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Domains and levels of physical activity are linked to adult mental health and wellbeing in deprived neighbourhoods: a cross-sectional study

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Abstract

Although relationships between participating in physical activity and positive mental health and wellbeing are well established, little is known about the relative contributions of the different domains of physical activity (PA) —household, occupational, active travel, leisure and sport, family activities— to total PA and, in turn, to mental health and wellbeing. This is particularly important for deprived communities where PA is low and mental health and wellbeing poor.

Using multivariate multilevel regression of cross-sectional survey data collected in 2011, we examined self-reported PA levels and the domains and diversity of sources of PA among 2,654 residents of 32 deprived neighbourhoods in Glasgow, UK. and their associations with measures of mental health, positive mental wellbeing, and physical and general health.

Household chores and active travel were the most commonly cited PAs. People achieving PA from family activities, and those doing more diverse PAs, had better mental wellbeing. Active travel was associated with better mental wellbeing and mental health among the highly and moderately physically active, respectively. Highly active people who engaged in leisure-based PA had better mental health. Long-standing illness was associated with worse health scores, although mental wellbeing was ameliorated amongst those who did domestic or occupational PA.

It is important to encourage greater diversity of PA in disadvantaged areas, including leisure and family activities and active travel for those out of work with low PA. Nevertheless, interventions aimed at managing long-term health conditions and providing employment may be of even greater importance.

Keywords: active travel, work, domestic chores, sport, poor communities

1. Introduction

The potential benefits of physical activity (PA) not only for alleviating and preventing poor mental health (Mammen and Faulkner, 2013), but also for encouraging positive mental wellbeing (Cerin, Leslie, Sugiyama, & Owen, 2009) are well established[1]. The PA targets recommended by health organisations and governments since the 1970s (Blair, LaMonte & Nichaman, 2004) for improving and maintaining physical and mental health, are underpinned by a concern for reaching or exceeding a total level of energy expenditure from doing PA. Although it is recognised that this involves activities done in various contexts and combinations of intensity, duration and frequency, public health messages focus more on total activity levels (e.g., Scottish Government, 2013) than on the activities by which they are achieved. Four domains of activity are customarily distinguished in the literature: household; occupational; active travel/transport; leisure-time (including sport). These domains may make distinct contributions to overall PA but relatively little is known about their differential contributions to mental health and positive mental wellbeing, although there is reason to expect that not all domains of PA will be positive for mental health and wellbeing. We review current evidence of the varied links between PA domains and mental health and wellbeing (and, to a lesser extent, physical health), and gaps in our knowledge.

Doing household PA has been associated with poorer mental health and wellbeing in some groups of women (Cerin, Leslie, Sugiyama, & Owen, 2009; Asztalos et al., 2009), but doing 'a lot' of domestic PA has been identified as the activity most strongly associated with self-reported happiness (assessed from a single question from the SF-36 Health Survey questionnaire) across all PA domains (Richards et al., 2015). Doing housework has been

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[1] In this paper, we use the term 'mental health' to mean primarily the absence of mental ill-health and psychological problems. Positive mental wellbeing is understood as being a latent characteristic comprising hedonic (experiencing positive affect) and eudaimonic (living well and fulfilling potential) components of experience. The term 'mental health and wellbeing' is used throughout to refer collectively to 'mental health' and 'positive mental wellbeing'.

linked to a lower risk of psychological distress (assessed using the GHQ-12) (Hamer et al., 2008), and to lower psychological stress, estimated from the GHQ-12 and SCL-90-R, among young adults with non-manual jobs (Asztalos et al., 2009).

The few known associations of occupational PA with mental health and wellbeing portray a mixed picture. One study noted a positive association with depression in Australian women, measured with the Composite International Diagnostic Interview (McKercher et al., 2009), while another used the Psychological Well-being Index Short Form to demonstrate poorer mental wellbeing among adult men who performed vigorous occupational PA (Kim et al., 2008). Still others have found no relationship (e.g., Harvey et al., 2010, using the Hospital Anxiety and Depression Scale). Similarly, links between occupational PA and physical health may be positive (Hu et al., 2007), detrimental (Krause et al., 2015) or non-existent (Sisson et al., 2009).

Active travel (typically, walking or cycling to work or school) also has mixed associations with mental health and wellbeing. Hansson et al. (2011) found better sleep quality, lower stress and greater vitality (SF-36 Vitality scale) in active commuters compared with car commuters. Conversely, Asztalos et al. (2009) noted that male blue-collar employees who commuted by bicycle felt more stressed than those who did not actively travel. Cerin, Leslie, Sugiyama, and Owen (2009) found no association between transport PA and mental wellbeing measured with the SF-12 MCS-12, except among the obese. Positive associations between active travel and physical health have been more consistently demonstrated (e.g., Bassett et al., 2008; Lubans et al., 2011; Shephard, 2008), although too much active commuting may reverse such benefits (Hu et al., 2002).

Leisure-time PA (including sports) is the most widely studied domain, and has been shown to alleviate depression (assessed with the Center for Epidemiological Studies Depression Scale; Chen et al., 2012) and to be associated with being happy more often (Richards et al., 2015). We have identified no examples in the literature of leisure-time PA

being detrimental to mental health and wellbeing. Its benefits to physical health are even more firmly established (e.g., pancreatic cancer, Farris et al., 2015; long-term sickness absence, Holtermann et al., 2012), negative associations between physical health and leisure-time PA being rarely reported (e.g., coronary heart disease, Clays et al., 2013).

It is also plausible that engaging in a more diverse range of activities is associated with higher rates of overall PA and subsequently mental health and wellbeing. We know little about whether the diversity of PAs *per se* is associated with achieving higher total levels of PA; a study of British 10-year-olds by Brooke et al. (2013), is an exception in showing that children achieving at least the recommended levels of PA engaged in a wider variety of activities than those who did not. To the best of our knowledge, no studies have sought links between the diversity of PA (e.g., as might be indicated by the number of PA domains from which people gain their PA) and its possible health consequences, although Curl et al (2016) established that older adults engaged in a greater number of outdoor activities reported higher levels of life satisfaction.

Overall, levels of PA tend to be lower in deprived areas. In Scotland as a whole, in the sample considered here, 40% of people in the most deprived quintile of neighbourhoods claimed to do low levels of PA, compared with 27% of those from neighbourhoods in the least deprived quintile (Scottish Government, 2012). In the study reported here, 47% respondents reported doing little or no PA. Likewise, area deprivation has often, if not always, been associated with poorer mental health (Fone et al., 2007; Stevenson et al., 2009) as well as poorer physical health (Marmot and Bell, 2012). Certainly, relatively low levels of mental wellbeing and poor physical health are associated with greater area deprivation in Scotland overall (Wilson et al., 2015, p.33-34) and in the areas studied here (GoWell, 2010).

Research has identified many of the residential, neighbourhood and community characteristics that influence people's propensity to undertake PA (e.g., Bauman et al., 2012), including in deprived urban areas (Ogilvie et al., 2008), where levels of PA or participation in

health-promoting PAs (Kavanagh et al., 2005; Rind and Jones, 2011) are often particularly low. We have previously investigated aspects of PA in a large sample of deprived neighbourhood residents in Glasgow (Scotland, UK) as part of a broader study of the effects of residential and neighbourhood change and regeneration on health and wellbeing (Mason & Kearns, 2013; Mason, Kearns, & Bond, 2011; Mason, Kearns, & Livingstone, 2013). However, this has rarely been considered alongside the types of PA people do, and whether these distinct domains of PA can have different consequences for mental health and wellbeing. However, Shortt et al (2014) found that walking for recreation was more common in less deprived areas and walking for transport more common in more deprived areas and postulate that non-recreational walking may not have the same health effects. Furthermore active travel may be greater among more deprived populations (Goodman, 2014). Thus, it is important to establish whether these more functional forms of PA have positive health and wellbeing outcomes, given their prevalence among deprived populations who may benefit from the health effects of increased PA.

