

INJURY

TITLE PAGE

Title: Trajectory of physical activity after hip fracture: an analysis of community-dwelling individuals from the English Longitudinal Study of Ageing.

Running title: Trajectories of physical activity pre/post-hip fracture

Authors: Tariq Aboelmagd¹, Jack R Dainty², Alex MacGregor², Toby O Smith³

Affiliations:

1. Trauma and Orthopaedics Department. Royal Berkshire Hospital, Reading, UK.
2. Norwich Medical School, University of East Anglia, Norwich, UK
3. Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Sciences, University of Oxford, UK

Corresponding Author: Dr Toby Smith, Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Sciences, Botnar Research Centre, Nuffield Orthopaedic Centre, Windmill Road, Oxford, OX3 7LD. Email: toby.smith@ndorms.ox.ac.uk. Telephone 044 (0)1865 223673

ABSTRACT

INTRODUCTION: To analyse physical activity participation in a community-dwelling people in England with hip fracture the interval prior to fracture, in the fracture recovery period, and a minimum of two years post-fracture.

MATERIALS AND METHODS: 215 individuals were identified from the English Longitudinal Study of Ageing cohort (2002-2014) who sustained a hip fracture following a fall and for whom data were available on physical activity participation relating to the period pre-fracture, within-fracture recovery phase and post-fracture (minimum of two years). Physical activity was assessed using the validated ELSA physical activity questionnaire. Prevalence of 'low' physical activity participation was calculated and multi-level modelling analyses were performed to explore physical activity trajectories over the follow-up phase, and whether age, depression, gender and frailty were associated with physical activity participation.

RESULTS: Prevalence of low physical activity participation within two years prior to hip fracture was 16.7% (95% Confidence Intervals (CI): 11.6% to 21.8%). This increased at the final follow-up phase to 21.3% (95% CI: 15.1% to 27.6%). This was not a statistically significant change ($P=0.100$). Age ($P=0.005$) and frailty ($P<0.001$) were statistically significant explanatory variables ($P=0.005$) where older age and greater frailty equated to lower physical activity participation. Neither gender ($P=0.288$) nor depression ($P=0.121$) were significant explanatory variables.

CONCLUSION: Physical activity levels do not significantly change between pre-fracture to a minimum of two years post-hip fracture for community-dwelling individuals. This contrasts with previous reports of reduced mobility post-hip fracture, suggesting that 'physical activity' and 'mobility' should be considered as separate outcomes in this population.

KEYWORDS: Physical activity; fracture; femur; recovery; longitudinal; community-dwelling

INTRODUCTION

Hip fractures are a major challenge for individuals who sustain them and for health services worldwide. Approximately 65,000 hip fractures occur each year in England, Wales and Northern Ireland [1]. Patients who sustain a hip fracture are typically elderly and frail, and their one-year post fracture mortality is reported to be as high as 30% [1,2].

Physical activity can be defined as any bodily movement produced by skeletal muscle that requires energy expenditure [3], and is a fundamental factor contributing to an individuals' health and wellbeing. Physical inactivity is the fourth leading risk factor for mortality globally [3]. Physical activity has been advocated to improve bone mineral density, reduce the risk of developing type 2 diabetes, breast cancer, dementia, obesity and depression [4]. Public Health England [5] recommend that people over the age of 65 years participate in at least 150 minutes of moderate intensity activity per week. However only 58% of men and 52% of women aged 65 to 74 years old, and 43% of men and 21% of women aged 75-84 years old in England meet these recommendations [6].

The United Kingdom National Health Survey has shown that physical activity levels decline with age [6]. Patients with hip fracture are particularly vulnerable to inactivity with previous literature demonstrating that mobility reduces following hip fracture [7]. This decline has been estimated where approximately 43% of people following hip fracture do not reach their pre-fracture level of mobility [7]. However, it remains unclear whether physical activity *per se*, rather than just mobility, changes before compared to after a hip fracture and how these may change over time, and what pre-fracture patient characteristics may be associated with post-fracture physical activity levels. The purpose of this study was to answer these questions using data from the English Longitudinal Study of Ageing (ELSA).

