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Title Page

Title: Trajectory of physical activity following total hip and knee arthroplasty: data from the English Longitudinal Study of Ageing (ELSA) cohort.

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ABSTRACT

Purpose: To determine the prevalence and trajectory of physical activity levels in people before and after total hip (THA) and total knee arthroplasty (TKA).

Materials and Methods: An analysis of the English Longitudinal Study of Ageing (ELSA) (2004/5 to 2014/15) cohort study, a prospective study of community-dwelling older adults. 201 people who received a THA or TKA for the management of osteoarthritis were identified. Physical activity was assessed through the frequency of engagement in sedentary, mild, moderate and high physical activity levels pre-operatively, during the recovery phase and a minimum of two years' post-operatively.

Results: There was a statistically significant decrease in physical activity from the pre-arthroplasty phase to the operative-recovery phase ($p<0.01$), and a significant increase in physical activity from the operative-recovery phase to final follow-up ($p=0.05$). However, overall there was no significant change in physical activity from pre-operatively to final follow-up where prevalence altered from 8% (95% Confidence Intervals (CI): 5% to 12%) to 13% (95% CI: 9% to 18%)($p=0.15$). Increasing age, male gender and greater depressive symptoms were explanatory variables associated with physical inactivity ($p<0.02$).

Conclusion: Physical activity does not increase following THA or TKA. A proportion of the arthroplasty population remain physically inactive.

Keywords: Joint replacement; osteoarthritis; longitudinal; exercise; rehabilitation

INTRODUCTION

Total hip (THA) and knee (TKA) arthroplasty are two of the most common and successful orthopaedic surgery procedures undertaken worldwide [1]. These operations are projected to increase annually to an estimated 95,877 THAs and 118,666 TKAs by 2035 in the United Kingdom alone [2]. This increase mirrors trends reported from the United States [3], the Netherlands [4] and Nordic countries [5]. Although a proportion of these procedures are performed for patients under the age of 55 years [6,7], within the literature, the mean patient age ranges from 68 to 74 years [1,8]. The aim of both THA and TKA is to reduce the pain and disability associated with degenerative joint disease, to facilitate greater quality of life and increased physical activity engagement [9,10].

Physical activity is a generic term which encompasses active living, active transport, and sports and exercise [11]. Active living includes the participation in household and social activities such as gardening, housework, shopping and recreational pursuits [12]. Active transport is defined as the expenditure of physical energy by an individual to move from one place to another [13]. Finally exercises most commonly undertaken by people before and following arthroplasty have been reported as walking, cycling, golf and swimming [14,15].

Physical inactivity is a leading cause of mortality worldwide [16]. It has been estimated that between 6% to 10% of all deaths from non-communicable diseases are attributed to physical inactivity [17]. There is an established body of literature supporting the adoption and maintenance of physical activity in individual's lifestyles [16-18]. Physical and mental health benefits associated with undertaking regular physical activity have included reduced risk of cardiovascular diseases and diabetes, enhanced

mental wellbeing with decreased anxiety and depressive symptoms, and lower risk of some cancers [18].

It may be expected that physical activity should increase through pain relief following THA and TKA [19]. However the qualitative evidence suggests that this may not be the case [20]. Individuals may have considerable reluctance to increase physical activity following lower limb arthroplasty [20]. Previous quantitative analyses have provided variable and inconsistent conclusions on physical activity after THA and TKA [21-28]. However, the current evidence-base has focused on assessing changing participatory levels of sports and exercise, rather than lower levels of physical activity pursuits which may be more typical of the majority of the arthroplasty population [12]. It is also unclear whether these behaviours change over time.

Previous research provides important insights into the potential relationship between physical activity and arthroplasty. However this has been limited through potential recall bias, being largely collected retrospectively or through telephone interviews [26]. Furthermore, changes in physical activity have previously only been assessed over two time-points i.e. pre- versus post-arthroplasty, rather than over a number of intervals to assess trajectory. Data collected as part of a longitudinal, community-dwelling, cohort study, such as the English Longitudinal Study of Ageing (ELSA), would therefore negate these limitations. Accordingly, the purpose of this analysis was to determine the prevalence of physical inactivity in people following THA or TKA, and secondly to examine whether physical activity levels change pre-arthroplasty to a minimum of two years post-arthroplasty, by ascertaining the trajectory over time.