The mental health of residents in deprived areas tends to be worse than those of less deprived neighbourhoods. For example, in Scotland in 2011-2012 there were more than twice as many mental health inpatients in hospitals, and more than three times as many such patients discharged who were from the most, compared with the least deprived quintile of areas (ISD, 2015; p.20). Likewise, measures of positive mental wellbeing (WEMWBS, GCH-12 and life satisfaction) were significantly worse among people from the most deprived 15% areas of Scotland compared with the rest of the country in 2010 (Scottish Government, 2011). In addition, many aspects of physical and general health tend to be worse in these deprived areas (Scottish Government, 2015).Since the greatest need for PA interventions for health is among the least active, we may seek to understand what activities comprise the PA of those who are currently relatively inactive, and compare these with equivalent behaviours of the more active portion of the population.

Other characteristics of the people in our sample, such as the disproportionately large numbers of those without work, with long-term health conditions or with few educational qualifications are all associated with worse mental health and wellbeing (Wilson, Kellock, Adams, & Landsberg, 2015). Therefore, it is reasonable to surmise that there may be considerable scope to improve the mental and physical health of residents of these types of neighbourhoods through interventions that enable them to do more PA.

Through analyses of cross-sectional data from a study of urban regeneration and health in deprived communities, we set out to address three research questions (RQs):

1) How do levels and domains of PA differ between population groups?
2) Are people's levels of PA related to the types and diversity of the PAs they undertake?
3) How are PA domains and their overall diversity associated with mental health and wellbeing (and physical and general health) in deprived neighbourhoods?

2. Methods

2.1. Study context

Our study was conducted in Glasgow as part of the GoWell Research and Learning Programme, which is investigating the consequences of major residential, neighbourhood and community regeneration. We examined data from the third wave of a survey of 4,059 residents (householder or partner), aged 18 years or more, from 32 of the city's most deprived neighbourhoods, who were interviewed at home in spring/summer 2011. The survey achieved a 45.4% response rate. The majority were British citizens, but substantial numbers of asylum-seekers, refugees, European migrant workers and students were also interviewed. The questionnaire sought information about personal and residential circumstances, health and recent physical activity, amongst other items. Ethical approval was granted by the NHS Scotland B MREC committee (no. 05/MRE10/89).

2.2. Physical activity measures

The total amount of PA done was measured by the Short, 7-day International Physical Activity Questionnaire (IPAQ), which measures vigorous and moderate PA and walking done in the previous 7 days, from which estimates of MET-minutes per week enable respondents to be classified into low, moderate or high PA groups (Patterson, 2010).[2] Studies of the validity of the IPAQ-SF have taken place either in general populations or in sub-groups of particular ethnicity or with specific health conditions. A review of these studies has concluded that the IPAQ-SF overestimates the amount of physical activity compared with an objective measure. However, neither the target population nor the place of study affected the validity (Lee, Macfarlane, Lam, & Stewart, 2011).

The relative contribution of different activities to people's PA was captured by asking respondents to rank five PA domains "*in order of how much* [they] *did them*" in the previous seven days: 1) PA as part of household chores, including housework, shopping, etc.; 2) PA as part of a job; 3) active travelling (e.g., walking, cycling, etc.); 4) sport, gym, or active leisure pursuits; 5) family activities involving some physical exercise (e.g., a family bike ride or walk, swimming, or a kick-around in the park). For simplicity, ranks were recoded to values of 1 (done least) to 5 (done most), with unranked domains (those not mentioned by respondents) being scored as 0 (not done at all). It should be noted that family activities would be considered as leisure-time activities in the customary four-category classification of PA domains. However, we believe there may be an important distinction because of the social

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[2] The total METs are calculated as the sum of the products of the intensity, daily duration and number of days per week doing each of the three activities. The energy required (intensity) for each activity is set at 8 and 4 METs for vigorous and moderate PA, respectively, and 3.3 METs for walking. Roughly speaking, after limiting outlier values, the continuous measures are converted to PA level categories: High PA, > 3000 MET mins/wk (from a combination of all three activity types) or > 1500 MET mins/wk (derived entirely from vigorous PA); Moderate PA, 600-3000 MET mins/wk; Low PA, < 600 MET mins/wk. Broadly speaking,, those in the moderate or high PA group may be considered to achieve the recommended amounts of PA.

engagement offered by family activities which might enhance the mental health and wellbeing potential of these activities.

2.3. Health and wellbeing measures

Two mental health and wellbeing outcome measures were examined. Positive mental wellbeing was assessed with the Warwick-Edinburgh Mental Wellbeing Scale (WEMWBS) (Tennant et al., 2007). Scores are derived from five-point frequency-scale responses (never; rarely; some of the time; often; all of the time) to 14 statements about subjective happiness (e.g., 'I've been feeling optimistic about the future', 'I've been feeling cheerful') and effective psychological functioning (e.g., 'I've been dealing with problems well', 'I've been able to make my own mind up about things') over the previous two weeks. Responses are summed to give scores potentially ranging between 14 and 70 (poorest and best mental wellbeing, respectively).

Mental health was measured with the Mental Health Composite Score (MCS-12) of the SF-12v2 Health Survey (Ware, Kosinski, Turner-Bowker, & Gandek, 2002), which may take any value between 0 (worst health) and 100 (best health). These are derived from normalised weighted aggregate values from ordered categorical responses to 12 questions covering eight health domains: role emotional, vitality, mental health, and social functioning; general health, physical functioning, role physical, and bodily pain. The first four aspects are more heavily weighted than the latter four.

We compared the results of our analyses of mental health and wellbeing outcomes with those for physical and general health, using the SF-12v2 Physical Health Composite Score (PCS-12), derived from the scores for the same eight health domains (but with the latter four domains more heavily than the first four), and responses to its general health question (*In general, would you say your health is…?*), dichotomised as poor or fair *vs.* good, very good or excellent.

2.4. Sociodemographic and personal characteristics

We controlled for several sociodemographic and personal characteristics that are customarily considered in studies of this nature, and which have frequently proved to have significant associations in other analyses in the GoWell programme: gender (male; female); age group (16-24; 25-39; 40-54; 55-64; 65+ years); employment status (working; not working but of working age; retired); ethnicity (white British/Irish; not white British/Irish); presence of a long-standing illness or health condition (LSI) (no; yes); regular access to a car or vehicle (no; yes); housing tenure (social-rented; owned or private-rented).

2.5. Statistical analysis

Except for basic variable summaries, all analyses involved multilevel regression, to take account of any clustering of responses within neighbourhoods (level 1 = respondents; level 2 = neighbourhoods). Models were developed using MLwiN v2.3 (Centre for Multilevel Modelling, Bristol, UK).

To address RQ1, sample characteristics were summarised as percentages of variable categories. Differences between PA levels for the categories of each variable were assessed from the Wald statistics associated with the parameter estimates of multilevel multinomial logistic regression models.

To determine the distribution of types of PA undertaken (RQ2), we derived two-level models of the mean rank contribution of each PA domain with respect to PA level. The significance of group differences was calculated from the Wald statistics. The association between the number of PA domains cited and respondents' PA levels was similarly assessed.

For RQ3, the associations of PA domains with each health outcome were determined by two-level multivariate binomial logistic regression ('all-domain' models), wherein the relevant explanatory variable indicates whether the respondent did any PA at all from a particular domain (rather than its ranked contribution to overall PA). We present a set of

parsimonious models derived by backward selection from an initial model containing the main effects (the five PA domains; PA level; personal characteristics) and the interactions of PA domains with PA level and with LSI. WEMWBS, MCS-12 and PCS-12 scores were considered as continuous, quasi-normally distributed variables; the general health measure was modelled by logistic regression.