MATERIALS AND METHODS

ELSA Cohort

Data were drawn from the ELSA cohort. The ELSA cohort study was initiated in 2002. This is a prospective cohort study of English community-dwelling adults born on or before February 29th 1952, and was designed to examine the relationship between health, economic position and activity, social participation, productivity, networks and support [8,9].

From the 2002/2003 inception, participants are contacted every two years for a follow-up interview. It is a nationally representative sample of the non-institutionalised population, living in England, aged 50 years or older at the initial interview [8]. A total of 11,391 participants were recruited at the first data collection phase (Wave 1). The waves analysed in this study co-incided with the 2004/2005 to 2014/2015 follow-up phases.

Ethical approval was obtained from the National Research Ethics Service (MREC/01/2/91). Anonymised unlinked data for this sample was provided by the UK Data Service.

Participant Identification

In this present analysis, we identified all people who self-reported that they had sustained a surgically managed hip fracture. Data were collected to categorise the trajectory of each participant's physical activity levels in the wave prior to the hip fracture (within two years), the wave when the hip fracture occurred, and the subsequent wave (minimum of two years).

Data Collection

The primary outcome measure to estimate physical activity was the self-reported ELSA physical activity questions (ELSA-PAQ) where participants were asked how often they engaged in vigorous, moderate or mild physical activity [10,11]. For each type of activity, participants responded either as being: very active (more than once a week), active (once a week), moderately active (one to three times per month), and inactive (hardly ever/never). This method has been previously used to determine the level of physical activity participation undertaken by older people [10,11], and has demonstrated excellent convergent validity within this population [12]. From this measure, a summary index of physical activity was derived as described by Garfield et al [10], by summing responses to the three physical activity items each dichotomized around the frequency cut-point of once a week or more often. Using this approach, physical activity was analysed as: (1) sedentary (mild exercise one to three times a month, no moderate or vigorous activity); (2) low (mild, but no vigorous activity at least once a week); (3) moderate (moderate activity more than once a week, or vigorous activity between once a week to one to three times a month); and (4) high (heavy manual work or vigorous activity more than once a week).

Baseline data were taken from the pre-fracture assessment on age, gender and ethnic classification (white/non-white). Self-reported depressive symptoms were assessed using the eight-item version of Centre for Epidemiologic Studies Depression (CES-D) scale, with a cut-off value of four to classify someone with depressive symptoms [13]. Finally, the ELSA Frailty Index (ELSA FI) was calculated

[14,15]. This is a validated measure of frailty and has been reported as a predictor of mortality and institutionalisation [16,17,18]. It includes data on functional and sensory impairments, self-reported comorbidities, self-rated health and global cognitive function. Through this, 'robust' participants had an ELSA FI score of <0.2, 'pre-frail' were 0.2-0.35 and 'frail' were >0.35 (Wade et al, 2016).

Data Analysis

We analysed the data descriptively with summary statistics. Physical activity was assessed by determining the prevalence of 'low' participation in physical activity with 95% confidence intervals calculated for baseline and each of the follow-up phases.

Multilevel modelling approach was applied to take account of the lack of independence within the data. The method was used to determine whether the physical activity differed (significantly) between any two 'Time' points (levels=pre-fracture phase, fracture/recovery phase, post-fracture follow-up phase). Random intercept models (fixed slope) were compared to random intercept and (random) slope models. In all cases, the random intercept models (fixed slope) were preferred (due to model parsimony/best fit tests). Change of physical activity over time was assessed between the three consecutive time periods (Time=base (pre-fracture phase), Time=during (recovery phase), Time=post (minimum of two years post-fracture follow-up phase)). 'Age' (continuous), 'Gender' (factor: male/female), 'Depressed' (factor: self-reported yes/no) and 'ELSA Frailty Index' (continuous) were included as explanatory variables (in addition to the factor variable, 'Time') to explain some of the other variation in physical activity participation. We performed an age-stratification analysis where change in physical activity was stratified into two halves (50 to 72 years versus 73 to 89 years) by reference to the median age (72 years).

All analyses were performed using the R Statistics program (R Foundation for Statistical Computing, Vienna, Austria) using the 'lmer' function in the 'lme4' package.

