Mid-life Social Participation and Physical Performance at age 60-64: Evidence from the 1946 British Birth Cohort study

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Abstract

Background

Previous studies linking social activity and disability have been limited by focusing on self-reported physical performance in older adults (>65). We examined whether social participation in mid-life is associated with objective and subjective measures of physical performance in older age.

Methods

Participants of the Medical Research Council National Survey of Health and Development reported their involvement in social activities at ages 43 and 60-64 years; frequency of such involvement was classified into thirds. Physical performance was measured at age 60-64 using: grip strength; standing balance; chair rises; timed get-up-and-go (TUG); self-reported physical function (PF) from the Short Form-36. Multivariable regression was used to examine longitudinal associations between social participation and each physical performance measure. We also investigated whether change in social participation between 43 and 60-64 was associated with each outcome.

Results

In fully-adjusted models, higher frequency of social participation at 43 was associated with faster chair rise (1·42 repetitions/min, 95%CI 0·45-2·39) and TUG speed (2·47 cm/s, 95%CI 0·27-4·67) and lower likelihood of self-report limitations (OR of low PF 0.67, 95%CI 0.50-0.91) at 60-64 compared with low frequency. Better performance in objectively-measured outcomes was observed only if higher social participation persisted over time whereas lower odds of self-reported limitations were found in all groups when compared to those with persistently low participation (ORs 0.43 to 0.56, all p≤0.02).

Conclusion

Our findings suggest that associations between higher levels of social participation in mid-life and better physical performance exist only if this social participation persists through to older age.

Keywords

Disability; Mobility; Prevention; Epidemiology

Introduction

Preserving physical performance and independence in older adults has become a major public health priority as populations continue to age globally (1). Walking, balancing, getting up from a chair, and muscle strength need to be maintained to undertake many of the basic physical tasks of independent living and have been shown to predict outcomes relevant to healthy ageing (2, 3). Early mid-life is an optimal time to target modifiable risk factors, enabling a life course approach to health promotion (4).

. Research suggests participation in social activity is associated with all-cause mortality (5), circulatory disease mortality (6), depression (7, 8) and cognitive decline (9).Social participation, including involvement in community, hobby, or sports organisations, has also been associated with lower risk of incident disability (11-15). Theories underpinning the relationship between social participation and health include Durkheim's work on social integration and suicide, and role accumulation theory, which purports that participation in a larger number of various kinds of social activities is beneficial for health. There is evidence that lack of integration into established social institutions (e.g. some religious groups, marriage) is associated with poorer health. Berkman et al have conceptualised the pathway by which social relationships and participation may affect health, incorporating socio-cultural, psychological, and physiological components (16).Social participation has been described as "a person's involvement in activities that provide interaction with others in society or the community"(17). This study focuses on community-based social participation. Studies have not previously been published on the relationship of social participation with both objective and subjective measures of physical performance. Furthermore, no existing studies have examined whether the association of social participation with physical performance is cumulative i.e. frequency of social participation over time on the effect of physical performance.

Therefore, our aims were (i) to investigate whether longitudinal associations exist between engagement in social group activities and physical performance in later life, using performance-based and self-reported measures and (ii) whether changes in social participation between ages 43 and 60-64 were associated with physical performance.

Methods

Study Population

This study utilizes data from the UK Medical Research Council National Survey of Health and Development (NSHD). This is a socially stratified sample of 2547 females and 2815 males born during the first week of March 1946, in England, Scotland and Wales (18). Data for these analyses were drawn from nurse-led home visits at age 43 and comprehensive clinical assessments at age 60-64. In 2006-2010, at age 60-64, study members completed a postal questionnaire and were invited to an assessment at one of six clinical research facilities or a nurse-led home visit. At this age, 2661 members completed a postal questionnaire and/or clinical assessment (19). Ethical approvals were obtained at each data collection and participants provided written informed consent.

Outcome variables

Physical performance was assessed at age 60-64 using measures of grip strength, standing balance, chair rise, and timed get-up-and-go (TUG). Trained nurses conducted these tests using standardized protocols as described elsewhere (20). Grip strength was assessed isometrically using an electronic handgrip dynamometer (21). Standing balance time was recorded as the longest time (in seconds) for which the participant could stand on one leg with their eyes closed, up to a maximum of 30 seconds. Standing balance times were positively skewed so were transformed using natural logarithms (ln(seconds+1)). Chair rise time was measured as the time taken to stand up straight from a seated position and then sit back down again ten times as quickly as possible. Chair rise speed (repetitions/minute) was then calculated by dividing 10 by the total time taken in seconds and multiplied by sixty.In the TUG test (22) participants rose from a chair, walked three metres at usual pace and returned to a seated position. Walking aids were permitted (n=24). The time taken to complete the test was recorded and the speed (cm/s) was calculated by dividing distance walked by the time taken.