Another set of multilevel models, which considered the number of domains from which PA was undertaken (instead of the five domains as separate variables) was developed to address the association of diversity of PA with each health measure ('domain-diversity' models).

3. Results

3.1. Sample characteristics

Analyses were based on the 2,654 of the 4,059 participants (65.4%), having excluded 338 participants without complete data for all variables considered. With regard to the health outcome measures, missing responses meant that scores for WEMWBS, SF-12 MCS and PCS, and the SF-12 general health measure were unavailable for 4.3%, 3.6% and 0.3% of the 4059 participants, respectively. In respect of the physical activity measures, we excluded 1067 participants (26.3%) who reported doing some PA but not from any of the suggested PA domains, or doing a zero level of PA but doing PA from one or more domain. The analytical sample therefore has a systematic bias towards including the more physically active. The demographic composition and personal characteristics of the sample are summarised in Table 1.

[Table 1]

3.2. Distribution of levels and domains of PA

With respect to RQ1, Table 1 also illustrates residents' PA levels. Low levels of PA were widespread, with almost half the respondents regarding themselves, in effect, as doing

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less PA weekly than recommended in 2011[3]. Due to the preferential exclusion of low-PA respondents in deriving the analysable sample this figure was less than the level of 61% for Scotland in that year (Scottish Government, 2012). The percentages of people doing little PA ranged from 36.1 to 61.1% across the categories of sociodemographic and personal characteristics. Physical inactivity was particularly prevalent among those aged 55+ years and retired people, and those with an LSI. Having a job was the characteristic most often linked to doing high levels of PA (27.4% of those in work) and least associated with low levels of PA (36.4%). Not having access to a car was also relatively often associated with a high level of PA (20.2% of those without a car).

Table 2 summarises the percentages of respondents doing at least some PA from each domain, overall and with respect to their personal characteristics. Overall, doing household chores was the most common PA domain, contributing to the total PA of 91.6% of respondents, followed by active travel (42.4%). Fewer respondents obtained any of their PA from family activities (21.2%). Only 20.3% of all participants did PA as part of a job, but 62.3% of those in work were physically active in their job. Active leisure and sport was the least frequently cited source of PA (14.7% of participants).

[Table 2]

Men were more likely than women to do PA associated with a job, active travel and leisure, but less likely to do PA through chores. Occupational PA was most common amongst 25-54-year-olds. Leisure- and family activity-based PA became rarer with age. Working respondents were more likely than those without work or, even more so, the retired, to do leisure and family-based PA (and, of course, occupational PA), but less likely to obtain any of their PA from domestic chores. White British/Irish respondents were less likely than those of other ethnicities to get their PA from chores. Those who had access to a car were more likely

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[3] These recommendations were those current for Scotland between 2008 and 2011.

to do occupational, leisure and family activity-based PAs, but less likely to be physically active doing chores or through active travel. Social renters were more likely than those living in private-sector homes to do PAs involving chores, but less likely to do PA as part of a job or through leisure activities. Finally, respondents with an LSI had a markedly lower likelihood of doing PA as part of a job, through active travel, or from leisure and family activities than those with no such health condition, although the two groups were equally likely to do chore-based PA.

3.3. Ranking of PA domains by PA level

RQ2 is addressed in Table 3 and Figure 1, which summarise the PA domain rankings (higher values indicate a greater relative contribution to total PA), overall and by level of PA achieved. These values highlight the prevalence of household chores (mean rank = 4.2) and active travel (1.7), confirming them as the two most common PA domains, while those of the other three domains (mean rank d 0.9) corroborate their less frequent contribution to total PA.

[Figure 1] & [Table 3]

Multilevel modelling revealed that achieving higher levels of PA was generally associated with higher rank scores for occupational, active travel, leisure and family activity-based PA ($p < 0.017$) (Table 3). However, the contribution of active travel among those who achieved a high level of PA was less than for those attaining a moderate level, and there was no difference between the moderate and high PA groups with respect to the rank of family activities. Strikingly, however, a converse relationship was seen with the rank scores for household chore PA, whereby its importance lessened across successively more physically active groups ($p < 0.001$).

Higher levels of PA were associated with doing more diverse activities (Table 3), whereby participants in the moderate and high PA groups did, respectively, 1.3 and 1.4 times as many types of PA on average as those in the low PA group ($p < 0.001$).

There was a small but significant degree of clustering of responses within neighbourhoods. The variance partition coefficients indicated that 2.0% to 8.5% of the total variation in the PA domain rankings was due to differences between neighbourhoods.

3.4. Health outcomes, PA levels and PA domains

In the overall sample, the mean WEMWBS score was 52.0, with individual values across the whole range (from 14 to 70), which is higher than the mean score of 49.9 for the whole of Scotland in 2011 (Scottish Government, 2012). The mean MCS-12 and PCS-12 scores were respectively 50.1 (range 0.0-74.2) and 48.5 (range 5.9-75.2). 72.1% of the respondents claimed to be in good-excellent general health, somewhat lower than the Scotland-wide figure of 76% for 2011 (Scottish Government, 2012).

To address RQ3, the patterns of variation of these health outcome measures were examined in two sets of multivariate multilevel models (Tables 4 and 5).

The all-domain multivariate regression models show the differences between respondents who undertook PA from a particular domain (irrespective of its relative contribution to total PA) and those who did not do so. The estimates for the models of the main effects and the PA domain x PA level interactions are presented in Table 4, which also includes the parameter estimates of significant personal characteristics, most notably the presence of an LSI, which consistently showed very strong associations, and its interactions with the PA domains. The corresponding domain-diversity model parameter estimates of the number of PA types done, PA levels and presence of an LSI, and the corresponding interactions (but, for brevity, not those of the sociodemographic and personal variables) are presented in Table 5.

Although a link between successively higher levels of PA and better mental health and wellbeing was observed in exploratory bivariate multilevel models of these data (results not shown), no independently significant associations were found for either index (WEMWBS and MCS-12) in the all-domain models once all other significant terms had been

fitted (Table 4). However, the physical health scores (PCS-12) were at least 2.1 points higher on average, and the odds of citing good-excellent general health were significantly higher (OR e 1.5) amongst the more physically active groups. In the domain-diversity models, doing more PA was associated with better scores on all four health measures (Table 5).

[Table 4]

3.4.1. WEMWBS

Five types of PA were associated with higher mental wellbeing (Table 4). Active leisure and family activities were both associated with a e 1.5-point higher WEMWBS score, irrespective of the level of PA achieved. The association of better mental wellbeing with doing PA through active travel was only apparent among those doing high levels of PA, who had a 2.7 point higher score than the least active group. However, doing higher levels of PA was not significantly associated overall with better mental wellbeing. Participants with an LSI had a 9.6-point lower WEMWBS score on average than those without, but this was ameliorated in those who undertook PA in the course of doing domestic chores or as part of their job (by 4.2 and 2.8 points, respectively).

In the domain-diversity model, for every extra type of PA done, there was an average 0.8-point increase in the WEMWBS score for all participants, with an additional boost for the high-PA group, implying that greater PA diversity is associated with better mental wellbeing. Likewise the lower scores of participants with an LSI was somewhat offset by the increasing diversity of PA done (1.3 points per extra domain) (Table 5). Higher levels of PA were independently associated with better mental wellbeing.

3.4.2. MCS-12

Only two domains of PA showed significant associations with the MCS-12 mental health measure (Table 4). Although there were no overall associations, PA through active travel and leisure were linked to 2.5- and 3.2-point higher MCS-12 scores in the moderately

and highly physically active groups, respectively. As with the mental wellbeing score, doing higher levels of PA showed no significant association overall with better mental health.

