PHYSIOTHERAPY

TITLE PAGE

Title: Demographic and geographical variability in physiotherapy provision following hip and knee replacement. An analysis from the National Joint Registry for England, Wales, Northern Ireland and the Isle of Man.

Concise Title: Provision physiotherapy post-joint replacement

Authors and Affiliations:

Dr Toby O Smith – Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Sciences, University of Oxford, Oxford, UK. Email: toby.smith@ndorms.ox.ac.uk

Dr Jack R Dainty – Norwich Medical School, University of East Anglia, Norwich, UK. Email: jack.dainty@uea.ac.uk

Dr Emma M Clark - Bristol Medical School, University of Bristol, Bristol, UK. Email: emma.clark@bristol.ac.uk

Mr Michael R Whitehouse - Bristol Medical School, University of Bristol, Bristol, UK. Email: michael.whitehouse@bristol.ac.uk

Professor Andrew J Price - Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Sciences, University of Oxford, Oxford, UK. Email: andrew.price@ndorms.ox.ac.uk

Professor Alex J MacGregor - Norwich Medical School, University of East Anglia, Norwich, UK. Email: a.macgregor@uea.ac.uk

Corresponding Author: Dr Toby Smith, Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Sciences, Botnar Research Centre, University of Oxford, Old Road, Oxford, OX3 7LD, UK. Email: toby.smith@ndorms.ox.ac.uk; Telephone: 01865 227663

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ABSTRACT

BACKGROUND: Total hip (THR) and knee replacement (TKR) are two of the most common elective orthopaedic procedures worldwide. Physiotherapy is core to the recovery of people following joint replacement. However, there remains uncertainty as to physiotherapy provision at a national level.

OBJECTIVES: To examine the relationship between patient impairment and geographical variation on the provision of physiotherapy among patients who undergo primary total hip or knee replacement (THR/TKR).

DESIGN: Population-based observational cohort study.

METHODS: Patients undergoing THR (n=17,338) or TKR (n=20,260) recorded in the National Joint Registry for England (NJR) between 2009 and 2010 and completed Patient Reported Outcome Measures (PROMs) questionnaires at Baseline and 12 months postoperatively. Data were analysed on the frequency of physiotherapy over the first postoperative year across England's Strategic Health Authorities (SHAs). Logistic regression analyses examined the relationship between a range of patient and geographical characteristics and physiotherapy provision.

RESULTS: Following THR, patients were less likely to receive physiotherapy than TKR patients ('some' physio within 1st post-operative year: 53% vs. 79%). People with worse functional outcomes 12 months postoperatively, received more physiotherapy after THR and TKR. There was substantial variation in provision of physiotherapy according to age (younger people received more physiotherapy), gender (females received more physiotherapy) ethnicity (non-whites received more physiotherapy) and geographical location (40% of patients from South West received some physiotherapy compared to 40 73% in London after THR).

CONCLUSIONS: There is substantial variation in the provision of physiotherapy nationally. This variation is not explained by differences by patient's clinical presentation.

Keywords: Rehabilitation; Arthroplasty; Lower Limb; Provision; Inequality; PROMs

CONTRIBUTION OF THE PAPER

- Individuals with higher perceived disability are more likely to access physiotherapy within the first 12 postoperative months following THR or TKR.
- Access to physiotherapy following THR and TKR varies according to age, gender and ethnicity.
- There is significant geographic al variation in England for physiotherapy provision that is not accounted for by population demographics or by the perceived severity of impairment postoperatively.

INTRODUCTION

Total hip (THR) and knee replacement (TKR) are two of the most common elective surgical procedures performed worldwide [1,2]. There were over 200,000 THR and TKR procedures carried out in England and Wales in 2017 [3]. Currently, the UK National Institute for Health and Care Excellence (NICE) recommend that THR and TKR should be offered to patients with end-stage hip or knee osteoarthritis [4]. Both procedures are successful interventions for reducing pain and increasing function [5,6].

Physiotherapy, principally exercise prescription and gait re-education, is advocated for people after THR and TKR [7,8]. Previous trials have demonstrated the effectiveness of physiotherapy for both groups of patients [9-11]. Westby et al [12] recommended that patients should be provided with a minimum of six weeks physiotherapy after THR and TKR, both for those whose recovery is uneventful and for those with immediately poor outcomes following surgery. Whilst these international recommendations are clear, there remains uncertainty as to what postoperative physiotherapy provision is within healthcare services in the United Kingdom (UK). There is substantial variability in the delivery and content of physiotherapy post-joint replacement [13]. This is currently being viewed by clinical commissioners in the UK who seek evidence to support or refute physiotherapy care-pathways for people following joint replacement [14].

No data have been previously reported on the provision of physiotherapy at a national level in the NHS for individuals following THR or TKR. We present the first analysis of the National Joint Registry of England, Wales, Northern Ireland and the Isle of Man (NJR) data to determine: (objective 1) what the current level of physiotherapy provision is across England following primary THR and TKR; and (objective 2) what factors are associated with whether patients receive physiotherapy following THR or TKR.

PATIENTS and METHODS

The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines were followed in the reporting of this comparative prospective cohort study [15].

Setting and Data sources

The NJR was established in 2003. It is the largest joint replacement registry in the world, recording all primary THR and TKRs undertaken in England and Wales (and more recently Northern Ireland and the Isle of Man), including UK's National Health Service (NHS) and independently-funded procedures. The latest NJR report noted that in 2018 there were 92,874 primary THR and 99,093 primary TKR operations recorded in the NJR registry [3].

In 2009, the NJR commissioned a longitudinal patient reported outcome measures (PROMs) study in patients who underwent primary THR and TKR procedures in a 12 month period in 2009 and 2010. This analysis combined data obtained in the first year after surgery from the longitudinal study with preoperative data that had been obtained separately as part of routinely collected national PROMs data collection. The longitudinal study included details on access to physiotherapy in that first year. In 2010 the regsiter estimated that it had caputured data on 98% of implants [16].

The PROMs data were additionally linked to core data from the NJR that included details on the type of operation (hip or knee), age at surgery, body mass index (BMI), gender and the hospital site where the surgery was performed. Hospital Episode Statistics (HES) were also linked to enable the inclusion of postal district, allowing social deprivation to be inferred from data included in the English Indices of Multiple Deprivation (IMD) database [17]. HES linkage also provided information on ethnicity.

Participants

Patients who underwent a primary THR or TKR performed in England between 2009 and 2010, registered in the NJR and were part of the NJR longitudinal PROMs programme. **Supplementary Figure 1** contains details of inclusion criteria and an overview of the rationale for the final patient cohort. **Supplementary Figure 1** contains details of inclusion criteria and an overview of the rationale for the final patient cohort.

