Does measuring the range of motion of the hip and knee add to the assessment of disability in people undergoing joint replacement?

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ABSTRACT
Background and hypothesis: Range of motion (ROM) is a core component of some commonly used measures of disability, such as the American Knee Society Score and Harris Hip Score. However, the relationship between ROM and function is contested. The aim of this cross-sectional analysis was to investigate the relationship between pre-operative range of motion (ROM) and disability in patients undergoing hip and knee joint replacement.

Patients and methods: Two hundred and forty-nine patients recorded on NHS records as listed for joint replacement completed a range of measures prior to surgery. Pre-operative hip or knee ROM was measured by a trained research nurse using a hand-held goniometer. Joint pain severity was assessed using the WOMAC Pain Scale. Self-report activity limitations and participation restrictions were measured with the WOMAC Function Scale and the Aberdeen Impairment, Activity Limitation and Participation Restriction Measure. Observed activity limitations were assessed through three performance tests: 20-metre timed walk, sit-to-stand-to-sit, and 20-cm step tests.

Results: Pre-operative hip and knee ROM correlated weakly with self-report activity limitations (0.11 to 0.43), observed activity limitations (0.09 to 0.39) and self-report participation restrictions (−0.32 to 0.06). In comparison to ROM, correlations between joint pain and self-report activity limitations and participation restrictions were consistently moderate-high (−0.53 to 0.80). However, patients with restricted knee joint flexion (<110°) had significantly worse pain, activity limitations and participation restrictions than patients with non-restricted flexion (≥110°). Patients with restricted hip joint flexion (<95°) had greater activity limitations on some measures than patients with non-restricted flexion (≥95°).

Discussion: This study suggests that modest restrictions of ROM are of little relevance to functional ability but that a certain amount of flexion is required for adequate function. We recommend that ROM is not the best means of assessing patients’ disability prior to surgery.

Level of evidence: III – cohort study.

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1. Introduction

Joint replacement for advanced hip or knee osteoarthritis (OA) is the only intervention with evidence of a large effect size [1]. Assessment of outcome after surgery provides evidence effect, but many different measures are used and most lack any theoretical basis [2]. The World Health Organization’s (WHO) International Classification of Functioning Disability and Health (ICF) [3] offers a theoretical framework for describing and assessing disability. Disability is conceptualised as comprising impairment, activity limitation and participation restriction, and the ICF has been applied to joint replacement [2].

Existing assessments of impairment in people with OA include: pain, stiffness, altered joint range of motion (ROM), muscle weakness, instability and measures of structural changes such as x-rays. Activity limitations can be measured through self-report or objective techniques such as accelerometry or clinic based tests such as the ‘get-up and go’ test, and participation restrictions can be assessed by self-report. Some measures commonly used to assess patients’ disability include assessment of ROM, for instance, the American Knee Society Score (AKSS) [4] and Harris Hip Score (HHS) [5]. However, the relationship between ROM and function is contested, with some authors regarding ROM as a determinate of function [6], whilst others report poor correlations [7,8].
In view of ongoing use of ROM and continuing uncertainty about its relationship with function, this study aimed to investigate the relationship between pre-operative ROM and disability in patients undergoing joint replacement.

2. Patients and methods

The data are from a prospective single-centre UK cohort study comparing functional measures in patients undergoing joint replacement between February 2010–November 2011. Detailed information on study design, ethical approval, patient recruitment and consent, and assessment methods are in the study protocol [9]. Briefly, patients recorded on NHS records as listed for primary or revision hip or knee replacement surgery were eligible. Patients listed for several joint replacement procedures were included to enable assessment of outcome measures across their full range of application. Patients completed a range of functional measures before surgery, and the following measures were included in this analysis.

2.1. Measures of impairment

2.1.1. Range of motion

ROM measurements on the joint to be replaced were made by a trained research nurse using a hand-held goniometer while patients were supine on a couch (except for internal and external hip rotation). Active flexion in patients listed for knee replacement was assessed by measuring how far patients could bend their knee using their own muscle power. Active knee extension was measured as how far patients could flatten their knee onto the couch using their own muscle power. For patients listed for hip replacement, measurement of ROM included hip flexion, abduction, adduction, internal rotation and external rotation. Measurement of hip flexion, patients bent their knee and the examiner brought the patients’ knee as close to their chest as possible. Abduction was measured by the examiner moving patients’ legs out to the side as far as possible, whilst the pelvis was stabilised. Adduction was measured by the examiner moving patients’ leg across the midline, and then anteriorly crossing over their opposite leg. Measurements of hip rotation were made with patients sitting on a couch with their legs hanging down. Internal rotation was measured by the examiner stabilising the thigh and then bringing patients’ lower leg out to the side and external rotation by moving patients’ lower leg in toward the opposite leg. For analysis, hip abduction and adduction were summed to produce abduction + adduction scores and hip internal and external rotations were summed to produce an arc of rotation score.