In the corresponding domain-diversity model (Table 5), each additional domain from which PA was done was associated with average 1.0- and 1.3-point increases in MCS-12 score in the moderately and highly physically active groups, respectively. The model indicated that higher levels of PA were associated with better mental health.

3.4.3. PCS-12 and general health

Better physical health (PCS-12 score) was not directly associated with doing PA from any of the domains, regardless of the amount of PA participants achieved (Table 4). However, the lower scores amongst those with an LSI were significantly offset among participants who obtained PA from chores, their job, active travel and family activities (2.0–5.8 points). Participants were more likely to report good-excellent general health if their PA was obtained through active travel (OR = 1.3) or family activity (OR = 1.6). Overall, those who achieved a moderate or high level of PA scored better than the least active group on both health measures.

The corresponding domain-diversity models (Table 5) indicated that the slightly higher PCS-12 scores arising from doing PA from more domains (0.9 points for each additional domain) were counteracted in the moderate and high PA groups (by -1.1 points). Unsurprisingly, participants with an LSI had markedly lower PCS-12 scores than those without, but this negative association was offset by a 2.7-point increase in the score for each additional PA domain contributing to overall PA. The odds of reporting good-excellent general health increased by a factor of 1.3 as a result of doing each additional type of PA, irrespective of the level of PA or presence of an LSI.

[Table 5]

3.4.4. Other significant associations

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Significant negative associations with all four outcome variables were also noted among participants who were out of work, older and of white British/Irish ethnicity (Table 4). Women had lower mental health scores than men. Having access to a car and being a home-owner were associated with better mental wellbeing.

Finally, the variance partition coefficients of the multilevel models indicated a small degree of clustering of scores of the four health measures within neighbourhoods; in the all-domain models, 0.1-4.9% of the total variation was due to differences between neighbourhoods (Table 4).

4. Discussion

Deprived communities like those considered here are often characterised by relatively poor mental health and wellbeing and physical and general health (GoWell, 2010; Scottish Government, 2014). For example, in Scotland, in 2012-2013, a 4.6-point lower WEMWBS score was recorded among people in the most compared with the least deprived quintile of data zones (Wilson, Kellock, Adams, & Landsberg, 2015; p.33). Given the broad benefits of physical activity to health (Warburton, Nicol, & Bredin, 2006; Mammen and Faulkner, 2013), and the observation that, in Scotland, those people who met the recommended physical activity levels in 2012-2013 had on average a 5.4-point higher WEMWBS score than those who did not meet the advised levels (Wilson, Kellock, Adams, & Landsberg, 2015; p.48), it is reasonable to propose that residents of such deprived neighbourhoods may be among the best placed to achieve health gains via appropriate interventions that boost PA levels. Here we have examined deprived-area residents' levels of PA with respect to the types and diversity of PA comprising their total PA, and related these patterns to self-reported measures of mental health and wellbeing and physical and general health.

4.1. Levels of PA vary between population groups

Our study corroborated earlier findings from these neighbourhoods (Mason & Kearns, 2013; Mason, Kearns, & Bond, 2011; Mason, Kearns, & Livingstone, 2013). PA levels were particularly low amongst women, those aged 40+ years, and working-age people without a job, as reported nationally (Leadbetter, Geyer, & O'Connor, 2014). However, contrary to national findings, in our study white British participants were less physically active than other ethnicities (cf. Leadbetter, Geyer, & O'Connor, 2014). In terms of fostering the inclination or opportunity to do PA in deprived neighbourhoods, social engagement via employment may offer the most scope for intervention. Nevertheless, the high incidence of long-standing health conditions (in 29% of participants, increasing markedly with age from 5.5% in the 16-24 year-old group to 60% in the 65+ year-old group) in the study neighbourhoods appears to be the factor most strongly linked to the failure to achieve moderate or high levels of PA. This is a cause for concern, given the findings from the analysis of Scottish Health Survey data for 2012 and 2013, which revealed significantly lower WEMWBS scores (by 1.3-4.8 points) among people suffering from one or more of five types of doctor-diagnosed chronic conditions (Wilson, Kellock, Adams, & Landsberg, 2015; p.59).

4.2. Domains of PA undertaken vary across PA levels

More respondents engaged in PAs entailing a degree of obligation —most commonly, household chores, but also active travel, and, for those in employment, PA as part of their job— than did optional or pleasurable ones (i.e., leisure and sports, and family-based activities). This broadly coincides with findings for the country as a whole of the 2011 Scottish Health Survey (Scottish Government, 2012). This reported heavy housework to be the most popular form of PA for women and a common source of PA for men (61% and 48%, respectively, had done some in the previous four weeks). Sport and exercise was the second most popular type, although participation was higher among men than women (54% vs. 45% having taken part at least once in the previous four weeks). The links between the types of PA undertaken and mental health and wellbeing of the national sample are not described.

One of the main messages to emerge from this study is that diversity of PA domains may be a good thing in itself for raising overall levels of PA. For many this would most likely entail doing more PA for pleasure, since the amount of obligatory forms of PA achieved (household chores and occupational) are probably already at a maximum. Diversity of PA might sustain better mental wellbeing and physical health outcomes among the low PA group in particular (see below).

We also saw how different PA domains contribute substantially to different levels of PA. Thus, active travel was a major contributor to helping people achieve a moderate level of PA, suggesting this may be a significant lever for raising activity in the low PA group. Occupational PA and active leisure were also domains that contributed to participants' total PA, irrespective of how much PA they did in total, but were especially important sources for those doing high levels of PA.

4.3. Links between PA and mental health and wellbeing in deprived neighbourhoods

We found several clear associations between undertaking PA from particular domains and mental health measures. People doing PA for pleasure, through active leisure and family activities (i.e., those who tended to be in the higher PA level groups), generally had better mental wellbeing, consistent with other studies of leisure-time PA (e.g., Richards, 2015). This is therefore of particular relevance to the most inactive people, suggesting that the provision of infrastructure and amenities enabling physically active leisure and sport for individuals and families might be a route by which the relatively inactive can raise their level of PA and improve their mental wellbeing. However, it should be borne in mind that there may be financial barriers to participation in leisure-based PA (e.g., paying for gym membership fees, sporting equipment, etc.) that make it less likely this will be a route by which the least active can increase their overall level of PA and thereby improve their mental health and wellbeing: more than twice as many participants who were in work than those not in work, but of working age, did some type of leisure-based PA (25.0% vs. 11.8%).

Active travel was linked to better mental wellbeing scores amongst the most physically active, and to better mental health scores in the moderately physically active, adding to the scarce evidence base of the benefits of active travel to mental health and wellbeing (Asztalos et al., 2009; Hansson, Mattisson, Björk, Östergren, & Jakobsson, 2011). We also found that even among the least active group, those who did a greater variety of PAs had better mental wellbeing, although there was no significant link with mental health scores. Thus, doing even a small amount of a wider range of activities, including domestic chores, with family, leisure, and active travel may be an effective means for boosting mental wellbeing in the low PA group.

However, the strongest associations were seen among those participants with a long-term health condition. Among this group, lower mental wellbeing scores tended to be offset (but not reversed) if they undertook PA as part of obligatory activities, such as domestic chores or as part of their job. Furthermore, lower physical health scores of participants with long-standing health conditions were substantially ameliorated by occupational PA, domestic chores and family activities . However, by contrast, none of the PA domains appeared to ameliorate the mental health scores.

The complexity of the patterns of association between mental health and wellbeing and PA in deprived neighbourhoods highlight the need for further research into the mechanisms that underlie them. However, it is not possible to address this matter adequately with the cross-sectional data provided by the current study.