Outcome measures by objective

Primary objective measure: provision of physiotherapy (yes/no) was self-reported on questionnaires returned at a mean one year (standard deviation: 0.3) postoperatively. Participants recorded if they had received physiotherapy within the follow-up interval, and how many physiotherapy sessions they had received. This was categorised as 'none', 1-5, 6-10 or more than 10 sessions. Geographical variation was analysed by Strategy Health Authority (SHA) which was the structure of health provision in the NHS from 2002 to 2013. Data were analysed by the boundaries of 10 SHA's in England [18].

Second objective measures: Patient-related preoperative clinical variables including: age, gender, co-habiting/home circumstance and ethnicity. We also collected data on social deprivation measured by the IMD. This consists of data on: income; employment; health and disability; education, skills and training; barriers to housing and services; living environment; and crime, and is a ranking of areas in England from one (most deprived) to 32,844 (least deprived area).[17] Joint-specific disability was assessed within the 12-month PROMs questionnaire using the measurement of the Oxford Hip Score (OHS) [19] and the Oxford Knee Score (OKS) [20]. Both scores consist of 12 questions, coded as: '4=no problems' to '0=impossible to do'. The cumulative OHS/OKS score across the 12 questions was calculated using the individual scores with 0=worse and 48=best. If more than two questions were missing, the cumulative score for that patient was coded as 'missing'. If data was missing for up to two questions, the mean score from the other questions was used to impute a value [21]. In addition, data on co-existing diseases, disease severity and BMI were collected. Patient-related postoperative clinical variables included: OHS or OKS at 12 months. Geographical location was assessed using the Local Authority District (LAD) Rural Urban Classification [22].

Data Analysis

Descriptive statistics were presented as means with standard deviations, medians with interquartile ranges, or frequencies as percentages according to the type of data and data distribution. Geographical variability within England was also illustrated through mapping frequency of physiotherapy by SHA region.

In the analysis, data on the physiotherapy outcome was classified as either: 'none' (not received any physiotherapy postoperatively at year 1) versus 'some' (at least one session of physiotherapy postoperatively at year 1), or 'none' versus 'at least 10 sessions of physiotherapy'. After testing for normality, continuous data were analysed by two sample t-tests and categorical (2x2 tabular) data by chi-squared tests. Differences in physiotherapy provision between SHA were tested (using logistic regression) by comparing those patients who had answered 'none' for physiotherapy access at one year postoperatively to those patients who had answered 'some'. This analysis was adjusted to take into account the effects of age at surgery, gender, OHS (or OKS) and how rural (versus urban) patient location (as defined by the LAD Rural Urban Classification [22]). These variables were selected *a priori*.

All statistical analyses were performed using 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/.)

RESULTS

Characteristics of the population

17,338 people following THR and 20,260 people following TKR were included in the analyses (**Supplementary Figure 1**). The characteristics of the cohort are presented in **Table 1** and **Table 2**.

In total, 4,111 people following THR and 4,537 people following TKR from the NJR longitudinal PROMs dataset were not included in the analysis due to missing data (**Supplementary Table 1**).

Primary Objective: Provision of physiotherapy

Across all regions in England, physiotherapy provision was greater following TKR compared to THR (**Figure 1**). Within the first postoperative year, 79% (16,058/20,260) of people following TKR received at least one physiotherapy session after hospital discharge compared to 53% (9273/17,338) of those following THR. Of those who received any physiotherapy for either procedure, most received between one and five sessions of treatment (75% (6949/9273) following THR and 63% (10,145/16,058) following TKR).

There was a substantial range in the provision of physiotherapy post-THR and TKR across England (**Figure 1; Figure 2**). For example, the South West SHA in England demonstrated lower provision of physiotherapy (40% (1003/2480) of patients had 'some') after THR than any of the other nine SHAs in England (range: 47% (1043/2199)-73% (905/1248); **Figure 2**; **Table 3**).

Secondary Objective: Factors affecting provision of physiotherapy

Patients with higher self-reported disability for OHS and OKS at baseline and 12 months postoperatively received physiotherapy ('some' physiotherapy is defined as >=1 physiotherapy session) more frequently (THR: mean(SD) OHS (at 12 months): 'some' physiotherapy=38.0 (10.0) vs. no physiotherapy=40.6 (8.7) , p<0.001; TKR: mean(SD) OKS (at 12 months): 'some' 34.5 (10.5) vs. no 37.3 (9.8), p<0.001; **Supplementary Table 2; Figure 3; Figure 4**).

In the first 12 months postoperatively, the average age of those receiving physiotherapy was younger when compared with those receiving no physiotherapy (THR: mean(SD) age: 'some'

physiotherapy=68.1 years (10.5) vs. no physiotherapy=69.0 (9.7); p<0.001; TKR: mean(SD) age: 68.7(9.1) vs. 70.6(8.8); p<0.001). A slightly higher proportion of women accessed at least one session of physiotherapy when compared with men (THR: 55% of women had 'some' vs. 51% of men had 'some' physiotherapy, p<0.05; TKR: 80% vs. 78%, p<0.05). A greater proportion of people who were non-white received physiotherapy compared to those who did not (THR: 64% non-white patients ('some' physiotherapy) vs. 36% non-white patients (no physiotherapy); p<0.05; TKR: 85% vs. 15%; p<0.05).

When analysing the characteristics of people who received 10 or more sessions of physiotherapy in the first postoperative year, a similar trend was evident where younger people accessed more physiotherapy (THR: mean(SD) age: >10 appointments=65.4 years (12.4) vs. no physiotherapy=69.0 years (9.7), p<0.05; TKR: mean(SD) age: 65.4(9.7) vs. 70.6(8.8), p<0.05), and women accessed more physiotherapy (THR: 5% of women had > 10 sessions vs. 3% of men had >10 sessions, p<0.05; TKR: 11% vs. 8%, p<0.05). Those who lived in a more urban area more frequently accessed 10 sessions or more of physiotherapy (THR: 67% urban area (>10 appointments) vs. 62% urban area (no physiotherapy), p<0.05; TKR: 73% vs. 68%, p<0.05).

