropriate, or attended by others of a similar age, all
320 factors rated as important among older adults.³⁶ Furthermore, a primary factor in encouraging
321 older people to take part in PA is identified as being motivated by the social environment,³⁷
322 indicating that the social aspect of activities is likely to be an important element in future
323 provision for older people. Finally, a previous evaluation of the exercise referral scheme in

324 Northumberland reported that this intervention was more successful in those aged over 55
325 years,³⁸ suggesting that building on this type of programme may lead to increased access for
326 those who are older.

327 We also reported that those from more deprived areas were less likely to access the local
328 authority leisure centres. As those living in more deprived areas have potentially less
329 disposable income, it is possible that price is a contributing barrier to access but we were
330 unable to examine the effect of concession pricing, as in the period covered by the data
331 extract the trust made changes to their concessionary access scheme. This was further
332 complicated by the way that memberships were tagged in the FDS, with the term
333 concessionary applied to any discounted membership, rather than just to those on low
334 incomes or who were registered disabled. Pricing in the local authority leisure sector to
335 encourage use by targeted groups is complex. Quantitative studies have reported that offering
336 free memberships can increase participation,^{20 21 39 40} but that if free use is removed, then
337 usage is not always maintained.³⁹ Of interest, in the current study, the majority of exercise
338 referral usage was on a pay-as-you go basis. Given that those who took out prepaid/monthly
339 memberships used the centres for a much longer period, the leisure trust should explore how
340 to encourage a move from pay-as-you-go to pre-paid/monthly membership for this group as it
341 may have the potential to improve retention. A caveat for this must be that pricing strategies
342 do not exclude those in who are in the lowest income brackets. Qualitative evidence indicates
343 that navigating the competing pressures of providing services for public 'good' and
344 remaining commercially viable makes pricing decisions difficult, and that pricing is only one
345 barrier for accessing facilities.⁴¹ While recognising the complexities, in the case of this
346 leisure trust ensuring that concession pricing is clearly defined and accurately tagged within
347 the FDS would enable future examination of the effect of pricing strategies.

348 4.2 *Strengths and weakness of this study*

349 The strength of this study is the novel analysis that used individual level data of attendance at
350 local authority leisure centres over a one-year period and combined it with intensity levels of
351 activities attended, to create a new measure of weekly leisure centre-based LTPA. This
352 provides a more robust analysis than self-reported surveys as it can be done at large scale,
353 and does not involve participant recall, thereby eliminating inaccurate memory, social
354 desirability and direct prompting by questionnaires.⁴² The measure is still subject to some
355 estimation of actual LTPA achieved and does not account for weeks where holiday or illness
356 are the reason for non-attendance. We are unaware of any previously published research that
357 has attempted to quantify leisure centre-based activity in this way. FDS providers could
358 integrate the method presented in this paper into the setup of FDSs and their associated
359 reporting systems to allow for regular reporting of these type of data.

360 Measuring attendance using FDS data may be subject to error. Users may not swipe their
361 membership card to record an activity when entering a facility. Additionally, they may
362 choose to do another activity while onsite without booking, may leave an activity early or
363 may book online and then decide not to attend the activity. Due to limitations on numbers in
364 fitness classes, these are the most likely to be pre-booked and therefore most prone to error
365 using our methodology. This trust had identified an issue with non-attendance at fitness
366 classes after booking, but staff mitigated this to an extent by checking attendance due
367 problems with waiting lists for sessions. Participant who booked 3 sessions and did not attend
368 had booking privileges removed for 2 weeks. This will have reduced, but not eliminated
369 potential problems with non-attendance.