4.4. Policy implications

The prevalence of physical inactivity in many societies throughout the world (Hallal et al., 2012) is so widespread that doing any amount of PA rather than none, irrespective of the form it takes, may be considered a step towards a healthier lifestyle, even if this falls short of recommended levels of PA. However, a more nuanced knowledge of for whom different

types of PA are most likely to lead to health benefits, including those related to mental health and wellbeing, is required if effective policy and interventions are to be developed (Heath et al., 2012). For example, a substantial group residing in deprived areas are those with long-term health conditions, and for this group we found that both job-related physical activity and domestic chores can be beneficial for wellbeing and physical health. Whilst actions to assist the long-term sick into work are probably ongoing, support to encourage more home-centred PA in this group is more likely to be unrecognised and currently missing from service provision.

Our findings imply that policy actions for regenerating deprived areas should encourage those with relatively inactive or sedentary lifestyles to focus on sport and leisure and family-based PAs. These findings support the argument for a strong link between public health and regeneration policy in deprived areas (Beck et al., 2010), wherein the improvement of dilapidated environments seeks to ensure that neighbourhoods can serve domestic and residential functions (Kearns and Parkinson, 2001). This includes providing conditions and routes that are more attractive for walking (for leisure, active travel, leisure and family activities) (Dulin-Keita et al, 2015), especially in green spaces (Ward Thompson, Roe, & Aspinall, 2013).

Regeneration has not typically been very successful at providing better quality shops and other destinations to which local people can actively travel and use for daily functions. Regeneration has in the past included the provision of local leisure and social facilities (e.g., swimming pools, parks, community centres), though not always ones that are accessible and attractive to potential users who, in all probability, cannot afford to venture far for such opportunities. It is particularly important that providers of leisure facilities to deprived communities consider whether access can be free of charge for those out of work, since we found that leisure and family activities to be especially beneficial for mental wellbeing, a key indicator of quality of life which regeneration seeks to enhance. Fortunately, although the promoting of PA and better mental health and wellbeing may not be a primary aim of urban

regeneration, the means by which these health benefits for the physically inactive and those with long-term health problems may be realised are likely to be broadly consistent with those employed to bring about neighbourhood renewal.

These findings should nevertheless be placed in perspective of other aspects of people's lives that may more strongly influence their psychological health. Boosting PA, though a good thing in itself, may not be the most direct pathway to better mental health and wellbeing. For example, our results highlight the detrimental effect a long-term health condition may have on mental health and wellbeing, and that having a job is likely to be responsible for better mental health and wellbeing (although we recognise that these causal pathways may run in both directions). Thus, effective health care and economic regeneration remain the two highest priorities, despite what we have said about physical and social regeneration.

4.5. Strengths and limitations

A major strength of our study is that it considers relatively poor people living in deprived places. We examine and compare the little-studied domains of PA (household, occupational, active travel), extending the ground-breaking work of Cerin, Leslie, Sugiyama, and Owen (2009) and Asztalos et al (2009), contributing to a currently limited evidence base, while highlighting the need for more PA domain-specific research. We also consider the possible value of diversifying the types of PA undertaken.

The study benefits from its large study sample, and the use of well established health (SF-12v2) and mental wellbeing (WEMWBS) metrics. Associations between sociodemographic and personal characteristics of the sample and the health measures considered are broadly similar to those found in other analyses of GoWell survey data.

However, there are some limitations to the adopted approach. This was a cross-sectional study, so we cannot draw any conclusions about the direction of causality or how people's health might improve if their PA habits changed. The study relied on self-reported

health, levels of PA, and self-assessments of the relative importance of the domains of PA; we have no absolute, objective measures of the amount of energy expended doing activities from the difference PA domains. The categories of domains of PA were defined by the researchers, whereas respondents may have differed in the way they interpreted the definitions and descriptions of these activities; it is clear from the sample selection that many respondents felt that the PA they undertook did not fit the descriptions of any of the suggested PA domains. However, similar associations have been found between the numbers of self-described, salient 'personal projects' and life satisfaction (Curl, Ward Thompson, Alves, & Aspinall, 2016) adding weight to the argument that a diverse range of activities is important for overall mental wellbeing or self-reported life satisfaction. Furthermore, the participants may not have considered the domains to be mutually exclusive.

5. Conclusion

Our study highlights the potential for participation in any type of physical activity — the household, occupational, active travel, leisure-time and family-related domains— to enable people to achieve recommended levels of PA, and thereby improve their mental health and wellbeing (and physical and general health). Our findings draw attention to the fact that the less well studied, non-leisure-time PA domains, in particular that of household chores, can make substantial contributions to overall PA. Especially for the physically inactive and for those with long-standing health conditions, for whom doing any PA is better than doing none, these may offer an effective route towards becoming more active and enjoying improved mental health and wellbeing. Our study also shows that doing a wide range of PAs may in itself be linked to better health.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

Acknowledgments

References

Asztalos, M., Wijndaele, K., De Bourdeaudhuij, I., Philippaerts, R., Matton, L., Duvigneaud, N., et al. (2009). Specific associations between types of physical activity and components of mental health. *Journal of Science Medicine & Sport*, *12*, 468–474.

Bassett, D. R. J., Pucher, J., Buehler, R., Thompson, D. L., & Crouter, S.E. (2008). Walking, cycling, and obesity rates in Europe, North America, and Australia. *Journal of Physical Activity & Health, 5*(6), 795–814.

Bauman, A. E., Reis, R. S., Sallis, J. F., Wells, J. C., Loos, R. J. F., & Martin, B.W. (2012). Correlates of physical activity: why are some people physically active and others not? *Lancet*, *380*, 258–271.

Beck, S., Hanlon, P., Tannahill, C., Crawford, F., Ogilvie, R., & Kearns, A. (2010). How will area regeneration impact on health? Learning from the GoWell study. *Public Health, 124*(3), 125–130.

Blair, S. N., LaMonte, M. J., & Nichaman, M. Z. (2004). The evolution of physical activity recommendations: how much is enough? *American Journal of Clinical Nutrition, 79 Suppl*, 913S–920S.

Brooke, H. L., Corder, K., Griffin, S. J., Ekelund, U., & van Sluijs, E. M. F. (2013). More of the same or a change of scenery: an observational study of variety and frequency of physical activity in British children. *BMC Public Health*, *13*, 761.

Cerin, E., Leslie, E., Sugiyama, T., & Owen, N. (2009). Associations of multiple physical activity domains with mental well-being. *Mental Health & Physical Activity, 2*, 55–64.

Chen L. -J., Stevinson, C., Ku, P. -W., Chang, Y. -K., & Chu, D. -C. (2012). Relationships of leisure-time and non-leisure-time physical activity with depressive symptoms: a

population-based study of Taiwanese older adults. *International Journal of Behavioral Nutrition & Physical Activity, 9*, 28.

Clays, E., De Bacquer, D., Janssens, H., De Clercq, B., Casini, A., Braeckman, L., et al. (2013). The association between leisure time physical activity and coronary heart disease among men with different physical work demands: a prospective cohort study. *European Journal of Epidemiology, 28*(3), 241–247.

Curl, A., Ward Thompson, C., Alves, S., & Aspinall, P. (2016) Outdoor Environmental Supportiveness and Older People's Quality of Life: A Personal Projects Approach *Journal of Housing for the Elderly 30*(1):1-17

Dulin-Keita, A., Clay, O., Whittaker, S., Hannon, L., Adams, I. K., Rogers, M., & Gans, K. (2015). The influence of HOPE VI neighborhood revitalization on neighborhood-based physical activity: A mixed-methods approach. *Social Science & Medicine*, *139*, 90–99.

Farris, M. S., McFadden, A. A., Friedenreich, C. M., & Brenner, D. R. (2015). The association between leisure time physical activity and pancreatic cancer risk in adults: a systematic review and meta-analysis. *Cancer Epidemiology, Biomarkers & Prevention*, *24*(10), 1462-1473.