METHODS

ELSA Cohort

Data were drawn from the English Longitudinal Study of Ageing (ELSA) cohort. The methods, sampling and data collection procedures for ELSA have been fully reported elsewhere [29]. The ELSA cohort study commenced in 2002. It is a study of community-dwelling adults born on or before February 29th 1952. It aims to examine the relationship between health, economic position and activity, social participation, productivity, networks and support [30]. It includes a nationally representative sample of the non-institutionalised population, living in England, aged 50 years or older at the initial interview [30]. From the 2002/2003 inception, participants are contacted every two years for a follow-up interview. Participants are also contacted every four years for a medical examination. A total of 11,391 participants were recruited at the first data collection phase.

Ethical approval was given by the London Multi-Centre Research Ethics Service (MREC/01/2/91) and written informed consent obtained from all participants. Anonymised unlinked data for this sample were provided by the UK Data Service.

Participant Identification

In this present analysis, we identified all people who self-reported having undergone a primary THA or TKA within a 10-year follow-up interval (2004/2005 to 2014/2015). This ensured that physical activity participation could be determined within the assessment prior to their THA or TKA (within two years) termed 'pre-operative phase', the assessment visit during the arthroplasty and recovery occurred, termed 'operative-recovery phase' and the subsequent assessment visit (two to four-years post-arthroplasty), termed 'final follow-up phase'. We only included unilateral THA or TKA where the indication for surgery was non-trauma. We excluded people who had undergone unicompartmental knee or isolated patellofemoral arthroplasty, and those who underwent hip hemiarthoplasty or resurfacing procedures.

Measurements

The primary outcome for physical activity participation was self-reported by asking participants how often they engaged in mild, moderate or vigorous physical activity within the follow-up face-to-face interviews. Before answering, participants were provided with cue cards to understand potential examples for these three types of activities. Examples of mild activities included laundry and home repairs, moderate intensity activities included gardening, walking at a moderate pace, dancing and cleaning a car, whilst vigorous intensity exercises included running, swimming, cycling, aerobic/gym workout, tennis or digging with a spade. 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). We derived a summary index of physical activity by summing responses to the three physical activity items once dichotomized around the frequency cut-point of once a week or more often, as described by Garfield et al [31]. Through this, physical activity was analyses 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). This physical activity assessment method has been previously used to determine the level of physical activity participation undertaken by older people [31,32], and has demonstrated excellent convergent validity within this population [33].

Based on the pre-arthroplasty (2004/2005) assessment, data were collected on age, gender, ethnic classification (white/non-white), self-reported hip, knee, foot and low back pain visual analogue score and self-reported difficulties with dizziness and balance with possible responses being: 'always', 'very often', 'often', 'sometimes', or 'never'. Self-reported depressive symptoms were assessed using the eight-item version of Center for Epidemiologic Studies Depression (CES-D) scale, with a cut-off value of four to classify someone with depressive symptoms [34].

Data Analysis

Demographic characteristics for this cohort were reported using mean and standard deviations values and frequencies. The frequencies of responses for each of the four indexed catagorise [31] of physical activity were calculated at each assessment time-point. Prevalence of the four different physical inactivity levels with 95% confidence intervals (CI) were calculated for each of the three assessment phases.

Multilevel modelling was used to determine whether the 'Time' variable was significant between the three consecutive time periods (Time=base (pre-operative phase), Time=during (recovery phase), Time=post_1 (minimum of two years post-operative)). Random intercept models were compared to random intercept and slope models. In all cases, the random intercept models were preferred (due to model parsimony/best fit tests). 'Age' (continuous), 'Gender' (factor: male/female), 'Arthroplasty' (factor: THA/TKA) and 'Depressed' (factor: self-reported yes/no) 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 61 to 72 years or 73 to 89 years by reference to the median age (72 years).

All analyses were performed in the R Statistics program (R Core Team (2015). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.) using the 'lmer' function in the 'lme4' package. For all analyses, a p-value of ≤0.05 was deemed as statistically significant.