RESULTS

Of the 11,391 participants at inception, 280 single hip fractures were surgically managed during the study time-frame. Of these, full data were available at the three follow-up phases for 215 participants. Accordingly 65 participants were excluded from the analysis due to missing data. The demographic characteristics of these participants is presented in Table 1. This included 80 males and 135 females

with a mean age of 71.8 years. The mean ELSA Frailty Index at pre-fracture assessment was 0.23 indicating the cohort had a mean index which was 'pre-frail'.

Prevalence

The prevalence of 'low' physical activity pre-fracture was 16.7% (95% CI: 11.6% to 21.8%). This increased at the post-fracture follow-up phase to 21.3% (95% CI: 15.1% to 27.6%). This trend was not observed for those in age 50 to 72 year old age-stratified analysis (pre-fracture: 10.9% vs. final follow-up: 9.8%), but the prevalence of 'low' physical activity participation did increase in those aged 73 to 89 years (pre-fracture: 17.0% vs. post-fracture follow-up phase: 33.8%). This indicates that there is a large difference in prevalence in 'low' physical activity at final follow-up between the two age groups (17.0% aged 50 to 72 years versus 33.8% aged 73 to 89 years).

Trajectory for Physical Activity

When controlled for age and gender, there was no statistically significant difference in physical activity (when assessed as a cumulative assessment of all three measures) at pre-fracture to post-recovery phase ($P=0.100$; Figure 1). This remained consistent within age strata analysis (aged 50 to 72: $P=0.152$; aged 73 to 89: $P=0.992$). Similarly, there was no statistically significant difference between pre-fracture and the fracture/recovery phase ($P=0.285$) or between the fracture/recovery phase and post-fracture follow-up phase ($P=0.910$) (Table 2).

Explanatory Variables

Age was a statistically significant explanatory variable ($P=0.005$) with an older age equating to lower physical activity participation. The ELSA Frailty Index was also a significant explanatory factor. Those who reported greater frailty demonstrated lower physical activity participation ($P<0.001$). This relationship with frailty was evident within age strata (aged 50 to 72: $P<0.001$; aged 73 to 89: $P<0.001$).

Neither gender ($P=0.288$) nor depression ($P=0.121$) were significant explanatory variables in this analysis, and no association within age strata (Table 2).

DISCUSSION

The results of this analysis indicate that there is no significant difference in physical activity levels two years following a hip fracture for individuals compared to levels reported two years prior to fracture. Approximately 40% of people are physically inactive within two years after hip fracture. Physical

activity levels were shown to decrease with age. Whilst frailty was shown to be a significant explanatory variable, where increased frailty leads to less physical activity, depression was not.

The analysis indicated that physical activity participation, as assessed by overall levels of physical activity, did not significantly change from pre-operative to a minimum of two years post-fracture. This is in contrast to previous literature which has suggested that mobility declines following hip fracture, with approximately 43% of survivors after hip fracture not returning to pre-fracture level of mobility and 13% who were previous ambulant unable to walk [7,19]. The disagreement between our results and these may be firstly attributed to the specific cohort characteristics assessed in this analysis. This analysis only included community-dwelling participants, with those who demonstrated the greatest physical and cognitive impairment at initial assessment not enrolled. Nonetheless, the findings suggest that for this specific sub-set of the hip-fracture population, decline in overall physical activity may not be as dramatic as previously thought, where prevalence of those participating in 'low' levels of physical activity did not significantly change over time. Whilst inferences therefore cannot be made on those who live in institutional care, this does provide an indication that within an English cohort, return to overall physical activity is achievable and does occur following this fracture. Secondly, this result also reinforces the notion that physical activity is more complex than just mobility, and encompasses other physical components such as social interaction, functional participation and physical engagement [7].

Whilst the levels of physical activity did not appear to significantly change post-fracture, there remains a significant proportion of this population which demonstrate either sedentary or mild levels of physical activity participation post-fracture (21% and 18% respectively). Given the wealth of literature on the health and social benefits of being physically active within older age [4], there is therefore a need to intervene post-recovery with greater physical activity strategies within this population. Further consideration should be given to potential barriers and facilitators to physical activity for people following hip fracture.