370 4.3 *Implications of this study*

371 Leisure centre provision in Northumberland accounted for pre-paid/monthly members
372 achieving 55 of the recommended 150 minutes of moderate/vigorous weekly PA for a median
373 of 44 weeks per year. This is a valuable contribution, but leisure providers could also work
374 with public health teams to develop and promote positive messages about PA outside leisure
375 centre visits to ensure that users achieve sufficient PA to benefit health. Since the median
376 period of usage for registered pay-as-you-go members was only 4 weeks, these users need
377 targeting within a few weeks of their first usage with long-term membership offers that are
378 accessible to all. Investment in attracting and retaining users from groups known to have the
379 greatest PA inequalities (women, older people and those more deprived areas) can be an
380 important population health approach.

381 Further qualitative research should attempt to understand what explains these findings, and
382 how this information could be used to deliver more accessible and effective leisure centre
383 provision. Given that this study examines data from only one area of England, future studies
384 are required to understand if findings same or different globally.

385 **5 Conclusion**

386 Using this novel measure of local authority leisure centre attendance, we demonstrated that
387 usage contributed a median of 55 minutes (IQR 30-99) of moderate/vigorous LTPA per week
388 to the recommended ≥ 150 minutes of moderate/vigorous PA per week and that older adults
389 and female participants were more likely to achieve the recommended PA levels. FDS
390 providers could integrate the method into systems to provide industry-wide data, which
391 would lead to an understanding of how publically and privately owned fitness facilities
392 contribute to addressing physical activity inequalities.

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Table 1: Registered user characteristics compared to the Northumberland adult population between July 2018 and June 2019.

Characteristic	All registered users (n=20,904)		Pre-paid/monthly Members (n=13,407)		Registered pay-as-you-go members (n=7,497)		Adult Northumberland Population 2018 (n=259,631)	
	n	(%)	n	(%)	n	(%)	n	(%)
Sex**								
Male	8,662	(41.3)	6,143	(45.8)	2,519	(33.6)	125,375	(48.1)
Female	12,237	(58.7)	7,263	(54.2)	4,974	(66.3)	135,018	(51.9)
Age group**								
18-29	4,986	(23.9)	3,180	(23.7)	1,806	(42.1)	36,942	(14.2)
30-39	3,530	(16.9)	2,138	(15.9)	1,392	(18.6)	34,706	(13.4)
40-49	3,591	(17.2)	2,264	(16.9)	1,327	(17.7)	38,399	(14.8)
50-59	3,619	(17.3)	2,448	(18.3)	1,171	(15.6)	50,055	(19.3)
60-69	3,067	(14.7)	2,084	(15.5)	983	(13.1)	46,029	(17.7)
70+	2,111	(10.1)	1,293	(9.6)	818	(10.9)	53,500	(20.6)
IMD quintile* (2015)								
IMD 1	2,738	(13.0)	1,754	(13.1)	984	(13.1)	42,083	(16.2)
IMD 2	3,580	(17.2)	2,216	(16.5)	1,364	(18.2)	49,952	(19.2)
IMD 3	2,713	(13.2)	1,775	(13.2)	938	(12.5)	66,080	(25.5)
IMD 4	5,367	(26.2)	3,519	(26.2)	1,848	(24.6)	47,980	(18.5)
IMD 5	5,663	(27.5)	3,692	(27.5)	1,971	(26.3)	54,009	(20.8)
Not Stated	843	(4.0)	451	(3.4)	392	(5.2)		
Leisure centre classification^***								
Small	1,225	(5.9)	703	(5.2)	522	(7.0)		
Large	19,654	(94.0)	12,704	(94.8)	6,950	(92.7)		
Not stated	25	(0.1)			25	(0.3)		

[^]*Leisure centre classification: small (limited opening times, limited facilities e.g. with one of pool or gym or fitness studio) large (all day opening, pool, gym, fitness classes), *p<0.05, **p<0.001*

Table 2: All users' attendance and activity choices.