Self-reported physical performance was assessed using the physical functioning subscale of the Short Form-36 (SF-36) questionnaire (23) at age 60-64 (supplemental material). Scores range from 0-100; higher scores denote better physical function. A binary variable was created using the subscale as the distribution was skewed; the lowest quartile was defined as "limited physical functioning" (24).

Exposure variables

Frequency of social participation was summarised at age 43 using self-reported items on whether a participant was involved in, or helped to run, activities including: church activities; playgroup/nurseries or school; local government; trade unions; voluntary services; sports clubs; evening classes/adult education; pubs/clubs or social activities; other organisations. To capture the frequency of participation we created a scale system of points. Four points were attributed for each group activity an individual participated in on a weekly basis; one point for each group activity they participated in monthly; 0.17 points for each group activity they participated in less often than monthly (regarded as participation every 6 months); no points for those who did not belong to a group activity or did not participate regularly. The scores from each of the nine activities were summed to create a variable ranging from 0 (no group activity) to 36 (all nine group activities on a weekly basis).

Due to the skewed distribution of the summary score, an *a priori* decision was made to convert the score to tertiles (low [0-3.99], moderate [4-5], and high social participation [5.1-24]).

For the second set of analyses, the change in self-reported social participation between ages 43 and 60-64 years was used as an exposure variable. Measures used at 60-64 were similar in detail to those collected at 43. We created a variable classifying participants into one of five groups based on reported frequency of social participation at ages 43 and 60-64: low participation at both time points; relative decrease in participation from 43 to 60-64; relative increase in participation from 43 to 60-64; moderate participation at both time points; high participation at both time points.

Covariates

Potential confounders were identified *a priori* based on plausible relationships and evidence from the literature (sex(25), height (26, 27), BMI (15), marital status(28), education (25), socio-economic status (29), affective symptoms(29), smoking(30) and health conditions (13)). Height (cm) and weight (kg) were measured by nurses at home visits at age 43. Body mass index (BMI) was calculated as weight (kg)/ height (m^2). Marital status at 43 was categorised as married, previously married; and never married. Highest educational level attained by age 26 was categorized into five groups: university degree or higher; UK General Certificate of Education-Advanced level (A levels), national school qualifications usually attained at age 18 years; UK General Certificate of Education-Ordinary level (O levels), national school qualifications usually attained at age 16 or their equivalents; certificate of secondary education, clerical course or equivalent; none. Current or most recent own occupational class at age 43 years was categorized using the Registrar General's Social Classification into three groups: I or II (professional, managerial, technical occupations); III (skilled manual and non-manual occupations); IV or V (partly- or unskilled occupations). The Maudsley Personality Inventory (31) questionnaire was administered at age 26 to assess extraversion and neuroticism and both scores were dichotomized as ≤6 versus 7–12 (32). Data from the 18-item Psychiatric Symptom Frequency Scale at 43 were used to provide a measure of affective symptoms (anxiety or depression). A cut-off value of 23 was used (33). A binary variable was created to indicate the presence / absence of one or more self-reported health conditions at 43: heart trouble; back problems; stroke; arthritis; chronic cough. Smoking status at 43 was categorized as current; recent ex-smoker; long-term ex-smoker; never smoker. Additional covariates includedfor the analyses of change in social participation from mid-life to later-life and physical performance were: retirement status at 60-64; financial stability (assessed using the question "have you found you have been unable to pay the bills in the last year because you were short of money?"); smoking history up to 60-64; change in marital status between 43 and 60-64; psychiatric morbidity at 60-64 from the 28-item General Health Questionnaire where a cut-off value of 4 was used (34).

Statistical analyses

Multivariable linear regression was used to assess the associations of social participation with the objective measures of physical performance. Associations between social participation and the self-reported PF subscale were tested using logistic regression. The main analyses included all participants with complete exposure, covariate, and outcome data ("complete case analysis"). Where it was documented that a participant was unable to complete a physical performance test because of health reasons (n= 136 for chair rise, n=89 for standing balance, n= 34 for TUG and n=49 for grip strength), that participant was randomly allocated a value from the bottom 5% of the distribution of participants with complete data. This ensured that those participants with the worst physical performance were not excluded from the analyses. Interactions with sex were explored but no evidence of this was found therefore all subsequent models were adjusted for sex.