The inter- and intra-rater reproducibility of the ROM measurements was assessed in 20 patients (10 patients listed for knee replacement and 10 listed for knee replacement) and 10 healthy controls. ROM measurements were conducted independently by two assessors on the same day and then repeated a week later by one assessor. Concordance correlation coefficients [10] suggested moderate-excellent inter-rater (0.548–0.913) and intra-rater (0.536–0.935) reproducibility.

2.1.2. Joint pain severity

The severity of pain in the joint to be replaced was assessed using the Western Ontario and McMaster Universities Osteoarthritis Index Pain Scale (WOMAC-p) [11], standardised to produce a score from 0–100 (worst to best).

2.2. Measures of activity limitation

2.2.1. Self-report activity limitations

Self-report activity limitations were assessed using the WOMAC Function Scale (WOMAC-f) [11] which produces a standardised score from 0–100 (worst to best) and the Activity Limitations Scale from the Aberdeen Impairment, Activity Limitation and Participation Restriction Measure (IAP-A) [2] which produces a score from 0–68 (best to worst).

2.2.2. Observed activity limitations

Observed activity limitations were assessed through performance tests. If patients were unwilling to attempt any test or the research nurse was unhappy to proceed because of safety concerns, the test was designated as not performed. All tests were performed in the order described below.

2.2.2.1. Timed 20-metre walk Patients were timed as they walked a 20-metre straight distance at a comfortable speed.

2.2.2.2. Sit-to-stand-to-sit Patients sat on a stool whose height was adjusted to ensure 90° flexion at the hip and knee. They stood up without using their hands, waited two seconds and sat down again. The recorded outcome was test completion.

2.2.2.3. Step test Patients stepped up onto a 20-cm high block leading with the index leg, waited two seconds, and then stepped down from the block with the contra-lateral leg leading, without using their arms. The recorded outcome was test completion.

2.3. Measure of participation restrictions

Participant restrictions were measured using the IAP Participation Restriction Scale (IAP-P) [2] which produces a score from 0–36 (best to worst).

2.4. Patient demography

Data were collected in the pre-operative questionnaire on age, gender, socioeconomic status (living arrangements, education level, working status) and joints affected by arthritis. Medical co-morbidities were recorded using the Functional Co-morbidity Index [12] and the Hospital and Anxiety Depression Scale [13] was used to assess psychological status.

3. Statistical analysis

Analyses were conducted separately for patients listed for hip and knee replacement. Spearman’s Rank Correlation coefficients were used to assess correlations between continuous variables. Point biserial correlation coefficients were used to assess correlations between continuous and dichotomous variables. These correlation measures range from –1 to +1. The strength of correlation was interpreted as: (0.00–0.25) = non-existent, (0.26–0.49) = low, (0.50–0.69) = moderate, (0.70–0.89) = high, (0.90–1.00) = very high [14]. Linear regression was conducted to adjust for the effect of demographic factors (age, gender, socioeconomic status, joints affected by arthritis, co-morbidities, and psychological status) on the relationship between WOMAC-p and self-report activity limitations. To adjust for the effect of demographic factors on the relationship between WOMAC-p and participation restrictions, the IAP-P was transformed with a root square function to comply with the assumptions of the linear model.

To compare functional measures between patients with low and high active flexion, patients were dichotomised into those with
low flexion and high flexion. Low flexion was defined as <110° for knee patients and <95° for hip patients. Continuous variables were compared between these two groups using unpaired t-tests or Mann-Whitney U tests for non-normally distributed variables. Categorical variables were compared using Chi-square tests. Statistical analysis was performed using Stata 12.