Fone, D., Dunstan, F., Lloyd, K., Williams, G., Watkins, J., & Palmer, S. Does social cohesion modify the association between area income deprivation and mental health? A multilevel analysis. *International Journal of Epidemiology*, *36*, 338–345.

Goodman, A (2013) Walking, Cycling and Driving to Work in the English and Welsh 2011 Census: Trends, Socio-Economic Patterning and Relevance to Travel Behaviour in General *PLoS ONE 8:8 e71790*

GoWell. (2010). *Progress for people and places: Monitoring change in Glasgow's communities. Evidence from the GoWell surveys 2006 and 2008.* Glasgow, UK: Glasgow Centre for Population Health

Hallal, P. C., Andersen, L. B., Bull, F. C., Guthold, R., Haskell, W., Eklund, U., Lancet Physical Activity Series Working Group. (2012). Global physical activity levels: surveillance progress, pitfalls, and prospects. *Lancet*, *380* (9838)*,* 247–257.

Hamer, M., Stamatakis, E., & Steptoe, A. (2009). Dose-response relationship between physical activity and mental health: the Scottish Health Survey. *British Journal of Sports Medicine*, *43*, 1111–1114.

Hansson, E., Mattisson, K., Björk, J., Östergren, P. O., & Jakobsson, K. (2011). Relationship between commuting and health outcomes in a cross-sectional population survey in southern Sweden. *BMC Public Health*, *11*, 834.

Harvey, S. B., Hotopf, M., Øverland, S., & Mykletun, A. (2010). Physical activity and common mental disorders. *British Journal of Psychiatry*, *197*, 357–364.

Heath, G. W., Parra, D. C., Sarmiento, O. L., Andersen, L. B., Owen, N., Goenka, S., Montes, F., Brownson, R. C., Lancet Physical Activity Series Working Group. (2012). Evidence-based intervention in physical activity: lessons from around the world. *Lancet*, *380*(9838), 272–81.

Holtermann, A., Hansen, J. V., Burr, H., Søgaard, K., & Sjøgaard, G. (2012). The health paradox of occupational and leisure-time activity. *British Journal of Sports Medicine*, *46*, 291–295.

Hu, G., Jousilahti, P., Borodulin, K., Barengo, N. C., Lakka, T. A., Nissinen, A., & Tuomilehto, J. (2007). Occupational, commuting and leisure-time physical activity in relation to coronary heart disease in middle-aged Finnish men and women. *Atherosclerosis*, *194*, 490–497.

Hu, G., Pekkarinen, H., Hanninen, O., Yu, Z., Guo, Z., & Tian, H. (2002). Commuting, leisure-time physical activity, and cardiovascular risk factors in China. *Medicine & Science in Sports & Exercise*, *34*(2), 234–238.

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Information Services Division. (2015). *Mental Health Inpatient Hospital Care: Trends up to 31 March 2014*. Edinburgh: National Health Services Scotland

Kavanagh, A. M., Goller, J. L., King, T., Jolley, D., Crawford, D., & Turrell, G. (2005). Urban area disadvantage and physical activity: a multilevel study in Melbourne, Australia. *Journal of Epidemiology & Community Health, 59*, 934–940.

Kearns, A., & Parkinson, M. (2001). The significance of neighbourhood. *Urban Studies, 38*(12), 2103–2110.

Kim, K., Shin, Y. J., Nam, J. H., Choi, B. Y., & Kim, M. K. (2008). A dose–response relationship between types of physical activity and distress. *Journal of Korean Medical Science*, *23*, 218–222.

Krause, N., Brand, R. J., Arah, O. A., & Kauhanen, J. (2015). Occupational physical activity and 20-year incidence of acute myocardial infarction: results from the Kuopio Ischemic Heart Disease Risk Factor Study. *Scandinavian Journal of Work, Environment & Health*, *41*(2), 124–139.

Leadbetter, C., Geyer, J., O'Connor, N. (2014). The Scottish Health Survey: Physical Activity. Edinburgh: The Scottish Government.

Lee, P.H., Macfarlane, D.J., Lam, T.H. & Stewart, S.M. (2011). Validity of the International Physical Activity Questionnaire Short Form (IPAQ-SF): a systematic review. *International Journal of Behavioural Nutrition and Physical Activity*, *8*(1), 115.

Lubans, D. R., Boreham, C. A., Kelly, P., & Foster, C. E. (2011). The relationship between active travel to school and health-related fitness in children and adolescents: a systematic review. *International Journal of Behavioral Nutrition & Physical Activity*, *8*, 5.

Mammen, G., & Faulkner, G. (2013). Physical activity and the prevention of depression: a
systematic review of prospective studies. *American Journal of Preventive Medicine*,
45(5), 649–657.

Marmot, M., & Bell, R. (2012). Fair society, healthy lives. *Public Health*, *126*, S4-S10.

Mason, P., Kearns, A., & Bond, L. (2011). Neighbourhood walking and regeneration in
deprived communities. *Health & Place*, *17*, 727–737.

Mason, P., Kearns, A., & Livingston, M. (2013). "Safe going": the influence of crime rates
and perceived crime and safety on walking in deprived neighbourhoods. *Social Science &
Medicine*, *91*, 15–24.

Mason, P., & Kearns, A. (2013). Physical activity and mental wellbeing in deprived
neighbourhoods. *Mental Health & Physical Activity*, *6*, 111–117.

McKercher, C. M., Schmidt, M. D., Sanderson, K. A., Patton, G. C., Dweyer, T., & Venn, A.
J. (2009). Physical activity and depression in young adults. *American Journal of
Preventive Medicine, 36*, 161–164.

Ogilvie, D., Mitchell, R., Mutrie, N., Petticrew, M., & Platt, S. (2008). Personal and
environmental correlates of active travel and physical activity in a deprived urban
population. *International Journal of Behavioral Nutrition & Physical Activity*, *5*, 43.

Patterson, E. (2010). Guidelines for data processing and analysis of the International Physical
Activity Questionnaire (IPAQ) – Short and long forms.
https://sites.google.com/site/theipaq/scoring-protocol (accessed 6 June 2015).

Richards, J., Jiang, X., Kelly, P., Chau, J., Bauman, A., & Ding, D. (2015). Don't worry, be
happy: cross-sectional associations between physical activity and happiness in 15
European countries. *BMC Public Health*, *15*, 53.

Rind, E., & Jones, A. P. (2011). The geography of recreational physical activity in England. *Health & Place*, *17*, 157–165.

Scottish Government. (2011). *The Scottish Health Survey 2010. Volume 1: Main Report.* The Scottish Government, Edinburgh.

Scottish Government. (2012). *The Scottish Health Survey 2011. Volume 1: Adults.* The Scottish Government, Edinburgh.

Scottish Government. (2013). *The Scottish Health Survey 2012. Volume 1: Main Report.* The Scottish Government, Edinburgh.

Scottish Government. (2015). *The Scottish Health Survey 2014. Volume 1: Main Report.* The Scottish Government, Edinburgh.

Shephard, R. J. (2008). Is active commuting the answer to population health? *Sports Medicine*, *38*, 751–758.

Shortt, N. K., Rind, E., Pearce, J., & Mitchell, R. (2014). Integrating environmental justice and socioecological models of health to understand population-level physical activity. *Environment and Planning A, 46*(6), 1479–1495. doi:10.1068/a46113

Sisson, S. B., Camhi, S. M., Church, T. S., Martin, C. K., Tudor-Locke, C., Bouchard, C., et al. (2009). Leisure time sedentary behavior, occupational/domestic physical activity, and metabolic syndrome in U.S. men and women. *Metabolic Syndrome & Related Disorders*, *7*, 529–536.