Individuals from less deprived areas accessed more physiotherapy following TKR (mean(SD) IMD score: 'some' physiotherapy=20.0 (9.7)vs. no physiotherapy=20.6 (10.2), p=0.009). However, the difference in these scores was numerically small, being less than one point in the IMD index. There was no difference in access to physiotherapy according to deprivation for THR patients (mean(SD) IMD score: 'some' physiotherapy=19.3(9.6)vs. no physiotherapy=19.1(9.3), p=0.211). Those who lived in an urban area accessed more physiotherapy following THR (THR: 68% urban ('some' physiotherapy) vs. 62% urban (no physiotherapy), p<0.05), but there was no difference for the TKR patients (TKR: 68% vs. 69%, p=0.139).

There was a notable difference in physiotherapy access in the Strategic Health Authorities (SHA) of the South West, East Midlands, London and West Midlands (all relative to the East of England SHA) for both THR and TKR, which was not explained by variations in age, gender, perceived postoperative disability (OHS/OKS) or rural/urban variations within the SHAs (**Table 3**).

DISCUSSION

This is the first nationwide study to report the provision of physiotherapy in England to people following primary THR and TKR. This has highlighted a difference in physiotherapy provision following

THR and TKR, with variation attributed to geographic and patient characteristics. This variation is not explained by the degree of disability experienced. Health care inequality is a major challenge in primary and secondary care [23]. The variation reported in this analysis is of concern, and suggests that groups of patients in different regions of England may not be optimally managed, with differing access to resources and support following primary THR and TKR. This inequality should be considered by organisations who aim for parity in service provision across the UK such as NHS England, NICE and the Care Quality Commission.

These findings should be reflected against three important past studies. Artz et al [24] previously mapped the provision of physiotherapy following THR or TKR. This was a telephone survey of 24 high-volume hospitals in the UK. Whilst this study provided indicative data that there is some variability in physiotherapy provision following THR and TKR, due to the limited size and reach, it was not possible to determine the true variability across all centres who undertake THR or TKR in England. Furthermore, as this was a survey of physiotherapists, these data may reflect how physiotherapists expect to treat patients rather than the realities of what patients are referred for or receive. In other healthcare systems, Jones et al[25] has previously explored practice variations in physiotherapy following THR and TKR, although only within one region of Canada (Alberta). They reported some variability across providers, but this was largely on an individual level rather than at a region level, as assessed in our data. Finally, Hamilton et al's [13] recent analysis of 2769 patients who self-referred to physiotherapy (or not) following THR and TKR in a UK teaching hospital. They reported that not all patients self-referred and those who did had poorer outcomes, suggesting greater clinical need. This highlights that not all patients necessarily require post-operative physiotherapy but that variation should be disability-dependent..

The findings based on national-level data show that while, as might be expected, those patients who are more impaired receive more physiotherapy postoperatively, there are substantial differences in the provision of physiotherapy nationally and that provision may be determined by factors which are unrelated to an individual's clinical need. This variability should be corrected in current service provision to provide a more equitable provision. The reported variation may primarily be related to resources relating to service provision. Alternatively the variation might be the result of differences in individual preferences for self-management. It remains unclear the extent to which an individual's preference or willingness to seek physiotherapy may be of importance in determining the uptake of any standard physiotherapy treatment which is prescribed. Further study is therefore warranted to better understand the findings reported as to why physiotherapy was not universally provided to or adopted by individuals following THR and TKR.

There is consensus based on evidence that land-based physiotherapy is effective.[7,8] However, there is limited consensus or recommendation on how physiotherapy provision should be implemented. There also remains uncertainty on a minimum standard on what is considered effective, based on dosage, period, delivery personnel and other prescribing variables. This may account, in part, for the current national variation in practice as demonstrated in these findings. NICE are currently preparing their guidelines around the wider management of hip, knee and shoulder replacement [26]. These new guidelines may provide a clear benchmark to assess the quality of service provision. However, our results should be used as baseline data for a future analysis of the impact of these NICE guidelines on reducing geographical variation in physiotherapy provision after THR and TKR.

The principal strength of this study was that it was performed on a large generalisable sample from a national prospective cohort with comprehensive coverage of THR and TKR. However, there was missing data for 4111 THRs and 4537 TKRs. The characteristics of this cohort were not different to the analysed cohort, providing assurances that differential bias was of low risk between analysed and missing participant data (**Supplementary Table 1**). Large sample size can result in small group differences achieving statistical significance and care must be taken to decide if they are important or clinically relevant. Further limitations include a reliance on patient recall of physiotherapy sessions. However, patients were asked to recall access to physiotherapy within one year of their procedure, and we believe that for most, the accuracy of their recall in this timeframe, is likely to be high. It was not possible to determine the precise exercise protocols that were implemented by the physiotherapists within these appointments. The quality of the service provided (through whatever quality indices) has not been explored. Whilst there may have been some variability in the interventions such as the prescription of hydrotherapy, resistance versus aerobic exercise and whether physiotherapy sessions were individual or group-based, the current evidence suggests that there are likely to be minimal difference in outcome following THR and TKR across the different approaches [7,10,11]. Finally, the data included in this analysis were collected in 2009 to 2010. While the provision of physiotherapy has not altered since this time, further assessment may be warranted to explore changes in NHS and clinical commissioning group practice.

To conclude, this analysis demonstrates that there is wide geographical variation in physiotherapy provision in England that is not accounted for by patient characteristics or perceived severity of impairment after the operation. Younger, female patients in urban areas are accessing more physiotherapy postoperatively .The study highlights the need to understand reasons for non-universal provision of an effective, evidence-based, physiotherapy intervention for patients following primary

THR and TKR in England. This will provide an important benchmark to begin to understand the effect of this inequality on longer-term outcome. A better understanding of the streams for service provision is important to ensure that this current potential 'postcode lottery' of physiotherapy does not affect the outcomes patients could receive following THR and TKR in England. Addressing the reported inequality should be considered by organisations, which aim to promote equitable services across a national health system.

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should verify all relevant representations, statements and information with their own professional advisers.

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Sponsorship: This work was undertaken as part of the National Joint Registry strategic plan.

Conflict of Interest: All authors declare that they have no conflicts of interest in relation to this paper.

Ethical Approvals: Research ethics committee (REC) approval was granted by the NRES London – Central REC (10/H0718/89). The research project was internally approved by the NJR Research Committee.

Data sharing: Access to data is available from the National Joint Registry for England and Wales.

FIGURE AND TABLE LEGENDS

Table 1. Characteristics of THR patients tabulated by physiotherapy visits in the first year post-operatively (n=17,338 completed physiotherapy question).

Table 2. Characteristics of TKR patients tabulated by physiotherapy visits in the first year post-operation (n=20,260 completed physiotherapy question).