As a sensitivity analysis, we used multiple imputation with chained equations to impute all missing values (35). We assumed data were missing at random and 25 imputed datasets were generated. All fully-adjusted regression models were repeated using the imputed datasets. The variables included in the imputation model were the explanatory factors, all five outcomes, and all covariates included in the regression models.

Results

Description of sample

Characteristics of the sample at age 43 are in Table 1. Eighty-three percent of participants included in the analyses were married, 44% had an occupational class of I or II, and 75% were non-smokers. The high prevalence of co-morbidity in this sample is due to the presence of self-reported back problems (34%). The sample in the baseline characteristics table includes those with data on frequency of group participation at 43, covariates and at least one objective or subjective physical performance measure at 60-64. The proportion of missing data per covariate ranged from 5.2% (marital status) to 9.9% (neuroticism).

Associations between social participation at age 43 and physical performance at age 60-64

In sex-adjusted analyses, individuals reporting high frequency of social participation at age 43 had faster chair rise speed (1.77 rep/min 95%CI 0.77-2.77) and TUG speed (3.06 cm/s, 95%CI 0.82-5.30) at age 60-64 when compared with those who reported low frequency (Table 2). No association seen for standing balance time or grip strength. After adjustment for confounders, there remained evidence of an association for these two outcomes (chair rise speed 1.42 rep/min, 95%CI 0.45-2.39; TUG speed 2.47 cm/s, 95%CI 0.27-4.67). No single confounding variable was identified as driving the attenuation. A similar pattern was observed for self-reported PF limitations; those with high social participation at age 43 had 33% lower odds of low PF when compared with those reporting low frequency in the fully-adjusted models (OR 0.67, 95%CI 0.50-0.91).

Associations between changes in social participation between ages 43 and 60-64 and physical performance at age 60-64

In sex-adjusted analyses, those who reported high levels of participation at both ages had faster chair rise speed (2.57 rep/min, 95%CI 1.05-4.08), faster TUG speed (6.21 cm/s, 95%CI 2.88-9.56) and longer standing balance times (0.20 ln(sec), 95%CI 0.09-0.31) than those who reported low levels of participation. The overall associations between change in social participation between ages 43 and 60-64 years and objective physical performance were attenuated after adjustment for covariates (Table 3) however, there was still evidence that those who reported high levels of participation at both time points had faster TUG speed (4.48 cm/s, 95%CI 1.08-7.89) and longer standing balance times (0.15 ln(sec), 95%CI 0.04-0.26) compared with those who reported low levels at both time points in fully-adjusted models. Moreover, those who had decreasing, increasing, or maintained moderate or high levels of social participation were less likely to report limitations using the PF subscale (OR 0.43-0.56) compared to those with low social participation at both ages.

Sensitivity analyses

When regression analyses were repeated using multiply imputed data, associations between social participation at age 43 and physical performance at age 60-64 were strengthened for all measures, however our overall conclusions are unchanged. A similar pattern was observed for the association between these outcomes and change in social participation. Imputing all missing values strengthened the evidence that persistent high participation was associated with chair rise, TUG, standing balance, and self-reported limitation. Analysis of the imputed datasets also revealed evidence for an association between persistent moderate social participation and chair rise though point estimates for both were smaller than those for persistent high social participation(Supplementary Tables).

Discussion

Our analyses suggest that engaging in high levels of social participation in mid-life is associated with better physical performance in TUG and chair rise tests at age 60-64, even after adjustment for confounders. Higher mid-life social participation was also associated with better self-reported physical performance at age 60-64.

Our findings support previous studies that show associations of lower levels of social participation with incident self-reported functional limitations (12-14, 36). Our study adds to the body of literature by including a longer follow-up period of over 20 years. Furthermore, some previous studies included informal contact with friends and family in addition to involvement in social activities. We focused solely on social participation, as interventions to increase involvement in social activities may be more achievable through community organisations than interventions to increase contact with family and friends.

In our study, the longitudinal associations with social participation did not exist for grip strength or standing balance in fully-adjusted models.. In NSHD, TUG and chair rise speeds are more strongly correlated with each other than with the other performance measures. This may be explained by the greater overlap between TUG and chair rise tests, in that the TUG measure commences with a single chair rise Being able to successfully get up and out of a chair and walk short distances without difficulty is an important marker of healthy ageing and is likely to be closely associated with the ability to live independently.