RESULTS

Participant Characteristics

Of the 11,391 participants in the ELSA dataset, data were available across the three assessment intervals for 201 individuals. This is itemised in **Figure 1**. The demographic characteristics of these participants are presented in **Table 1**. An analysis of the characteristics of the 201 participants included in the overall analysis and the 318 participants where complete physical activity data was not available was performed. This indicated no substancial difference between the groups in respect to mean age (Cohort: 73.1 years vs. Incomplete Data Cohort: 70.5 years), gender (Cohort: 44% male/56% female vs. Incomplete Data Cohort: 33% male/67% female) and percentage at baseline who presented with depressive symptoms (Cohort: 13% vs. Incomplete Data Cohort: 18%).

Trajectory of Physical Activity

Table 2 illustrates the absolute change in physical activity across the three time intervals.

There was no statistical difference in physical activity between the pre-arthroplasty to final follow-up phase intervals (p=0.10; **Figure 2**). When analysed by specific physical activity levels, for sedentary levels of physical activity, the prevalence pre-operatively changed from 8% (95% CI: 5 to 12) to 13%(95% CI: 9 to 18) at final follow-up. For mild pre-arthroplasty prevalence was 17% (95% CI: 13 to 23), and 20% (95% CI: 15 to 27) at final follow-up. For moderate levels of physical activity, prevalence was 62% (95% CI: 55 to 68) and 55% (95% CI: 48 to 61) at final follow-up. For high levels of physical activity, the pre-arthroplasty prevalence was 13% (95% CI: 9 to 18), and 12% (95% CI: 8% to 17%) at the final follow-up phase. There was no difference in physical activity between pre-arthroplasty to the final follow-up phase on the age-stratified analysis for participants aged 61 to 72 years (p=0.18) or those aged 73 to 89 years (p=0.35).

When analysed between the specific time-phases, there was a statistically significant difference in physical activity participation (p=0.001). There was a significant difference between the pre-operative compared to operative-recovery phase for physical activity engagement (p=0.001), where physical activity decreased within this phase (**Table 2**).

There was a statistically significant increase in physical activity between the operative-recovery phase to final follow-up phase (p=0.05). Although this increased in those participating in mild levels of physical activity, the largest changes were apparent at the mild and moderate levels of physical active (**Table 2**). Mild physical activity decreased from 28% (95% CI: 22 to 34) to 20% (95% CI: 15 to 27). Moderate levels of physical activity changed from 46% (95% CI: 39 to 53) to 55% (95% CI: 48 to 61) at final follow-up. High physical activity performed remained the same from 12% (95% CI: 8 to 17) to 12% (95% CI: 8 to 16).

Explanatory Variables

Age, gender and depression were significant explanatory variables. People who were older demonstrated lower physical activity engagement (p<0.001), females were less physically active than males (p=0.004), and people who reported greater depression were also associated with lower physical activity engagement (p=0.019). The type of arthroplasty (THA or TKA) was not a statistically significant explanatory variable (p=0.73).

DISCUSSION

The findings of this study indicate that physical activity levels are not significantly different from pre- to two years' post-arthroplasty. However, when assessed by trajectory, there appears a statistically significant decrease in physical activity in the operative-recovery phase compared to the pre-arthroplasty interval, and a subsequent significantly returns to pre-arthroplasty levels a minimum of two years.

The finding that physical activity does not increase, but remains at pre-arthroplasty levels is in agreement with data from national cohorts including those from the United States of America,

Australia and Germany [19,28,35]. Previous literature has attributed such limited change to a number of patient-level and service-level factors. Smith et al [20], in their meta-ethnography on physical activity beliefs and behaviours following THA and TKA, reported that barriers to engagement in higher levels of physical activity compared to pre-arthroplasty were largely related to limited patient information and empowerment, which culminated in fear avoidance on individual's recovery and the longevity of the arthroplasty. This analysis's finding indicates that these international perspectives are mirrored in the English population and therefore there appears an international need to address such issues to facilitate physical activity in this population.