Table 3: Geographic variability in physiotherapy provision during the first year post-operation in England by Strategic Health Authority (SHA) adjusted for age, gender, 1 year OHS (or OKS) and how rural the geographical location is (based on logistic regression of the outcome variable, 'none/some physiotherapy)

Figure 1: Geographical variation in post-operative physiotherapy access following TKR

Figure 2: Geographical variation in post-operative physiotherapy access following THR

Figure 3. Variation in baseline (pre-operation) Oxford Knee Score (OKS) and Oxford Hip Score (OHS) with physiotherapy visits in the first year post-operation following TKR or THR.

Figure 4. Variation in one year (post-operation) Oxford Knee Score (OKS) and Oxford Hip Score (OHS) with physiotherapy visits in first year post-operatively following TKR or THR.

Supplementary Table 1: Distribution of patient sociodemographic, health and surgery related factors for the responders and non-responders to physiotherapy question at first year post-operatively.

Supplementary Table 2: Oxford Hip Score (OHS) and Oxford Knee Score (OKS) responses (all at one year post-operation) following THR and TKR.

Supplementary Figure 1: Cohort flow chart

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Figure 1: Geographical variation in post-operative physiotherapy access following TKR

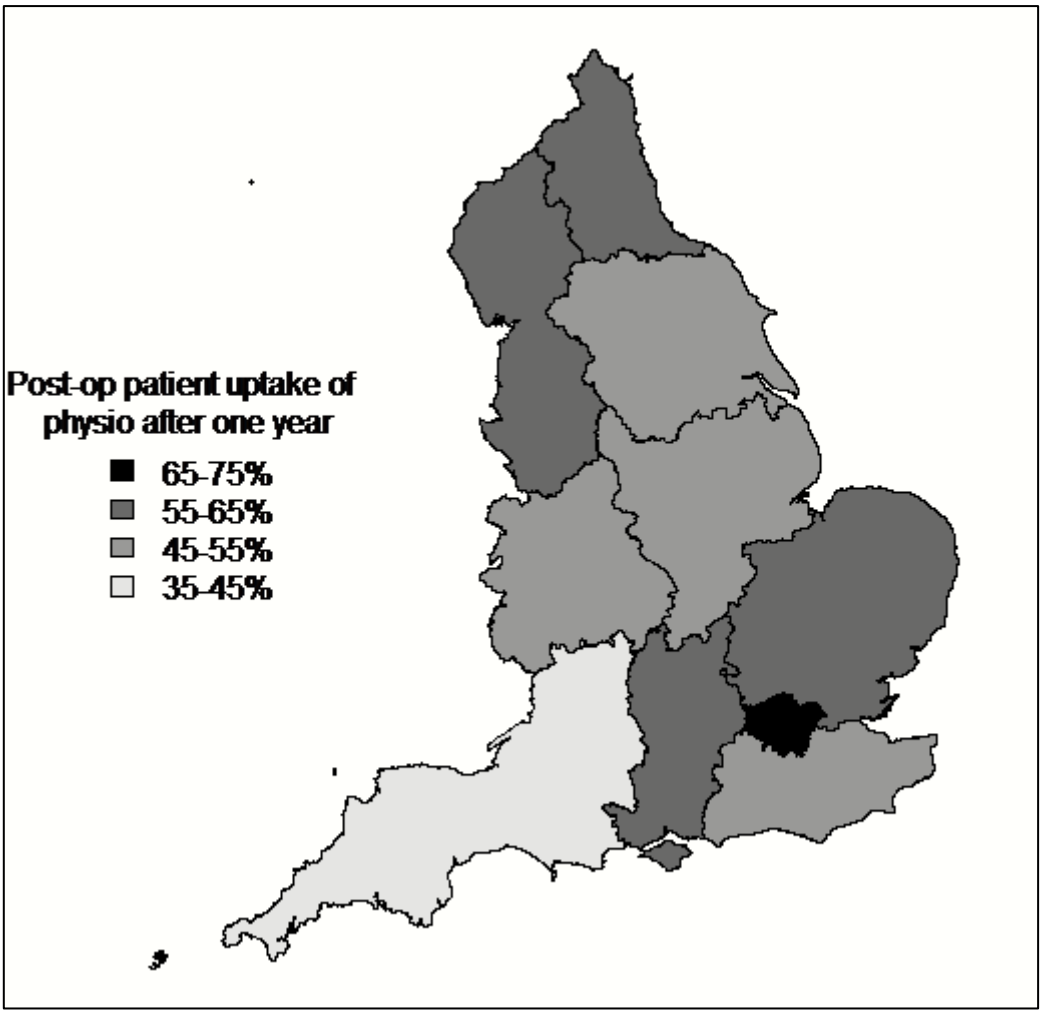

Figure 2: Geographical variation in post-operative physiotherapy access following THR