Age was reported as a significant predictor of physical activity participation; this agrees with previous understanding [20,21]. Paganini-Hill et al [22] reported the risk of falling and recurrent falls at age 90 years and over was 35 to 45% lower in those reporting 30 minutes/day or more of active physical activity aged 60 to 70 years compared with no activity. Given the mean age of this cohort was 72 years, targeting those who are least likely to be physically active following an earlier fracture may lead to greater benefit. Similarly frailty was a significant explanatory variable where increased frailty led to reduced physical activity. This is an important finding as it provides further justification for a targeted rehabilitation programme for those individuals identified as frail or pre-frail following a hip fracture.

Whilst it has been previously reported that approximately 5% of people who sustain a hip fracture are frail [23,24], this population have a significantly higher risk of recurrent falls (hazard ratio (HR): 1.48, $P=0.003$), secondary hip fracture (HR: 1.87, $P=0.04$), and death (HR: 2.32, $P<0.001$) compared to those who are not frail. Given the findings that this population may also have a greater risk of physical inactivity to further increase this risk, multi-component interventions to enhance the management of this subgroup of the hip fracture population are warranted.

Four potential limitations should be acknowledged. Firstly, the method of assessing physical activity, whilst valid and reliable, is self-reported and provides the potential for cognitive bias as a subject's perception of what may constitute vigorous exercise may differ over the follow-up. Secondly, due to missing data, this analysis was not able to consider the effects of co-morbidities as an explanatory variable for levels of physical activity. Katsanos et al [25] has shown that co-morbidities such as cardiovascular disease and dementia are independent predictors of one-year mortality following a hip fracture. Furthermore, we were unable to analyse the effects of the type of hip fracture sustained or the type of surgical intervention (e.g. dynamic hip screw, hemiarthroplasty) on physical activity following hip fracture as these were not reported in the dataset. Thirdly, attrition bias may have impacted on the findings. Sixty-five participants were excluded from the analysis due to missing physical activity and key characteristics/demographic data. Given the latter, it was not possible to ascertain whether this subgroup of the overall cohort substantially differed from the 215 analysed. Finally, whilst there were no significant differences in physical activity between the fracture/recovery phase and both the pre-fracture and post-recovery phase levels, we are unable to quantify whether there were any differences within these periods due to the data collection being limited to discrete collection periods ('waves'). Whilst it is to be expected that there would be a reduction in physical activity levels specifically surrounding the time of fracture, the data suggests that following a period of recovery there is no statistical difference between post recovery and pre-fracture physical activity levels.

CONCLUSION

This study has shown that overall physical activity does not decrease following a hip fracture in the non-institutionalised population. However, approximately 40% of people are physically inactive within two years after hip fracture. Increasing age and frailty was associated with declining physical activity participation. This population should therefore be targeted toward physical activity

interventions to ensure that they have specific support to increase overall physical and psychological health which physical activity can potentially offer following their rehabilitation.

FIGURE AND TABLE LEGENDS

Table 1: Baseline demographic characteristics

Table 2: Frequency of self-reported physical activity participation at sedentary, mild, moderate and high intensities.

Figure 1. Scatter-graph depicting the change in physical activity (jittered) when assessed at the three follow-up phases. Dashed red line represents a multilevel model fit to the data.

DECLARATIONS

FUNDING: No project funding was received in relation to this paper. Dr Toby Smith is supported by funding from the National Institute for Health Research (NIHR) Oxford Health Biomedical Research Centre.

ACKNOWLEDGEMENTS: None.

ETHICAL APPROVAL: Ethical approval was obtained from the National Research Ethics Service (MREC/01/2/91).