We recognise that these associations may not exist over a long period as our analyses looking at change in social participation from 43 to 60-64 revealed that a relationship persisted only with TUG speed and standing balance and only among those who maintained high levels of social participation over time. If there was a true, independent association with social participation at 43 and physical performance at 60-64, we would expect those who were highly socially active at 43 but who decreased their social participation by 60-64 to have retained some advantage on tasks compared to those who had persistently low participation. Thus, participation in earlier life may only be important in determining activity in later life, or there may be a cumulative benefit over time.

The mechanisms that link social networks with health outcomes are likely to include a variety of behavioural, psychological and physiological processes. One explanation for our finding is that exposure to social networks in mid-life may encourage health seeking behaviours, which in turn may increase an individual's chances of maintaining physical performance (and maintaining a social role) in later life. Engaging in high levels of social participation in mid-life may therefore encourage maintenance of high social participation – and better physical performance - in later life, consistent with continuity and activity theories of ageing (37)

Moreover, affective symptoms are included in the main models which may be viewed as an over-adjustment as they may be on the causal pathway between social participation and physical performance. If so, associations between social participation and physical performance are likely to be underestimated in this study.

In our analyses those who reported moderate or high frequency of social participation at least once also self-report better physical performance at 60-64. Whilst arguably subject to the same source bias, such subjective interpretations of physical performance are highly relevant to an individual's lived experience (38-40). Psychological well-being is associated with both social engagement and subjective health (41);this may explain the difference in association with the performance-based and self-reported physical functioning measures. Social participation is likely to contribute to a sense of attachment and social reinforcement and there may exist individuals with a discordance between poor objective measures who report their own perception of performance to be good.

Strengths

An important strength of our study when compared with previous research is our use of different standardized objective performance-based measures as well as the SF-36 which enabled us to assess physical performance both objectively and subjectively. We extended our analyses to consider whether there were any associations of change in social participation over time with later-life physical performance, which allowed us to test for a cumulative effect. A further strength of this study is the long follow-up time of twenty years and high retention rates. Previous studies investigating similar relationships tend to have investigated these over short periods of time and are conducted amongst populations not assessed until later in life.

Limitations

This study focused on frequency of organised social participation and did not assess the qualitative dimension of that participation. Pleasure and satisfaction may be important if benefits of social participation are imparted through psychological mechanisms. It is plausible that benefits seen in those with persistently high social participation could be explained by reverse causation as individuals who have maintained greater social participation over these two decades are also likely to be in better health. Moreover, multiple hypothesis testing was necessary to explore putative associations with the objective and subjective outcomes. Caution is thus required when interpreting the strength of evidence presented because of the possibility of type I errors. We chose not to adjust for some specific covariates such as physical activity which may be potential confounders because they can also be conceptualised as intermediary variables i.e. altered as a result of social participation and hence any adjustment would be an "over-adjustment".

Our focus was not on the specific types of social participation that might be relevant but on the accumulation of participation in these different social activities. However, we acknowledge the potential limitations of the approach taken to characterise social participation especially as this assumes equal weight for all activities. Therefore, in additional analyses we undertook factor analysis to see if latent variable groupings could be identified, however none were revealed (all Eigen factors <1).

Conclusion

We found increased social participation in mid-life was associated with better subjective and objective measures of physical performance in later life. However, the benefits for objective measures were only seen with persistent high levels of social participation. Establishing social participation in earlier life may facilitate later interventions through habit-formation or cumulative effects, however further work will be required to establish causality.

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Conflict of Interest: None to declare

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Key Points

- Previous studies have presented evidence of a link between social engagement and physical capability. However, these studies have been limited by an almost exclusive focus on self-reported physical performance in adults already in older age (>65 years and short follow-up periods <5 years).
- Our findings suggest that sustained social participation from mid-life may be effective in improving physical performance in later life, and thus may contribute to healthy ageing.

- Establishing social participation in earlier life may facilitate later interventions through habit-formation or cumulative effects.

References

1. Beard HPJR, Bloom DE. Towards a comprehensive public health response to population ageing. Lancet (London, England). 2015;385(9968):658.

2. Cooper R, Kuh D, Cooper C, Gale CR, Lawlor DA, Matthews F, et al. Objective measures of physical capability and subsequent health: a systematic review. Age and ageing. 2010;40(1):14-23.

3. Guralnik JM, Simonsick EM, Ferrucci L, Glynn RJ, Berkman LF, Blazer DG, et al. A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. Journal of gerontology. 1994;49(2):M85-M94.