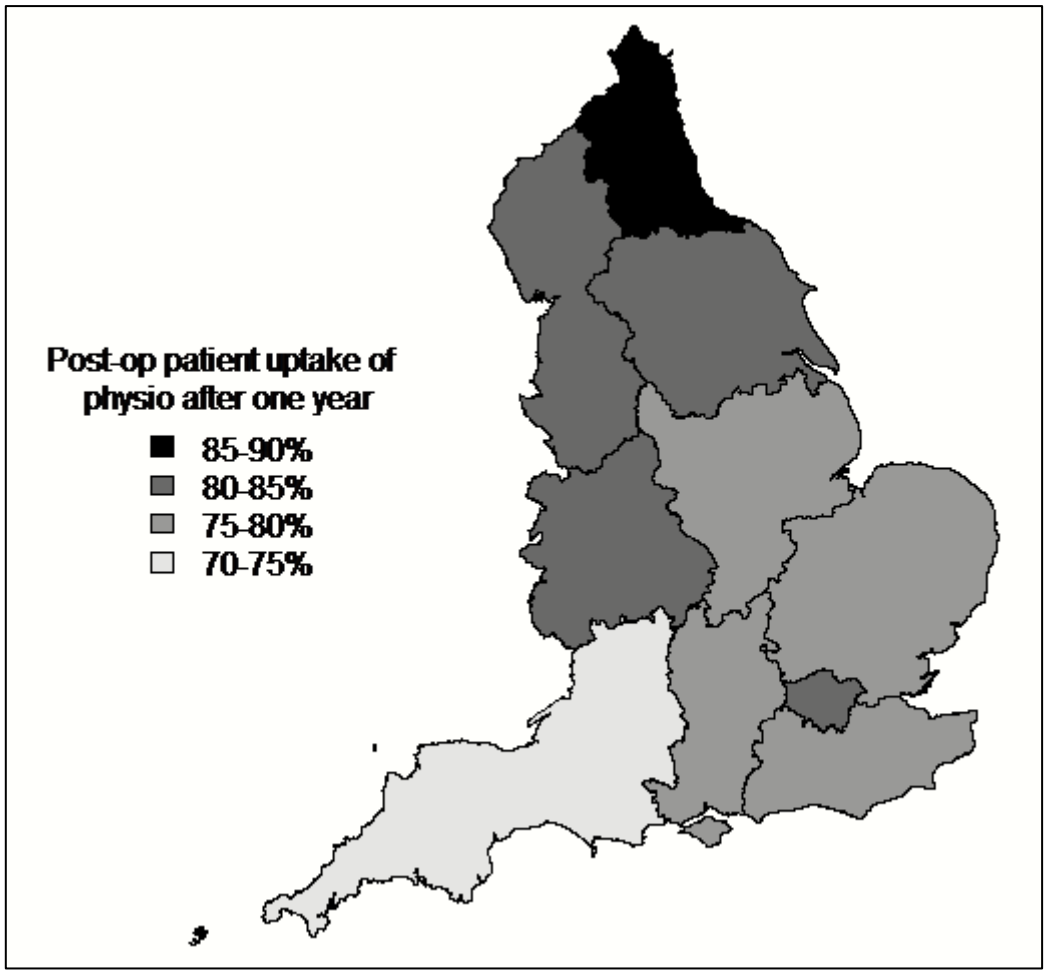

Figure 3. Variation in baseline (pre-operation) Oxford Knee Score (OKS) and Oxford Hip Score (OHS) with physiotherapy visits in the first year post-operation following TKR or THR.

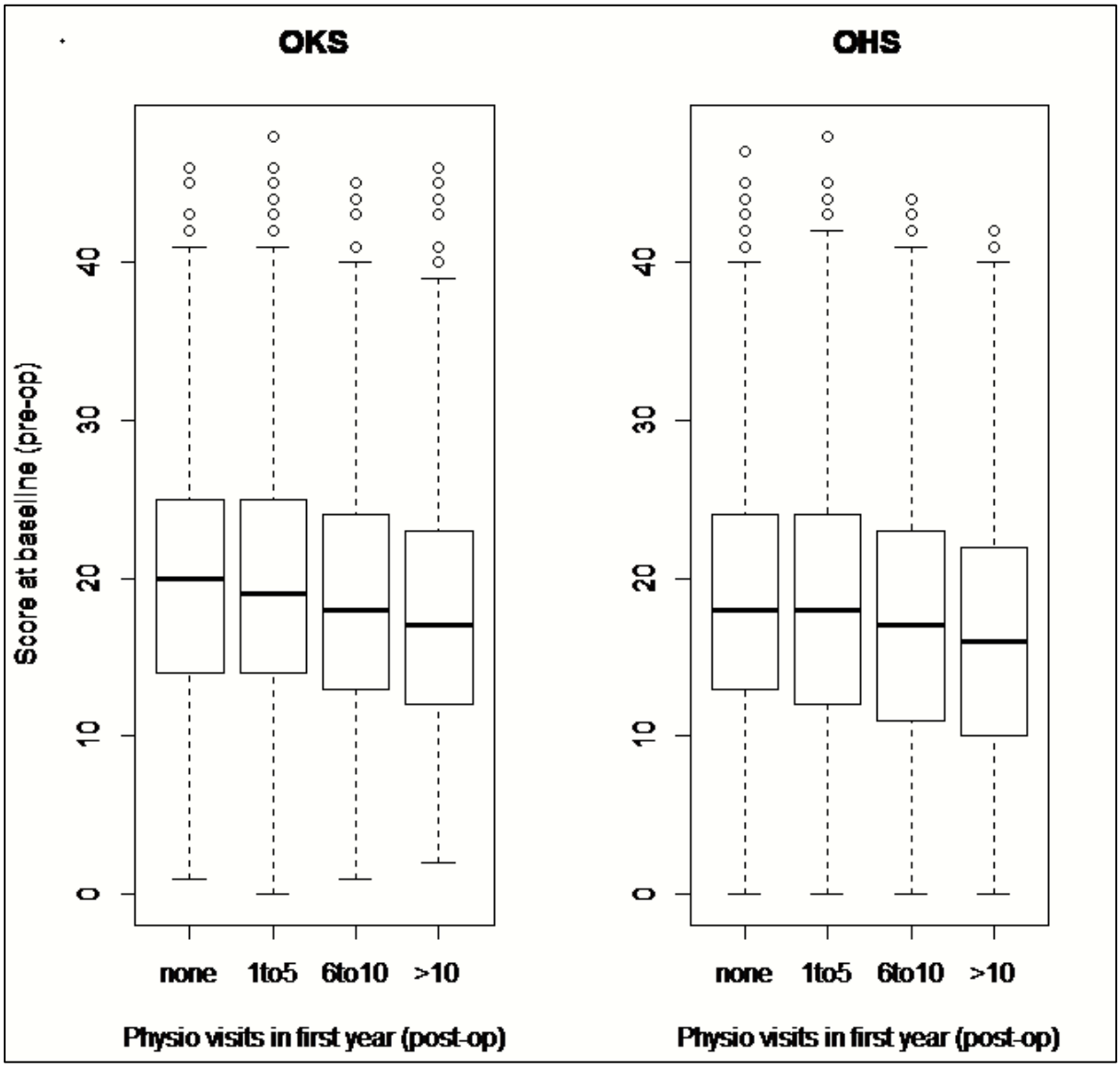

Figure 4. Variation in one year (post-operation) Oxford Knee Score (OKS) and Oxford Hip Score (OHS) with physiotherapy visits in first year post-operatively following TKR or THR.