Type of activity	Attendances(times)	% of usage
All users (n= not known)		
Gym	387,133	35.7
Fitness classes	367,812	33.9
Swimming	268,210	24.7
Health referral	33,376	3.1
Other**	28,506	2.6
Total Usage	1,085,037	
Pre-paid/monthly Members (n=13,407)		
Gym	367,843	44.7
Fitness classes	322,601	39.2
Swimming	106,724	13.0
Health referral	21,031	2.6
Other**	4,319	0.5
Total Usage	822,518	
Registered pay-as-you-go members (n=7,497)		
Gym	9,157	11.6
Fitness classes	38,117	48.2
Swimming	6,421	8.1
Health referral	11,315	14.3
Other**	14,069	17.8
Total Usage	79,079	
Non-registered pay-as-you-go users (n=not known)		
Gym	10,133	5.5
Fitness classes	7,094	3.9
Swimming	155,065	84.5
Health referral	1,030	0.6
Other**	10,118	5.5
Total Usage	183,440	

**Other: 5-a-side football, badminton, squash, table tennis*

Table 3: Sex stratified analysis of usage and activity choice for registered users

Type of activities	Female		Male	
	Attendances	% of usage	Attendances	% of usage
Overall	(n=12,237)		(n=8662)	
Gym	125,170	24.2	251,829	65.7
Fitness Classes	307,145	59.3	53,524	13.9
Swimming	62,250	12	50,895	13.3
Health Referral	18,880	3.6	13,466	3.5
Other*	4,654	0.9	13,722	3.6
Total Usage	518,099		383,436	
Pre-paid/monthly members	(n=7623)		(n=6143)	
Gym	121,838	26	246,004	69.5
Fitness Classes	274,537	58.6	48,015	13.5
Swimming	58,520	12.5	48,204	13.6
Health Referral	12,492	2.6	8,539	2.4
Other*	1,501	0.3	2,818	1
Total Usage	468,888		353,580	
Registered pay-as-you-go users	(n=4,974)		(n=2,519)	
Gym	3,332	6.8	5,825	19.5
Fitness Classes	32,608	66.3	5,509	18.5
Swimming	3,730	7.5	2,691	9
Health Referral	6,388	13	4,927	16.5
Other*	3,153	6.4	10,904	36.5
Total Usage	49,211		29,856	

*Other: 5-a-side football, badminton, squash, table tennis

Table 4: Overall attendance and maximum weeks usage for registered members

	All registered users (n=20,904)		Pre-paid/monthly Members (n=13,407)		Registered pay-as-you-go members (n=7,497)	
	Median	IQR	Median	IQR	Median	IQR
No. of attendances	20.0	4.0-59.8	41.0	15.0-84.0	3.0	1.0-12.0
Maximum weeks usage	29.0	5.0-49.0	44.0	15.0-51.0	4.0	1.0-25.0

Table 5: Level of weekly PA by category for pre-paid/monthly members

Activity Category	All members (n=13407)		Females (n=7263)		Males (n=6143)	
	n	%	n	%	n	%
Less than 30 minutes per week	3288	24.5	1471	20.3	1817	29.6
30 - 149 minutes per week	8390	62.6	4422	60.9	3967	64.6
150+ minutes per week	1729	12.9	1370	18.9	359	5.8

Table 6: Ordinal regression modelling for categorical weekly leisure centre-based PA for pre-paid/monthly members (n=13,407) between 01/07/2018 and 30/06/2019.

	All pre-paid/monthly members (n=13,407)	Female pre- paid/monthly members (n=7623)	Male pre- paid/monthly members (n=6143)
	OR (95% CI)	OR (95% CI)	OR (95% CI)
Sex	2.09 (1.95-2.35)**		
Age group	1.14 (1.11-1.16)**	1.13 (1.10-1.17)**	1.14 (1.06-1.18)**
IMD quintile	0.98 (0.96-1.00)	1.03 (1.00-1.06)*	0.91 (0.87-0.94)**
Leisure centre category	1.21 (1.03-1.42)*	1.37 (1.10-1.71)**	0.99 (0.79-1.24)

Age group: young age as reference; *IMD:* most deprived quintile as reference; *Leisure centre category:* small leisure centre as reference group; *Sex:* male as the reference *<0.05 **<0.000