REFERENCES

1. Royal College of Physicians. *National Hip Fracture Database Annual Report 2016*. London: RCP; 2016.
2. Leal J, Gray AM, Prieto-Alhambra D, Arden NK, Cooper C, Javaid MK, et al. Impact of hip fracture on hospital care costs: a population-based study. *Osteoporos Int* 2016;**27**:549–58.
3. World Health Organisation. No Title [Internet]. Accessed: 13 November 2017. Available from: http://www.who.int/topics/physical_activity/en/
4. Rhodes RE, Janssen I, Bredin SSD, Warburton DER, Bauman A. Physical activity: Health impact, prevalence, correlates and interventions. *Psychol Health* 2017;**30**:1-34.
5. Public Health England. Everybody Active, Every Day. Public Health England. Accessed: 13 November 2017. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/353384/Everybody_Active__Every_Day_evidence_based_approach_CONSULTATION_VERSION.pdf
6. Scholes S, Mindell J. Physical activity in adults. *Heal Soc Care Infrormation Centre HSE*. 2012;**1**:1–49.
7. Mariconda M, Costa GG, Cerbasi S, Recano P, Orabona G, Gambacorta M, et al. Factors predicting mobility and the change in activities of daily living after hip fracture: a 1-year prospective cohort study. *J Orthop Trauma* 2016;**30**:71-7.
8. Steptoe A, Breeze E, Banks J, Nazroo J. Cohort profile: The English Longitudinal Study of Ageing. *Int J Epidemiol* 2013;**42**:1640–8.
9. Bowling A, Windsor J. The effects of question order and response-choice on self-rated health status in the English Longitudinal Study of Ageing (ELSA). *J Epidemiol Comm Health* 2008;**62**: 81-5.
10. Garfield V, Llewellyn CH, Kumari M. The relationship between physical activity, sleep duration and depressive symptoms in older adults: The English Longitudinal Study of Ageing (ELSA). *Prev Med Rep* 2016;**4**:512-6.
11. Demakakos P, Hamer M, Stamatakis E, Steptoe A. Low-intensity physical activity is associated with reduced risk of incident type 2 diabetes in older adults: evidence from the English Longitudinal Study of Ageing. *Diabetologia* 2010;**53**:1877–85.
12. Hamer M, Molloy GJ, de Oliveira C, Demakakos P. Leisure time physical activity, risk of depressive symptoms, and inflammatory mediators: the English Longitudinal Study of Ageing. *Psychoneuroendocrinology* 2009;**34**:1050–5.
13. Radloff LS. The CES-D scale: a self-report depression scale for research in the general population. *Appl Psychol Meas* 1977;**1**:385–401.
14. Stafford M, McMunn A, Zaninotto P, Nazroo J. Positive and negative exchanges in social relationships as predictors of depression: evidence from the english longitudinal study of aging. *J Aging Health* 2011;**23**:607–28.

15. Wade KF, Marshall A, Vanhoutte B, Wu FC, O'Neill TW, Lee DM. Does pain predict frailty in older men and women? Findings from the English Longitudinal Study of Ageing (ELSA). *J Gerontol A Biol Sci Med Sci* 2017;**72**:403-409.
16. Rockwood K, Mitnitski A, Song X, Steen B, Skoog I. Long-term risks of death and institutionalization of elderly people in relation to deficit accumulation at age 70. *J Am Geriatr Soc* 2006;**54**:975-979.
17. Ravindrarajah R, Lee DM, Pye SR, Gielen E, Boonen S, Vanderschueren D, et al. The ability of three different models of frailty to predict all-cause mortality: results from the European Male Aging Study (EMAS). *Arch Gerontol Geriatr* 2013;**57**:360-368.
18. Shankar A, McMunn A, Banks J, Steptoe A. Loneliness, social isolation, and behavioral and biological health indicators in older adults. *Health Psychol* 2011;**30**:377-385.
19. Bertram M, Norman R, Kemp L, Vos T. Review of the long-term disability associated with hip fractures. *Inj Prev* 2011;**17**:365-370.
20. Guiney H, Keall M, Machado L. Physical activity prevalence and correlates among New Zealand older adults. *J Aging Phys Act* 2017:In Press.
21. Hawkins SA, Cockburn MG, Hamilton AS, Mack TM. An estimate of physical activity prevalence in a large population-based cohort. *Med Sci Sports Exerc* 2004;**36**:253-260.
22. Paganini-Hill A, Greenia DE, Perry S, Sajjadi SA, Kawas CH, Corrada MM. Lower likelihood of falling at age 90+ is associated with daily exercise a quarter of a century earlier: The 90+ Study. *Age Ageing* 2017:In Press.
23. Zaslavsky O, Zelber-Sagi S, Gray SL, LaCroix AZ, Brunner RL, Wallace RB, et al. Comparison of frailty phenotypes for prediction of mortality, incident falls, and hip fracture in older women. *J Am Geriatr Soc* 2016;**64**:1858-1862.
24. Tom SE, Adachi JD, Anderson FA Jr, Boonen S, Chapurlat RD, Compston JE, et al. Frailty and fracture, disability, and falls: a multiple country study from the global longitudinal study of osteoporosis in women. *J Am Geriatr Soc* 2013;**61**:327-334.
25. Katsanos S, Mavrogenis AF, Kafkas N, Sardu C, Kamperidis V, Katsanou P, et al. Cardiac biomarkers predict 1-year mortality in elderly patients undergoing hip fracture surgery. *Orthopedics* 2017;**40**:e417-e424.