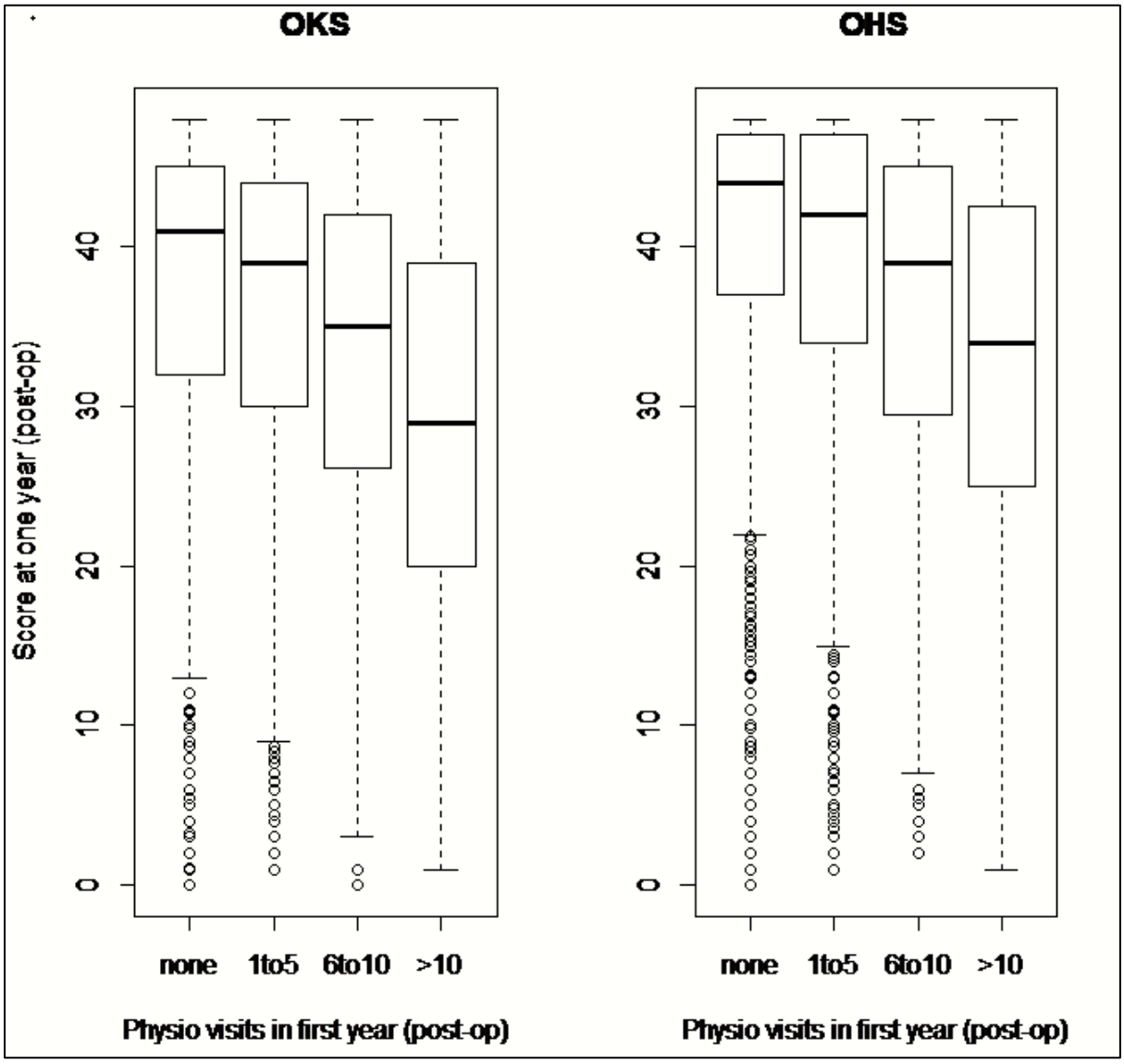

Table 1. Characteristics of THR patients tabulated by physiotherapy visits in the first year postoperatively (n=17,338 completed Physiotherapy question)

	'How many times have you seen a physiotherapist since you left hospital?'					
		'None'	**'Some'**			
Physio sessions	Non-responders	0 sessions	≥ 1 session	1-5	6-10	>10
N, year 1 (%)	4111	8065 (47)	9273 (53)	6949 (40)	1568 (9)	756 (4)
Age [Mean (SD)] † *	65.9 (13.0)	69.0 (9.7)	68.1 (10.5)	68.6 (10.1)	67.5 (11)	65.4 (12.4)
BMI [Mean (SD)]	29.0 (5.5)	28.6 (5.0)	28.7 (5.1)	28.7 (5.0)	28.8 (5.2)	28.4 (5.2)
Social Deprivation						
IMD [Mean (SD)]	20.9 (10.2)	19.1 (9.3)	19.3 (9.6)	19.3 (9.4)	19.4 (10.2)	19.3 (9.9)
Gender† *						
Males (%)	1602	3375 (49)	3528 (51)	2790 (40)	518 (8)	220 (3)
Females (%)	2509	4690 (45)	5745 (55)	4159 (40)	1050 (10)	536 (5)
Missing data	0	0	0	0	0	0
Ethnicity† *						
White (%)	3179	6503 (48)	7178 (52)	5362 (39)	1215 (9)	601 (4)
Non-white (%)	85	58 (36)	102 (64)	71 (44)	17 (11)	14 (9)
Missing data	847	1504	1993	1516	336	141
Geog. Location† *						
%Rural [Mean (SD)]	31 (33)	38 (35)	32 (33)	33 (33)	30 (32)	33 (33)
%Urban (=1-%Rural)	69 (33)	62 (35)	68 (33)	67 (33)	70 (32)	67 (33)
Living arrangements						
Family or spouse (%)	2756	5707 (47)	6500 (53)	4914 (40)	1069 (9)	517 (4)
Alone (%)	1145	2048 (46)	2421 (54)	1779 (40)	424 (9)	218 (5)
Nursing home/hospital (%)	11	6 (32)	13 (68)	10 (53)	2 (11)	1 (5)
Other (%)	28	34 (52)	32 (48)	23 (35)	6 (9)	3 (5)
Missing data	171	270	307	223	67	17
ASA grade						
Fit and Healthy (%)	592	1131 (46)	1338 (54)	975 (39)	236 (10)	127 (5)
Mild Disease (%)	2799	5829 (47)	6630 (53)	5008 (40)	1092 (9)	530 (4)
Incapacitating (%)	720	1105 (46)	1303 (54)	964 (40)	240 (10)	99 (4)
Missing data	0	0	2	2	0	0
Coexisting diseases						
None (%)	1845	3592 (46)	4190 (54)	3138 (40)	691 (9)	361 (5)
One (%)	1429	3012 (47)	3337 (53)	2507 (39)	560 (9)	270 (4)
Two (%)	581	1077 (45)	1310 (55)	971 (41)	244 (10)	95 (4)
Three or more (%)	256	384 (47)	436 (53)	333 (41)	73 (9)	30 (4)
Missing data	0	0	0	0	0	0

ASA – American Society of Anaesthesiologists; BMI – body mass index; IMD – index for multiple deprivation; SD – standard deviation; THR – total hip replacement; TKR – total knee replacement