4. Kuh D, Cooper R, Hardy R, Richards M, Ben-Shlomo Y. A life course approach to healthy ageing: OUP Oxford; 2013.

5. Holt-Lunstad J, Smith TB, Layton JB. Social relationships and mortality risk: a meta-analytic review. PLoS Med. 2010;7(7):e1000316.

6. Iwasaki M, Otani T, Sunaga R, Miyazaki H, Xiao L, Wang N, et al. Social networks and mortality based on the Komo-Ise cohort study in Japan. International journal of epidemiology. 2002;31(6):1208-18.

7. Chiao C, Weng L-J, Botticello AL. Social participation reduces depressive symptoms among older adults: an 18-year longitudinal analysis in Taiwan. BMC public health. 2011;11(1):292.

8. Cruwys T, Dingle GA, Haslam C, Haslam SA, Jetten J, Morton TA. Social group memberships protect against future depression, alleviate depression symptoms and prevent depression relapse. Social Science & Medicine. 2013;98:179-86.

9. James BD, Wilson RS, Barnes LL, Bennett DA. Late-life social activity and cognitive decline in old age. Journal of the International Neuropsychological Society. 2011;17(6):998-1005.
10. Vogt TM, Mullooly JP, Ernst D, Pope CR, Hollis JF. Social networks as predictors of ischemic heart disease, cancer, stroke and hypertension: incidence, survival and mortality. Journal of clinical epidemiology. 1992;45(6):659-66.
11. Kanamori S, Kai Y, Aida J, Kondo K, Kawachi I, Hirai H, et al. Social participation and the prevention of functional disability in older Japanese: the JAGES cohort study. PloS one. 2014;9(6):e99638.
12. Escobar-Bravo M-Á, Puga-González D, Martín-Baranera M. Protective effects of social networks on disability among older adults in Spain. Archives of gerontology and geriatrics. 2012;54(1):109-16.
13. Avlund K, Lund R, Holstein BE, Due P, Sakari-Rantala R, Heikkinen R-L. The impact of structural and functional characteristics of social relations as determinants of functional decline. The Journals of Gerontology Series B: Psychological Sciences and Social Sciences. 2004;59(1):S44-S51.
14. Avlund K, Lund R, Holstein BE, Due P. Social relations as determinant of onset of disability in aging. Archives of gerontology and geriatrics. 2004;38(1):85-99.
15. James BD, Boyle PA, Buchman AS, Bennett DA. Relation of late-life social activity with incident disability among community-dwelling older adults. Journals of Gerontology Series A: Biomedical Sciences and Medical Sciences. 2011;66(4):467-73.
16. Berkman LF, Glass T, Brissette I, Seeman TE. From social integration to health: Durkheim in the new millennium☆. Social science & medicine. 2000;51(6):843-57.

17. Levasseur M, Richard L, Gauvin L, Raymond É. Inventory and analysis of definitions of social participation found in the aging literature: Proposed taxonomy of social activities. Social science & medicine. 2010;71(12):2141-9.
18. Wadsworth M, Kuh D, Richards M, Hardy R. Cohort profile: the 1946 national birth cohort (MRC National Survey of Health and Development). International journal of epidemiology. 2006;35(1):49-54.
19. Stafford M, Black S, Shah I, Hardy R, Pierce M, Richards M, et al. Using a birth cohort to study ageing: representativeness and response rates in the National Survey of Health and Development. European journal of ageing. 2013;10(2):145-57.
20. Kuh D, Bassey EJ, Butterworth S, Hardy R, Wadsworth ME, Team MS. Grip strength, postural control, and functional leg power in a representative cohort of British men and women: associations with physical activity, health status, and socioeconomic conditions. The Journals of Gerontology Series A: Biological Sciences and Medical Sciences. 2005;60(2):224-31.
21. Kuh D, Hardy R, Butterworth S, Okell L, Wadsworth M, Cooper C, et al. Developmental origins of midlife grip strength: findings from a birth cohort study. The Journals of Gerontology Series A: Biological Sciences and Medical Sciences. 2006;61(7):702-6.
22. Podsiadlo D, Richardson S. The timed "Up & Go": a test of basic functional mobility for frail elderly persons. Journal of the American geriatrics Society. 1991;39(2):142-8.
23. Ware Jr JE, Sherbourne CD. The MOS 36-item short-form health survey (SF-36): I. Conceptual framework and item selection. Medical care. 1992:473-83.
24. Mishra GD, Black S, Stafford M, Cooper R, Kuh D. Childhood and maternal effects on physical health related quality of life five decades later: the British 1946 birth cohort. PloS one. 2014;9(3):e88524.