Depression was identified as a significant explanatory factor for decreasing levels of physical activity. It has been previously reported that people who have depressive symptoms are at greater risk of physical inactivity [36]. However, this is not a causal pathway as greater physical inactivity may increase the risk of depression among those who are not physically active [37]. Depressive symptoms are significant psychological features in a large proportion of the osteoarthritis population. Stubbs et al [38] estimated the prevalence of depressive symptoms in the osteoarthritis population to be 20% (95% CI: 16 to 25%). Given this, and the complex relationship between physical inactivity and depression, consideration to screening and managing depression and the causes of depressive symptoms, may be an important consideration in facilitating physical activity change for people post-arthroplasty.

This is the first analysis to compare pre- to post-operative trajectories of physical activity following arthroplasty across more than two time-points. This identified two important behaviours. Firstly, physical activity decreases between the pre-operative to operative-recovery phase. This may be anticipated given that, in this longitudinal analysis, it may be hypothesised that this decrease is related to an individual's joint pain and disability [39]. Secondly, the trajectory analysis identified that patients

significantly increased their physical activity following arthroplasty. This has not been reported previously since the analyses have been unable to evaluate change over multiple points. This increase may be attributed to rehabilitation or a natural increase in physical activity capability with the reduction in pain and symptoms [40]. It also indicates that this population do have the capability to increase their physical activity. Whether this is attributed to the rehabilitation process or natural recovery following arthroplasty remains unclear. Based on this, further research is warranted to determine how physiotherapists, orthopaedic surgeons and other healthcare professionals who manage this population can better support this population to be more physically active.

There was no statistically significant difference in physical activity participation between those who underwent a THA compared to a TKA. This may be regarded as a surprising finding given that people following TKA have reported poorer outcomes and more frequent persistent symptoms of pain and functional impairment compared to those who undergo THA [40]. It may be that people following THA and TKA have the same physical activity changes and levels but the symptoms during which these activities are undertaken differ. However, as Smith et al [20] acknowledged, people following arthroplasty largely avoid physical activity pursuits if pain is experienced, believing that pain is an indicator for causing harm. Further exploration is warranted to better understand whether clinicians and researchers should consider these two populations separately or collectively when designing physical activity interventions for post-operative rehabilitation.

This analysis presented three limitations. Firstly, physical activity was assessed through self-reported frequency of participation in mild, moderate and vigorous physical activity. Whilst this may be representative of the individual's perceived physical activity, there may be issues of recall bias and social desirability bias which may impact on findings [41]. Comparisons of this longitundinal assessment of physical activity when measured objectively using accelerometry may be valuable to

contrast these results, to objectively assessed physical activity in this population pre- to post-operatively. Secondly, it was not possible to ascertain the date of operation for this population. Although the ELSA cohort design meant that it was possible to analyse the pre-operative, operative-recovery and final follow-up phases, each of the three phases was two years in duration. Analysing by 'phase' negated an analysis of participants who may have been recovering following arthroplasty given that functional trajectories plateau between six and 12 months post-arthroplasty [40]. Finally, whilst this cohort included 201 participants, 318 participants were not included in the analysis since there was insufficient data to analyse their physical activity levels across the three assessment periods. Whilst we analysed the characteristics of the final cohort and incomplete data cohort, where this indiciated no substancial difference in characteristics, this omission reduces the impact of these findigns when trying to generalise the results to the wider population from which this cohort originated from.

CONCLUSION

Physical activity remains the same at a minimum of two years post-arthroplasty compared to pre-arthroplasty levels. There is however fluctuation within this period indicating that physical activity does decrease and then increase following THA and TKA. It is not possible to surmise whether this is attributed to rehabilitation or natural recovery. Nonetheless a significant proportion of this population remain physically inactive. This group have health benefits which could be gained with supported physical activity interventions.

FIGURE AND TABLE LEGENDS

Table 1: Demographic characteristics

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.

Figure 1: Participant flow chart illustrating the study cohort from the ELSA cohort.

Figure 2: Scatter-graph illustrating change in values for physical activity engagement at the pre-operative, operative-recovery phase and final follow phase.

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DECLARATIONS

ETHICAL APPROVALS

Research ethical approval was granted by the London Multi-Centre Research Ethics Service (MREC/01/2/91).

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COMPETING INTERESTS

None of the authors declare a conflict of interest in relation to this study.