† P<0.05 for the comparison of Physiotherapy='None' with Physiotherapy='Some' (i.e. at least one Physiotherapy session); * P<0.05 for the comparison of Physiotherapy='None' with '>10'

Table 2. Characteristics of TKR patients tabulated by physiotherapy visits in the first year postoperatively (n=20,260 completed physiotherapy question)

	'How many times have you seen a physiotherapist since you left hospital?'					
		'None'	**'Some'**			
Physio sessions	Non-responders	0 sessions	≥ 1 session	1-5	6-10	>10
N, year 1 (%)	4537	4202 (21)	16058 (79)	10145 (50)	3886 (19)	2027 (10)
Age [Mean (SD)]† *	67.1 (10.6)	70.6 (8.8)	68.7 (9.1)	69.6 (8.8)	68.0 (9.0)	65.4 (9.7)
BMI [Mean (SD)]	31.4 (5.6)	30.7 (5.3)	30.8 (5.3)	30.7 (5.3)	31.0 (5.2)	31.3 (5.5)
Social Deprivation† *						
IMD [Mean (SD)]	22.1 (10.8)	20.6 (10.2)	20.0 (9.7)	19.8 (9.5)	20.2 (9.9)	20.9 (10.2)
Gender† *						
Males (%)	1899	1968 (22)	6876 (78)	4514 (51)	1611 (18)	751 (8)
Females (%)	2638	2234 (20)	9182 (80)	5631 (49)	2275 (20)	1276 (11)
Missing data	0	0	0	0	0	0
Ethnicity† *						
White (%)	3048	3015 (21)	11496 (79)	7211 (50)	2809 (19)	1476 (10)
Non-white (%)	256	71 (15)	414 (85)	228 (47)	104 (21)	82 (17)
Missing data	1233	1116	4154	2706	973	475
Geog. Location*						
%Rural [Mean (SD)]	28 (32)	32 (34)	31 (33)	33 (34)	30 (32)	27 (32)
%Urban (=1-%Rural)	72 (32)	68 (34)	69 (33)	67 (34)	70 (32)	73 (32)
Living arrangements						
Family or spouse (%)	3152	2967 (19)	12485 (81)	7356 (48)	2913 (19)	2216 (14)
Alone (%)	1175	1069 (22)	3802 (78)	2366 (49)	829 (17)	607 (12)
Nursing home/hospital (%)	13	4 (21)	15 (79)	12 (63)	3 (16)	0 (0)
Other (%)	23	20 (27)	55 (73)	36 (48)	12 (16)	7 (9)
Missing data	174	142	598	375	129	94
ASA grade						
Fit and Healthy (%)	479	423 (19)	1803 (81)	1088 (49)	456 (20)	259 (12)
Mild Disease (%)	3278	3108 (21)	11928 (79)	7549 (50)	2899 (19)	1480 (10)
Incapacitating (%)	757	668 (22)	2325 (78)	1507 (50)	530 (18)	288 (10)
Missing data	0	3	2	1	1	0
Coexisting diseases						
None (%)	1702	1550 (19)	6515 (81)	3890 (48)	1499 (19)	1126 (14)
One (%)	1663	1704 (21)	6476 (79)	3994 (49)	1427 (17)	1055 (13)
Two (%)	845	715 (20)	2889 (80)	1653 (46)	689 (19)	547 (15)
Three or more (%)	327	233 (18)	1074 (82)	608 (47)	271 (21)	195 (15)
Missing data	0	0	0	0	0	0

ASA – American Society of Anaesthesiologists; BMI – body mass index; IMD – index for multiple deprivation; SD – standard deviation; THR – total hip replacement; TKR – total knee replacement

† P<0.05 for the comparison of Physiotherapy='None' with Physiotherapy='Some' (i.e. at least one Physiotherapy session); * P<0.05 for the comparison of Physiotherapy='None' with '>10'

Table 3: Geographic variability in physiotherapy provision during the first year post-operation in England by Strategic Health Authority (SHA) adjusted for age, gender, 1 year OHS (or OKS) and how rural the geographical location is (based on logistic regression of the outcome variable, 'none/some physiotherapy')

	THR				TKR			
	'Some' physio (%)	**OR (95%CI) unadjusted**	**OR (95%CI) adjusted**	**P (for adjusted)**	**'Some' physio (%)**	**OR (95%CI) unadjusted**	**OR (95%CI) adjusted**	**P (for adjusted)**
East of England	59	reference	reference		79	reference	reference	
South West	40	0.48 (0.42, 0.54)	0.49 (0.43, 0.55)	<0.0001	74	0.75 (0.66, 0.85)	0.75 (0.64, 0.87)	0.0002
East Midlands	50	0.69 (0.61, 0.79)	0.64 (0.55, 0.74)	<0.0001	75	0.82 (0.7, 0.95)	0.74 (0.63, 0.87)	0.0004
London	73	1.86 (1.6, 2.16)	1.66 (1.4, 1.97)	<0.0001	83	1.31 (1.11, 1.55)	1.33 (1.09, 1.62)	0.0054
North East	56	0.91 (0.78, 1.06)	0.88 (0.74, 1.05)	0.1655	87	1.78 (1.47, 2.15)	1.63 (1.31, 2.05)	<0.0001
North West	59	1.01 (0.89, 1.15)	0.88 (0.76, 1.02)	0.0809	85	1.52 (1.31, 1.78)	1.53 (1.28, 1.83)	<0.0001
South Central	61	1.08 (0.92, 1.27)	1 (0.84, 1.19)	0.9951	76	0.87 (0.74, 1.04)	0.89 (0.73, 1.08)	0.2448
South East	52	0.77 (0.67, 0.88)	0.73 (0.63, 0.84)	<0.0001	76	0.84 (0.72, 0.97)	0.87 (0.73, 1.03)	0.1106
West Midlands	47	0.63 (0.56, 0.72)	0.59 (0.51, 0.67)	<0.0001	83	1.29 (1.13, 1.49)	1.19 (1.02, 1.4)	0.0313
Yorkshire and Humberside	51	0.72 (0.64, 0.82)	0.68 (0.59, 0.78)	<0.0001	80	1.1 (0.95, 1.27)	1.06 (0.9, 1.24)	0.4914

CI – confidence intervals; OR – odds ratio; Physio – physiotherapy; THR – total hip replacement; TKR – total knee replacement

Supplementary Table 1: Distribution of patient sociodemographic, health and surgery related factors for the responders and non-responders to physiotherapy question at first year post-operatively.