INJURY

CONFLICT OF INTEREST STATEMENT

Title: Trajectory of physical activity after hip fracture: an analysis of community-dwelling individuals from the English Longitudinal Study of Ageing.

Authors: Tariq Aboelmagd¹, Jack R Dainty², Alex MacGregor², Toby O Smith³

Affiliations:

1. Trauma and Orthopaedics Department. Royal Berkshire Hospital, Reading, UK.
2. Norwich Medical School, University of East Anglia, Norwich, UK
3. Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Sciences, University of Oxford, UK

CONFLICTS OF INTEREST:

Tariq Aboelmagd, Jack Dainty, Alex MacGregor, and Toby Smith declare that they have no conflict of interest (11th January 2018)

Figure 1. Scatter-graph depicting the change in physical activity (jittered) when assessed at the three follow-up phases. Dashed red line represents a multilevel model fit to the data.

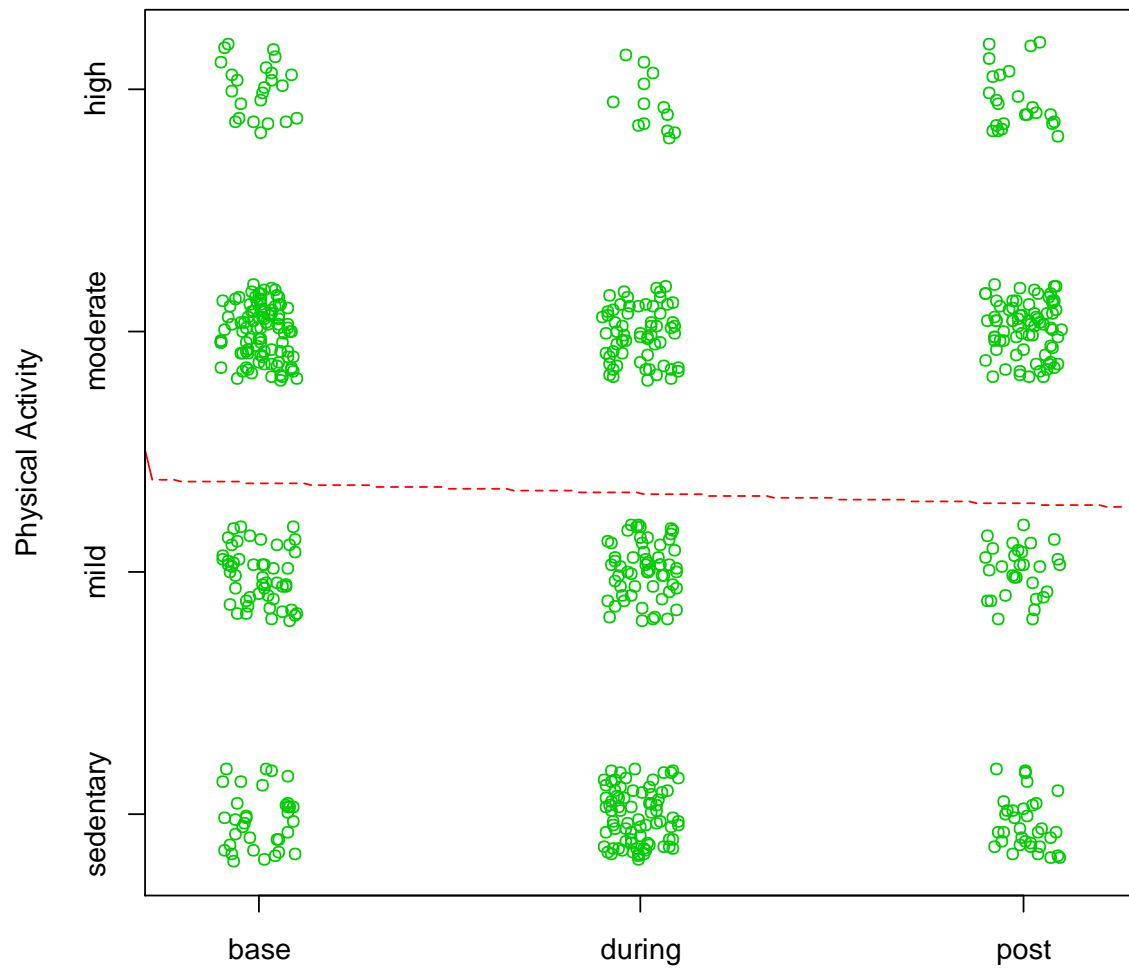


Table 1: Baseline demographic characteristics

Characteristics	Cohort
Gender (m/f)	80/135
Age in years (mean; SD)	71.8 (9.6)
Ethnic Group (%)	58.6: White 15.8: Non-white 25.6: Not reported
Self-reported comprised balance (%)	4.2: Always 3.7: Very often 3.3: Often 14.0: Sometimes 25.6: Never 48.8: Not reported
Self-reported dizziness (%)	0.9: Always 1.9: Very often 1.4: Often 8.4: Sometimes 37.7: Never 50.2: Not reported
Self-reported depression (CES-D defined; %)	16.0: Yes 84.0: No