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Table 1: Demographic characteristics

Characteristics (N=201)	
THA/TKA	114/87
Gender (M/F)	76/125
Mean Age (SD) in years	72.9 (10.7)
Ethnic Group (%)	72.1: White 15.9: Non-White 11.9: Not Defined
Pain VAS: low back (mean; SD)	4.0 (2.7)
Pain VAS: hip (mean; SD)	3.6 (3.3)
Pain VAS: knee (mean; SD)	3.9 (3.5)
Pain VAs: foot (mean; SD)	3.6 (3.2)
Balance difficulties (self reported; %)	4.0: Always 4.0: Very often 3.0: Often 14.4: Sometimes 23.9: Never 50.7: Not reported
Dizziness experienced (self-reported; %)	0.5: Always 2.0: Very often 1.5: Often 8.5: Sometimes 36.8: Never 50.7: Not reported
Depressive symptoms (CES-D defined; %)	10.0: Yes 49.8: No 40.2: Not reported

Center for Epidemiologic Studies Depression (CES-D) scale; f – female; m – male; N – number of participants; THA – total hip arthroplasty; TKA – total knee arthroplasty; SD – standard deviation; VAS – visual analogue scale.

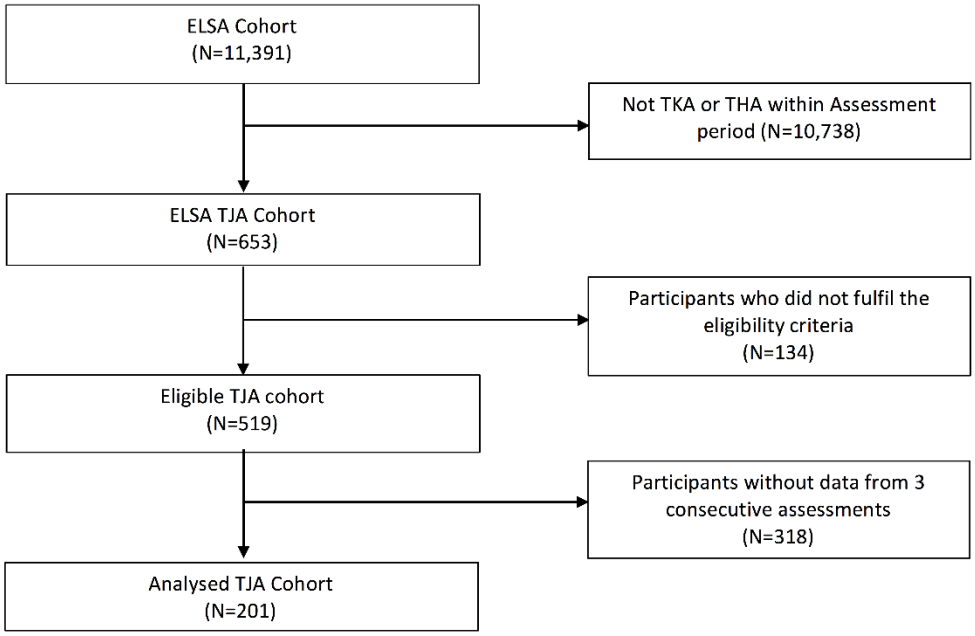
Table 2: Frequency (% with 95% confidence intervals) of self-reported physical activity participation at sedentary, mild, moderate and high intensities for the cohort and age stratified.

Physical Activity	Pre-Operative Phase	Operative-Recovery Phase*	Final Follow-Up Phase‡
Cohort (N=201)			
Sedentary (age=all)	7.5 (5-12)	13.9 (10-19)	12.9 (9-18)
Mild (age=all)	17.4 (13-23)	27.9 (22-34)	20.4 (15-27)
Moderate (age=all)	61.7 (55-68)	46.3 (39-53)	54.7 (48-61)
High (age=all)	13.4 (9-18)	11.9 (8-17)	11.9 (8-17)
Age-Stratified: 61 years to 72 years			
Sedentary (age=61-72)	5.4 (2-11)	13.0 (8-21)	7.6 (4-15)
Mild (age=61-72)	10.9 (6-18)	26.1 (18-35)	18.5 (12-28)
Moderate (age=61-72)	65.2 (55-73)	47.8 (38-57)	59.8 (50-68)
High (age=61-72)	18.5 (12-28)	13.0 (8-21)	14.1 (8-22)
Age-Stratified: 73 years to 89 years			
Sedentary (age=73-89)	9.2 (5-16)	14.7 (9-23)	17.4 (11-25)
Mild (age=73-89)	22.9 (16-32)	29.4 (21-38)	22.0 (15-31)
Moderate (age=73-89)	58.7 (49-68)	45.0 (35-54)	50.5 (41-61)
High (age=73-89)	9.2 (5-16)	11.0 (6-18)	10.1 (5-17)