25. Seeman TE, Berkman LF, Charpentier PA, Blazer DG, Albert MS, Tinetti ME. Behavioral and psychosocial predictors of physical performance: MacArthur studies of successful aging. The Journals of Gerontology Series A: Biological Sciences and Medical Sciences. 1995;50(4):M177-M83.
26. Balogun JA, Akinloye AA, Adenlola SA. Grip strength as a function of age, height, body weight and Quetelet index. Physiotherapy Theory and Practice. 1991;7(2):111-9.
27. Boisgontier MP, Cheval B, Chalavi S, van Ruitenbeek P, Leunissen I, Levin O, et al. Individual differences in brainstem and basal ganglia structure predict postural control and balance loss in young and older adults. Neurobiology of aging. 2017;50:47-59.
28. De Leon CFM, Glass TA, Beckett LA, Seeman TE, Evans DA, Berkman LF. Social networks and disability transitions across eight intervals of yearly data in the New Haven EPESE. The Journals of Gerontology: Series B. 1999;54(3):S162-S72.
29. Unger JB, McAvay G, Bruce ML, Berkman L, Seeman T. Variation in the impact of social network characteristics on physical functioning in elderly persons: MacArthur Studies of Successful Aging. The Journals of Gerontology Series B: Psychological Sciences and Social Sciences. 1999;54(5):S245-S51.
30. Giles LC, Metcalf PA, Glonek GF, Luszcz MA, Andrews GR. The effects of social networks on disability in older Australians. Journal of Aging and Health. 2004;16(4):517-38.
31. Eysenck HJ. A short questionnaire for the measurement of two dimensions of personality. Journal of Applied Psychology. 1958;42(1):14.
32. Shaw G, Hare E. The Maudsley Personality Inventory (Short Form). The British Journal of Psychiatry. 1965;111(472):226-35.
33. Lindelow M, Hardy R, Rodgers B. Development of a scale to measure symptoms of anxiety and depression in the general UK population: the psychiatric symptom frequency scale. Journal of Epidemiology and Community Health. 1997;51(5):549-57.

34. Goldberg DP, Gater R, Sartorius N, Ustun TB, Piccinelli M, Gureje O, et al. The validity of two versions of the GHQ in the WHO study of mental illness in general health care. Psychological medicine. 1997;27(01):191-7.
35. Sterne JA, White IR, Carlin JB, Spratt M, Royston P, Kenward MG, et al. Multiple imputation for missing data in epidemiological and clinical research: potential and pitfalls. Bmj. 2009;338:b2393.
36. James BD, Boyle PA, Buchman AS, Bennett DA. Relation of late-life social activity with incident disability among community-dwelling older adults. The Journals of Gerontology Series A: Biological Sciences and Medical Sciences. 2011:glq231.
37. Atchley RC. A continuity theory of normal aging. The gerontologist. 1989;29(2):183-90.
38. Haber LD. Issues in the definition of disability and the use of disability survey data. Disability statistics: An assessment. 1990:35-51.
39. Nagi S. Some conceptual issues in disability and rehabilitation. Sociology and rehabilitation. 1965.
40. Ueda S, Okawa Y. The subjective dimension of functioning and disability: what is it and what is it for? Disability and rehabilitation. 2003;25(11-12):596-601.
41. Maier H, Smith J. Psychological predictors of mortality in old age. The Journals of Gerontology Series B: Psychological Sciences and Social Sciences. 1999;54(1):P44-P54.

Table 1: Characteristics of the MRC National Survey of Health & Development

Exposure	**Total (n=1935)**	**Men (n= 929)**	**Women (n=1006)**
Social participation at 43 (n, %)			
Low	624 (32)	269 (29)	355 (35)
Moderate	702 (36)	338 (36)	364 (36)
High	609 (32)	322 (35)	287 (29)
Strength and physical performance at 60-64 [mean (sd)]; n varies (see footnotes)			
Grip strength (kg)[a]	35·6 (14·0)	45·5 (12·3)	26·4 (8·0)
Chair rise time (repetitions/min)[b]	24·9 (8·3)	25·4 (7·7)	24·4 (8·8)
TUG speed (cm/second)[c]	69·2 (18·0)	71·4 (19·2)	67·3 (16·6)
Standing balance time (seconds)[d]	3·4 (2·98)	3·7 (3·3)	3·1(2·8)
SF-36: Physical functioning subscale (PF) (0-100) [e]	81·3 (23·8)	84·6 (22·9)	78·3 (24·2)
Covariates			
Height at 43 (cm)	168·8 (8·9)	175·4 (6·5)	162·6 (6·0)
BMI at 43 (kg/m^2)	25·3 (4·0)	25·7 (3·4)	25·0 (4·4)
Marital status at 43 (n, %)			
Never married	104 (5)	61 (7)	43 (4)
Previously married	225 (12)	93 (10)	132 (13)
Married	1606 (83)	775 (83)	831 (83)
Educational level at 26 (n, %)			