Stevenson, A., Pearce, J., Blakely, T., Ivory, V., & Witten, K. (2009). Neighbourhoods and health: A review of the New Zealand literature. *New Zealand Geographer*, *65*, 211–221.

Tennant, R., Hiller, L., Fishwick, R., Platt, S., Joseph, S., Weich, S., et al. (2007). The Warwick-Edinburgh Mental Well-being Scale (WEMWBS): development and UK validation. *Health & Quality of Life Outcomes*, *5*(1), 63.

Warburton, D.E.R., Nicol., C.W., Bredin, S.D.S. (2006). Health benefits of physical activity: the evidence. *Canadian Medical Association Journal*, *174*, 801–809.

Ward Thompson, C., Roe, J., & Aspinall, P. (2013). Woodland improvements in deprived urban communities: What impact do they have on people's activities and quality of life? *Landscape & Urban Planning*, *118*, 79–89.

Ware, J. E., Jr., Kosinski, M., Turner-Bowker, D. M., & Gandek, B. (2002). *User's Manual for the SF-12v2® Health Survey With a Supplement Documenting SF-12® Health Survey*. Lincoln, RI: QualityMetric Incorporated.

Wilson, M., Kellock, C., Adams, D. & Landsberg, J. (2015). *The Scottish Health Survey Topic Report: Mental Health and Wellbeing.* The Scottish Government, Edinburgh.

Table 1

Sample composition, and distribution of levels of PA by demographic and personal characteristics (n=2,654).

Variable	Category	Percentage in sample	IPAQ group				
			Low	Moderate		High	
			Percentage in group	Percentage in group	p (moderate vs. low)	Percentage in group	p (high vs. low)
Overall			46.9	37.9		15.1	
Gender	Male	40.2	43.6	38.3		18.1	
	Female	59.8	49.1	37.7	0.081	13.2	<0.001
Age group (years)	16-24	9.4	40.6	41.0		18.5	
	25-39	30.3	36.1	45.3	0.133	18.7	0.449
	40-54	29.6	48.7	34.3	0.012	17.1	0.096
	55-64	130.0	56.1	32.8	0.001	11.0	<0.001
	65+	17.8	59.1	33.7	<0.001	7.2	<0.001
Employment	Working	28.9	36.4	36.2		27.4	
	Not working	50.0	48.0	40.4	0.079	11.5	<0.001
	Retired	21.1	58.7	34.3	<0.001	7.0	<0.001
Ethnicity	White British/Irish	76.1	47.8	36.2		16.0	
	Not white British/Irish	23.9	44.1	43.4	0.003	12.5	0.588
Long-standing illness	No	70.8	41.1	41.4		17.6	
	Yes	29.2	61.1	29.6	<0.001	9.3	<0.001
Access to car	No	71.8	46.5	33.4		20.2	
	Yes	28.2	47.1	39.7	0.083	13.2	<0.001
Tenure	Social-rented	79.7	47.6	38.2		14.2	
	Owned/private-rented	20.3	44.3	36.9	0.621	18.9	0.005

3 Probabilities are those associated with Wald statistics of parameter estimates from multilevel logistic regression models, indicating significant differences in the proportions of respondent
4 characteristics associated with the different levels of PA

Table 2

6 Percentages of people doing PA from each domain, by demographic and personal characteristics

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Variable	Category	Household chores		Occupational		Active travel		Leisure		Family activities	
		%	p	%	p	%	p	%	p	%	p
Overall		91.6		20.3		42.4		14.7		21.2	
Gender	Male	88.2		23.1		46.6		20.2		19.6	
	Female	94.0	<0.001	18.5	0.004	39.6	<0.001	10.9	<0.001	22.3	0.085
Age group (years)	16-24	90.4		14.1		47.8		22.9		24.1	
	25-39	94.2	0.039	23.5	0.002	44.2	0.257	19.5	0.193	31.5	0.067
	40-54	89.6	0.863	28.4	<0.001	39.0	0.002	14.6	0.001	19.4	0.051
	55-64	91.9	0.494	20.9	0.079	45.1	0.177	7.8	<0.001	15.1	0.003
	65+	91.3	0.669	4.4	<0.001	40.3	0.011	7.0	<0.001	9.7	<0.001
Employment	Working	85.5		62.3		46.0		25.0		27.6	
	Not working	94.3	<0.001	3.5	<0.001	40.6	0.063	11.8	<0.001	22.4	0.017
	Retired	93.7	<0.001	2.9	<0.001	41.7	0.119	7.2	<0.001	9.5	<0.001

Ethnicity	White British/Irish	90.8		21.2		42.9		14.8		20.1	
	Not white British/Irish	94.3	0.034	17.5	0.270	40.6	0.833	14.1	0.735	24.6	0.058
Long-standing illness	No	91.4		25.0		46.1		17.3		24.4	
	Yes	92.2	0.384	9.0	<0.001	33.3	<0.001	8.1	<0.001	13.4	<0.001
Access to car	No	93.0		15.0		43.1		12.2		19.5	
	Yes	88.1	<0.001	34.0	<0.001	40.6	0.050	21.0	<0.001	25.5	0.001
Tenure	Social-rented	92.7		17.6		42.4		12.9		20.9	
	Owned/private-rented	87.6	0.003	30.9	<0.001	42.4	0.611	21.7	<0.001	22.6	0.238

Table 3

Relative contribution of different types of physical activity, measured by mean reverse ranking of domains of PA in groups of respondents doing different levels of PA

Domain of PA	Overall	IPAQ group		
		Low	Moderate	High
Household chores	4.23 (4.12 - 4.35)	4.40 (4.28 - 4.53)	4.23 (4.11 - 4.35)	3.71 (3.56 - 3.87)
Occupational	0.93 (0.80 - 1.06)	0.62 (0.48 - 0.77)	0.87 (0.72 - 1.01)	2.02 (1.82 - 2.21)
Active travel	1.73 (1.50 - 1.95)	1.46 (1.22 - 1.70)	2.08 (1.91 - 2.24)	1.73 (1.51 - 1.96)
Leisure	0.53 (0.43 - 0.63)	0.24 (0.13 - 0.35)	0.65 (0.54 - 0.75)	1.14 (0.99 - 1.28)
Family activities	0.74 (0.64 - 0.84)	0.56 (0.44 - 0.67)	0.91 (0.78 - 1.04)	0.91 (0.74 - 1.08)
Number of domains cited	1.90 (1.81 - 1.99)	1.63 (1.54 - 1.73)	2.06 (1.98 - 2.45)	2.35 (2.24 - 2.45)

Figures are mean reversed ranks (0=not done, …, 5=done most) for the five domains of PA, and mean number of PA domains done.

95% confidence intervals in parentheses.

Table 4

Parameter estimates (and 95% confidence intervals) from all-domain multilevel multivariate models for the mental wellbeing, and mental, physical and general health measures. Significant parameter estimates (p<0.05) are highlighted in bold.