		TKR			THR		
		Non-responders N=4,537	Responders N=20,260	P-value *	Non-responders N=4,111	Responders N=17,338	P-value *
Gender	*Female (%)*	2,638 (58)	11,416 (56)	0.028	2,509 (61)	10,435 (60)	0.328
	Male (%)	1,899 (42)	8,834 (44)		1,602 (39)	6,903 (40)	
Age group at operation (years)	*Under 55 (%)*	556 (12)	1,192 (6)	<0.001	752 (18)	1,558 (9)	<0.001
	55-64 (%)	1,258 (28)	5,073 (25)		946 (23)	3,962 (23)	
	65-74 (%)	1,528 (34)	7,984 (39)		1,258 (31)	6,735 (39)	
	75+ (%)	1,195 (26)	6,010 (30)		1,154 (28)	5,082 (29)	
Ethnicity	*White (%)*	3,048 (92)	14,511 (97)	<0.001	3,179 (97)	13,681 (99)	<0.001
	Black (%)	68 (2)	132 (1)		32 (1)	70 (1)	
	Asian (%)	159 (5)	263 (2)		22 (1)	37 (<1)	
	Other (%)	29 (1)	84 (<1)		31 (1)	53 (<1)	
	Missing (%)	1,233 (27)	5,270 (26)		1,233 (21)	3,497 (20)	
IMD (2011)	*mean (SD)*	22.1 (10.8)	20.2 (9.8)	<0.001	20.9 (10.2)	18.7 (9.2)	<0.001
	Missing (%)	967 (21)	3,839 (19)		543 (13)	2,063 (12)	
ASA grade	*1 (%)*	479 (11)	2,236 (11)	<0.001	592 (14)	2,469 (14)	<0.001
	2 (%)	3,278 (72)	15,036 (74)		2,799 (68)	12,459 (72)	
	3-5 (%)	780 (17)	2,998 (15)		720 (18)	2,410 (14)	
Coexisting diseases (at baseline)	*No disease (%)*	1,702 (38)	7,724 (38)	<0.001	1,845 (45)	7,782 (45)	*<0.001*
	One disease (%)	1,663 (37)	7,860 (39)		1,429 (35)	6,349 (37)	
	Two diseases (%)	845 (19)	3,427 (17)		581 (14)	2,387 (14)	
	Three or more (%)	327 (7)	1,249 (6)		256 (6)	820 (5)	
Living arrangements (at baseline)	*Family or spouse (%)*	3,152 (72)	14,776 (76)	<0.001	2,756 (70)	12,207 (73)	<0.001
	Alone (%)	1,175 (27)	4,688 (24)		1,145 (29)	4,469 (27)	
	Nursing home/hospital (%)	13 (<1)	19 (<1)		11 (<1)	19 (<1)	
	Other (%)	23 (1)	74 (<1)		28 (1)	66 (<1)	
	Missing (%)	174 (4)	703 (3)		171 (4)	577 (3)	
BMI (at baseline)	*10-18.5 (%)*	10 (<1)	19 (<1)	<0.001	31 (1)	77 (1)	*0.003*
	18.5-25 (%)	243 (9)	1,186 (9)		478 (19)	2,138 (20)	

	25-30 (%)	854 (31)	4,479 (35)		918 (37)	4,502 (41)	
	30-60 (%)	1,668 (60)	7,029 (55)		1,025 (42)	4,173 (38)	
	Missing (%)	1,762 (39)	7,547 (37)		1,659 (40)	6,448 (37)	

* Chi squared test or t-test of whether there is a difference in patient/surgical factor distributions for responders and non-responders.

ASA – American Society of Anaesthesiologists; BMI – body mass index; IMD – index for multiple deprivation; SD – standard deviation; THR – total hip replacement; TKR – total knee replacement

Supplementary Table 2: Oxford Hip Score (OHS) and Oxford Knee Score (OKS) responses (all at one year post-operation) following THR and TKR.

	'How many times have you seen a physiotherapist since you left hospital?'					
		'None'	**'Some'**			
Physio sessions	**Missing**	**0 sessions**	**≥1 session**	**1-5**	**6-10**	**> 10**
THR (n=17,338)						
N, year 1 (%)	4111 (19)	8065 (38)	9273 (43)	6949 (32)	1568 (7)	756 (4)
OHS						
Pain (% no pain)	47	53	45	48	38	30
Washing (% no problems)	65	71	61	63	57	44
Transport (% no problems)	48	59	47	50	40	31
Walking (% no pain > 30 mins)	64	73	63	66	56	47
Standing (% no problems)	64	68	58	61	51	42
Limping (% no problems)	53	59	47	51	35	29
Dressing (% no pain)	38	46	37	39	32	23
Night pain (% no pain)	67	70	61	65	55	44
Work (% no problems)	56	64	53	56	46	37
Sudden pain (% no pain)	74	77	69	72	64	54
Shopping (% no problems)	52	64	53	57	45	36
Stairs (% no problems)	47	58	46	50	39	28
Mean OHS (SD) †	**38.8 (9.4)**	**40.6 (8.7)**	**38.0 (10.0)**	**38.9 (9.5)**	**36.0 (10.6)**	**32.7 (11.3)**
TKR (n=20,266)						
N, year 1 (%)	4537 (18)	4202 (17)	16058 (65)	10145 (41)	3886 (16)	2027 (8)
OKS						
Pain (% no pain)	36	40	29	33	25	13
Washing (% no problems)	64	73	64	68	60	42
Transport (% no problems)	37	46	35	40	29	15
Walking (% no pain > 30 mins)	54	64	56	61	52	33
Standing (% no problems)	41	50	38	43	32	17
Limping (% rarely)	46	55	43	48	38	20
Kneeling (% no pain)	6	9	5	7	4	2
Night pain (% no pain)	50	56	45	50	40	23
Work (% no problems)	41	51	39	44	34	18
Confidence (% no problems)	61	69	61	65	58	38
Shopping (% no problems)	49	60	50	55	46	28
Stairs (% no problems)	38	48	38	43	33	17
Mean OKS (SD) †	**35.0 (10.9)**	**37.3 (9.8)**	**34.5 (10.5)**	**36.1 (9.8)**	**33.5 (10.4)**	**28.7 (11.7)**

† P<0.05 for the comparison of Physiotherapy='None' with Physiotherapy≥1 ('Some')

Mins – minutes; N – number of cases; OHS – Oxford Hip Score; OKS – Oxford Knee Score; SD – standard deviation; THR – total hip replacement; TKR – total knee replacement

Supplementary Figure 1: Cohort flow chart