Degree or higher	204 (11)	150 (16)	54 (5)
A levels or equivalent	530 (27)	281 (30)	249 (25)
O levels or equivalent	407 (21)	133 (14)	274 (27)
CSE, clerical course or equivalent	136 (7)	50 (6)	86 (9)
None	658 (34)	315 (34)	343 (34)
Occupational class at 43 (n, %)			
I or II (High)	859 (44)	512 (55)	347 (34)
III (Medium)	741 (38)	337 (36)	404 (40)
IV or V (Low)	240 (13)	71 (8)	169 (17)
No job since 1982	95 (5)	9 (1)	86 (9)
Smokers at 43 (n, %)			
Never	610 (32)	261 (28)	349 (35)
Ex-smoker >7yrs	706 (36)	354 (38)	352 (35)
Recent Ex-smoker	134 (7)	74 (8)	60 (6)
Current	485 (25)	240 (26)	245 (24)
Self-reported health conditions 43 (n, %)			
None	1020 (53)	520 (56)	500 (49·7)
One or more	915 (47)	409 (44)	506 (50·3)
Affective symptoms at 43 (n, %)			
Non-case	1723 (89)	855 (92)	868 (86)

Case	212 (11)	74 (8)	138 (14)
Extraversion at 26 (n, %)			
Less	666(34)	276 (30)	390 (39)
More	1269 (66)	653 (70)	616 (61)
Neuroticism at 26 (n, %)			
Less	1055 (55)	614 (66)	441 (44)
More	880 (45)	315 (34)	565 (56)

[a] men= 764, women= 818, total n=1582; [b]men= 786, women =860, total n=1646; c men= 730, women= 805, total n=1535; [d] men= 791, women= 860, total n=1651, geometric mean (Interquartile range); [e] men= 858, women = 936, total n=1794

Table 2: Associations between social participation at 43 years and physical performance at 60-64

		Frequency of group participation (tertiles)			Test for trend
		Low	**Moderate**	**High**	**P-value**
Objective	**Difference in means (95%CI)**				
Chair rise (rep/min)	**n=1646**	**n= 514**	**n= 597**	**n=535**	
Sex adjusted		Ref	0·49 (-0·48-1·46)	1·77 (0·77-2·77)	<0·01
Fully adjusted*		Ref	0·47 (-0·47-1·40)	1·42 (0·45-2·39)	<0·01
TUG speed (cm/s)	**n=1535**	**n= 469**	**n= 557**	**n=509**	
Sex adjusted		Ref	1·64 (-0·55-3·83)	3·06 (0·82-5·30)	<0·01
Fully adjusted*		Ref	2·01 (-0·12-4·14)	2·47 (0·27-4·67)	0·03
Standing balance (ln(sec))	**n=1651**	**n= 515**	**n= 599**	**n=537**	
Sex-adjusted		Ref	-0·004 (-0·07-0·06)	0·07 (-0·004-0·14)	0·06
Fully adjusted*		Ref	-0·002 (-0·07-0·06)	0·05 (-0·02-0·12)	0·16
Grip strength (kg)	**n=1582**	**n= 490**	**n= 569**	**n=523**	

Sex-adjusted		Ref	0·24 (-1·00-1·49)	0·57 (-0·70-1·84)	0·38
Fully-adjusted*		Ref	0·32 (-0·89-1·53)	0·04 (-1·20-1·28)	0·96
Subjective	**Odds ratio (95%CI)**				
Limited PF[a]	**n=1794**	**n= 575**	**n= 642**	**n=577**	
Sex-adjusted		Ref	0·81 (0·63-1·04)	0·58 (0·44-0·75)	<0·01
Fully-adjusted		Ref	0·80 (0·61- 1·05)	0·67 (0·50-0·91)	<0·01

N: sample size; CI: confidence interval.