ELSA Frailty Index (mean; SD)	0.23 (0.17)

CES-D – Centre for Epidemiologic Studies Depression Scale; ELSA – English Longitudinal Study of Ageing; F – female; M – male; SD – standard deviation

Table 2: Frequency (% with 95% confidence intervals) of self-reported physical activity participation at sedentary, mild, moderate and high intensities for the cohort and age stratified.

Physical Activity Levels	Pre-Fracture Phase	Fracture-Recovery Phase	Post-Fracture Follow-Up Phase
Cohort (N=215)			
Sedentary	16.7 (12.3 to 22.3)	36.7 (30.6 to 43.4)	21.3 (16.5 to 27.4)
Mild	24.4 (19.0 to 30.3)	27.9 (22.3 to 34.3)	18.3 (13.6 to 23.8)
Moderate	47.4 (40.9 to 54.1)	29.3 (23.6 to 35.7)	45.7 (39.1 to 52.3)
High	11.5 (8.0 to 16.6)	6.0 (3.6 to 10.1)	14.6 (10.4 to 19.7)
Age-Stratified: 50 years to 72 years			
Sedentary	10.9 (7.2 to 15.5)	30.4 (24.5 to 36.7)	9.8 (6.5 to 14.5)
Mild	13.9 (10.0 to 19.2)	21.6 (16.5 to 27.4)	13.4 (9.6 to 18.7)
Moderate	60.4 (53.8 to 66.8)	39.2 (32.8 to 45.7)	54.9 (48.2 to 61.4)
High	14.9 (10.7 to 20.3)	8.8 (5.7 to 13.4)	22.0 (16.9 to 27.9)
Age-Stratified: 73 years to 89 years			
Sedentary	17.0 (12.8 to 22.8)	36.4 (30.2 to 42.9)	33.8 (28.6 to 40.5)
Mild	35.1 (28.8 to 41.5)	37.4 (31.0 to 43.8)	25.7 (26.2 to 31.8)
Moderate	39.4 (33.2 to 46.2)	23.2 (18.1 to 29.4)	32.4 (26.7 to 39.1)
High	8.5 (5.4 to 12.8)	3.0 (1.3 to 6.0)	8.1 (5.0 to 12.3)