Model term	WEMWBS		MCS-12		PCS-12		General health	
	B		B		B		OR	
Intercept	55.41	(53.31, 57.51)	56.33	(54.59, 58.07)	54.05	(52.04, 56.06)	16.63	(9.11, 30.35)
IPAQ group (ref: Low)								
Moderate	0.74	(-0.25, 1.73)	-0.38	(-1.51, 0.74)	**2.10**	**(1.36, 2.84)**	**1.51**	**(1.19, 1.90)**
High	1.23	(-0.14, 2.61)	0.58	(-1.00, 2.15)	**2.37**	**(1.35, 3.39)**	**1.70**	**(1.19, 2.43)**
PA domain cited (ref: not done):								
Chores: done	-1.24	(-2.70, 0.21)			-0.37	(-1.80, 1.05)		
Chores: done * IPAQ: moderate								
Chores: done * IPAQ: high								
Occupational: done	-0.76	(-1.95, 0.44)			-0.33	(-1.51, 0.85)		
Occupational: done * IPAQ: moderate								
Occupational: done * IPAQ: high								
Active travel: done	0.60	(-0.45, 1.65)	-1.05	(-2.22, 0.12)	0.36	(-0.44, 1.16)	**1.29**	**(1.03, 1.62)**
Active travel: done * IPAQ: moderate	1.06	(-0.43, 2.54)	**2.51**	**(0.83, 4.18)**				
Active travel: done * IPAQ: high	**2.73**	**(0.71, 4.74)**	1.55	(-0.74, 3.85)				
Leisure: done	**2.61**	**(1.58, 3.64)**	-1.04	(-3.23, 1.15)				
Leisure: done * IPAQ: moderate			1.66	(-1.03, 4.35)				
Leisure: done * IPAQ: high			**3.21**	**(0.16, 6.26)**				
Family activity: done	**1.49**	**(0.62, 2.36)**			0.68	(-0.26, 1.62)	**1.61**	**(1.19, 2.17)**
Family activity: done * IPAQ: moderate								
Family activity: done * IPAQ: high								
Long-standing illness (LSI) (ref: no)								

	Model 1	Model 2	Model 3	Model 4
LSI: yes	**-9.60 (-12.38, -6.82)**	**-5.51 (-6.45, -4.58)**	**-20.49 (-23.40, -17.57)**	**0.13 (0.10, 0.16)**
LSI: yes * PA domain: chores	**4.22 (1.43, 7.02)**		**5.32 (2.52, 8.12)**	
LSI: yes * PA domain: occupational	**2.78 (0.35, 5.21)**		**5.75 (3.35, 8.15)**	
LSI: yes * PA domain: active travel			**1.96 (0.44, 3.49)**	
LSI: yes * PA domain: leisure				
LSI: yes * PA domain: family activity			**4.28 (2.24, 6.33)**	
Gender (ref: Male)				
Female		**-1.62 (-2.40, -0.85)**		
Age group (ref: 16-24 years)				
25-39 years	**-2.01 (-3.27, -0.76)**	**-2.27 (-3.67, -0.87)**	-0.74 (-1.98, 0.50)	**0.49 (0.28, 0.84)**
40-54 years	**-3.07 (-4.37, -1.76)**	**-3.32 (-4.77, -1.86)**	**-1.84 (-3.12, -0.56)**	**0.30 (0.18, 0.52)**
55-64 years	**-2.44 (-4.05, -0.83)**	**-1.98 (-3.78, -0.18)**	**-3.95 (-5.53, -2.37)**	**0.28 (0.15, 0.51)**
65+ years	-0.24 (-2.40, 1.91)	-0.53 (-2.93, 1.88)	**-3.53 (-5.65, -1.40)**	**0.33 (0.16, 0.68)**
Employment status (ref: working)				
Not working	**-2.69 (-3.78, -1.60)**	**-3.94 (-4.88, -2.99)**	**-1.29 (-2.34, -0.23)**	**0.34 (0.25, 0.47)**
Retired	-1.38 (-3.28, 0.52)	**2.15 (0.18, 4.12)**	**-2.68 (-4.55, -0.81)**	**0.59 (0.35, 0.99)**
Ethnicity (ref: White British/Irish)				
Not white British/Irish	**2.53 (1.62, 3.45)**	**2.73 (1.71, 3.74)**	**1.26 (0.40, 2.13)**	**2.16 (1.57, 2.99)**
Owns or has access to car or van (ref: No)				
Yes	**1.12 (0.30, 1.94)**			**1.34 (1.03, 1.74)**
Tenure (ref: Social-rented)				
Owned/private-rented	**1.76 (0.82, 2.70)**		**1.22 (0.36, 2.09)**	

Table 5.

Parameter estimates (and 95% confidence intervals) from domain-diversity multilevel multivariate models for the mental wellbeing, mental and physical health and general health measures. For brevity, only PA domain, PA level and LSI main effects and interactions are shown. Significant parameter estimates (p<0.05) are highlighted in bold.

Model term	WEMWBS B	MCS-12 B	PCS-12 B	General health OR
Intercept	54.78 (53.21, 56.34)	56.80 (55.02, 58.58)	54.25 (52.81, 55.69)	18.16 (10.05, 32.82)
IPAQ group (ref: Low)				
Moderate	**1.25 (0.49, 2.01)**	**0.95 (0.11, 1.80)**	**2.00 (1.25, 2.74)**	**1.48 (1.18, 1.87)**
High	**2.12 (1.04, 3.20)**	**1.61 (0.41, 2.81)**	**2.37 (1.31, 3.42)**	**1.69 (1.19, 2.42)**
PA domain diversity	**0.81 (0.17, 1.45)**	-0.55 (-1.20, 0.11)	**0.93 (0.31, 1.55)**	**1.34 (1.17, 1.53)**
PA domain diversity * IPAQ: moderate	0.09 (-0.70, 0.89)	**0.98 (0.10, 1.86)**	**-1.14 (-1.92, -0.36)**	
PA domain diversity * IPAQ: high	**1.10 (0.13, 2.06)**	**1.29 (0.24, 2.35)**	**-1.11 (-2.05, -0.17)**	
Long-standing illness (LSI) (ref: no)				
LSI: yes	**-5.02 (-5.89, -4.15)**	**-5.51 (-6.44, -4.58)**	**-12.79 (-13.64, -11.94)**	**0.13 (0.10, 0.16)**
PA domain diversity * LSI: yes	**1.28 (0.39, 2.16)**		**2.66 (1.79, 3.53)**	

1
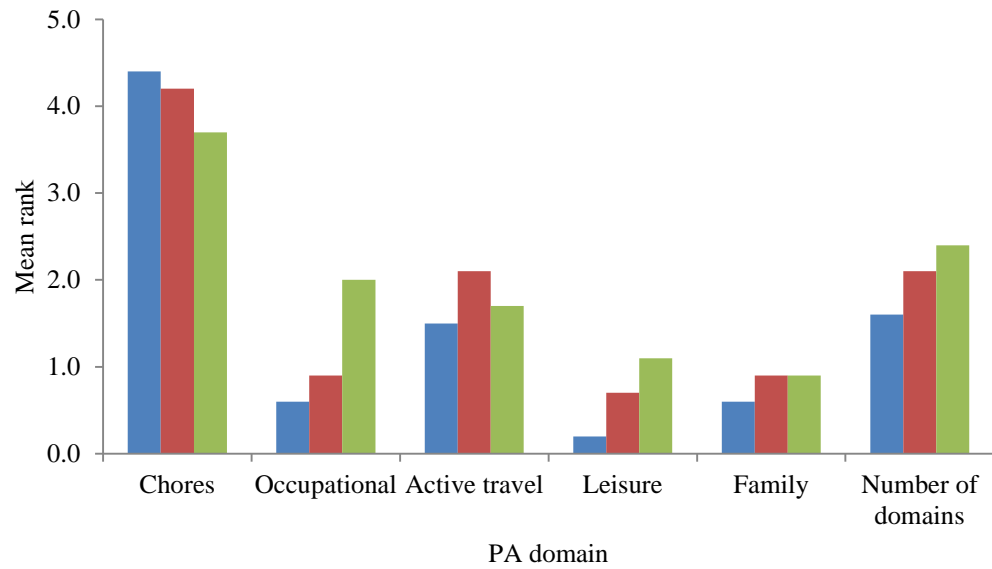
Figure 1. Mean rank of domains from which PA was undertaken, by level of PA: ■ low, ■ moderate, ■ high. Rank scores are reversed, so higher values

indicate doing proportionally more PA of that domain.

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