** Adjusted for sex, occupational class at 43yrs, educational level at 26yrs, marital status, smoking status, height (cm) at 43, body mass index, affective symptoms, self-reported health conditions at 43yrs (one or more of the following: heart trouble, back pain, arthritis, chronic cough), extraversion, neuroticism. [a] Lowest quartile of the Physical function subscale of SF-36 was defined as limited physical functioning (PF)*

Table 3: Associations of change in social participation between ages 43 and 60-64 with physical performance measures at 60-64 years

	Low at 43 & 60-64	**Decrease between 43 & 60-64**	**Increase between 43 & 60-64**	**Moderate at 43 & 60-64**	**High at 43 & 60-64**	**Test for heterogenity**
Objective	**Difference in means (95%CI)**					**P-value**
Chair rise speed (rep/min) N=1368	**n= 198**	**n= 372**	**n= 348**	**n= 218**	**n= 232**	
Model 1	Ref	1·13 (-0·25-2·51)	2·36 (0·97-3·75)	1·03 (-0·51-2·57)	2·57 (1·05-4·08)	<0·01
Model 2	Ref	0·71 (-0·64-2·06)	1·27 (-0·12-2·67)	0·43 (-1·08-1·93)	1·46 (-0·08-2·99)	0·28
Model 3	Ref	0·69 (-0·65-2·02)	1·04 (-0·35-2·43)	0·38 (-1·11-1·88)	1·49 (-0·39-3·02)	0·35
TUG speed (cm/s) N=1286	**n= 178**	**n= 346**	**n= 331**	**n= 204**	**n= 227**	
Model 1	Ref	2·09 (-0·99-5·17)	4·23 (1·13-7·33)	2·45 (-0·98-5·87)	6·21 (2·88-9·56)	<0·01
Model 2	Ref	1·41 (-1·65-4·46)	2·24 (-0·90-5·37)	1·57 (-1·82-4·96)	4·13 (0·73-7·54)	0·18
Model 3	Ref	1·33 (-1·69-4·35)	1·98 (-1·14-5·11)	1·53 (-1·84-4·90)	4·48 (1·08-7·89)	0·11

Standing balance (ln (secs)) N=1370	**n= 199**	**n= 374**	**n= 347**	**n= 218**	**n= 232**	
Model 1	Ref	0·05 (-0·04-0·15)	0·13 (0·04-0·23)	0·06 (-0·05-0·17)	0·20 (0·09-0·31)	<0·01
Model 2	Ref	0·04 (-0·06-0·13)	0·06 (-0·04-0·16)	0·03 (-0·08-0·14)	0·12 (0·01-0·23)	0·22
Model 3	Ref	0·04 (-0·05-0·14)	0·06 (-0·04-0·16)	0·03 (-0·08-0·14)	0·15 (0·04-0·26)	0·07
Grip Strength (kg) N=1314	**n= 187**	**n= 357**	**n= 335**	**n= 209**	**n= 226**	
Model 1	Ref	0·24 (-1·52-1·99)	1·64 (-0·13-3·41)	1·99 (0·03-3·94)	1·28 (-0·64-3·20)	0·10
Model 2	Ref	-0·36 (-2·07-1·36)	0·55 (-1·22-2·32)	1·14 (-0·77-3·05)	-0·12 (-2·06-1·82)	0·42
Model 3	Ref	-0·28 (-1·99-1·43)	0·37 (-1·40-2·14)	1·11 (-0·79-3·02)	-0·18 (-2·13-1·76)	0·51
Subjective	**Odds ratio (95%CI)**					
Limited PF N=1364	**n= 200**	**n= 373**	**n= 343**	**n= 217**	**n= 231**	
Model 1	Ref	0·56 (0·38-0·81)	0·37 (0·25-0·54)	0·49 (0·32-0·75)	0·36 (0·23-0·56)	<0·01
Model 2	Ref	0·59 (0·40-0·88)	0·48 (0·31-0·73)	0·57 (0·36-0·90)	0·50 (0·31-0·81)	0·01
Model 3	Ref	0·56 (0·37-0·86)	0·49 (0·31-0·77)	0·55 (0·34-0·89)	0·43 (0·26-0·73)	0·01

Model 1: adjusted for sex

Model 2: adjusted for Model 1, BMI at 43 and height at 43, educational level at 26 and occupational class at 43, self-reported health conditions at 43, extraversion, neuroticism, and affective symptoms at 43

Model 3: adjusted for Model 2, BMI at 60-64, psychiatric morbidity at 60-64, change in marital status from 43 to 60-64, retirement status at 60-64, financial stability at 60-64, and smoking history up to 60-64

[a] *Lowest quartile of the Physical function subscale of SF-36 was defined as limited physical functioning (PF)** Test of association was analysed using a likelihood ratio test.*