* statistically significant change from Pre-Operative to Operative-Recovery Phase (p=0.001)

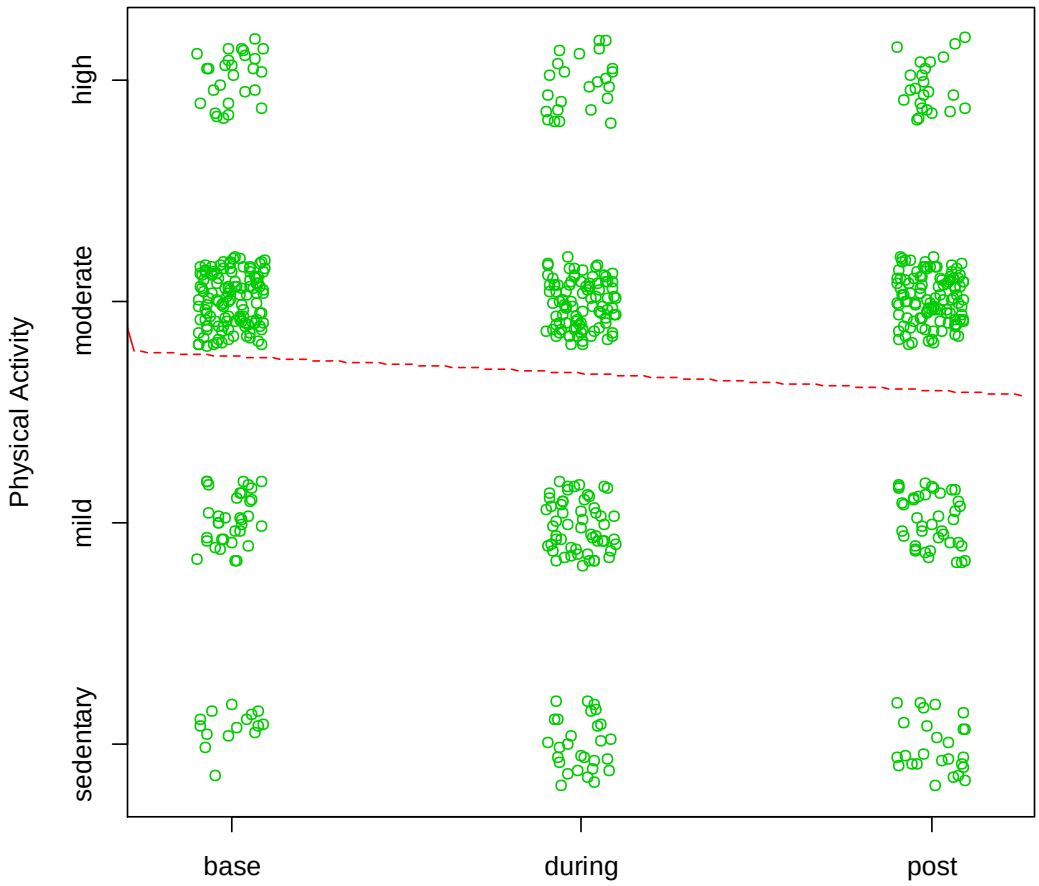
‡ statistically significant change from Operative-Recovery Phase to Final Follow-Up Phase (p=0.05)

Figure 1: Participant flow chart illustrating the study cohort from the ELSA cohort.



ELSA – English Longitudinal Study of Ageing; THA – Total Hip Arthroplasty; TJA – Total Joint Arthroplasty; TKA – Total Knee Arthroplasty

Figure 2: Scatter-graph illustrating change in physical activity engagement at the pre-operative, operative-recovery phase and final follow phase.



*Dotted line indicates the model fit to the data.