4. Results

4.1. Patient characteristics

Overall, 1451 eligible patients recorded on NHS records as listed for hip or knee replacement were approached about this study and 264 (18.2%) consented to participate. There was no difference in the age, gender or planned surgery type between participants and non-participants. Five patients listed for patellofemoral joint replacement were excluded from the analysis due to the small numbers. Two hundred and forty-nine patients had complete pre-operative data and were included in the analysis. Of these patients, 125 were listed for hip surgery (82 for primary replacement, 43 for revision replacement) and 124 for knee surgery (50 for primary replacement, 42 for revision replacement, 32 for unicompartmental knee replacement). Patients listed for hip replacement had a mean age of 65 years (95% confidence intervals of 63–67) and 50% were female. Patients listed for knee replacement had a mean age of 67 years (95% confidence intervals of 65–69) and 52% were female.

4.2. Relationship between pre-operative measures of impairment and activity limitations

Correlations between the measures of impairment (ROM and WOMAC-p) and measures of activity limitations (WOMAC-f, IAP-A, performance tests) are displayed in Table 1. Hip and knee ROM correlated weakly with self-report (0.11 to 0.43) and observed (0.09 to 0.39) activity limitations. In comparison, correlations between pain and self-report activity limitations were moderate to high (−0.63 to 0.80), and remained so after adjustment for demographic factors (data not shown). However, correlations between pain and observed activity limitations were low (0.13 to −0.44).

Correlations between individual WOMAC-f items and ROM measurements were investigated to determine if ROM correlated with specific functions. All correlations were found to be low (−0.01 to −0.40). The highest correlation in patients listed for hip replacement was between flexion and getting on/off toilet (−0.37) and in patients listed for knee replacement it was between flexion and getting in/out of a car (−0.40) and putting on socks/stockings (−0.40).

4.3. Relationship between pre-operative measures of impairment and participation restrictions

Correlations between measures of impairment and participation restrictions (IAP-P) are displayed in Table 1. Hip and knee ROM correlated poorly with participation restrictions (−0.32 to 0.06). In comparison, correlations between pain and participation restrictions were high in patients listed for hip replacement (−0.71) and moderate in patients listed for knee replacement (−0.53), and these correlations remained strong after adjustment for demographic factors (data not shown).

4.4. Comparison of functional measures between patients with low and high active flexion

To investigate whether restricted joint flexion had a negative impact on function, patients were divided into a low flexion group (<110° for knee patients and <95° for hip patients) and a high flexion group ≥110° for knee patients and ≥95° for hip patients). Patients listed for knee replacement with low flexion had significantly worse results on all measures of impairment, activity limitations and participation restrictions compared to patients with high flexion (Table 2). Patients listed for hip replacement with low flexion had significantly worse activity limitations as measured by the IAP-A and sit-to-stand-to-sit test compared to patients with high flexion.

5. Discussion

The WHO ICF model offers a theoretical framework for describing and assessing disability. The data from this study show that in patients listed for joint replacement there is a poor relationship between ROM and any of the disability measures used in this study, which contrasts with the strong relationship found between pain, activity limitations and participation restrictions. Previous studies have arrived at discordant conclusions about the relationship between function and ROM. Some reports suggest that ROM is an important determinate of function [6,15], whilst others disagree [7,8]. Furthermore, it is suggested that ROM is important for some specific functions, or that a threshold of flexion is required for adequate function [7]. Our data suggest that there may be such a threshold, but that pre-operative ROM does not correlate with specific activities on the WOMAC-f and modest restrictions of ROM are of little relevance to functional ability.

These findings are important for two reasons. First, commonly used methods of assessing patients’ disability, such as the AKSS
Table 2
Comparison of functional measures between patients with low and high active flexion.

<table>
<thead>
<tr>
<th>Impairment measures</th>
<th>Patients listed for knee replacement</th>
<th>Patients listed for hip replacement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low flexion (&lt;110°) (n=54)</td>
<td>High flexion (≥110°) (n=67)</td>
</tr>
<tr>
<td>WOMAC Pain Score</td>
<td>37 (32–42)</td>
<td>50 (46–54)</td>
</tr>
<tr>
<td>(mean, 95% CI)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WOMAC Function</td>
<td>43 (38–47)</td>
<td>58 (53–62)</td>
</tr>
<tr>
<td>Score (mean, 95% CI)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IAP-A Score (mean,</td>
<td>28 (26–31)</td>
<td>22 (19–24)</td>
</tr>
<tr>
<td>95% CI)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20-metre walk test</td>
<td>28 (22–36)</td>
<td>20 (17–27)</td>
</tr>
<tr>
<td>time in seconds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(median, Q1–Q3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sit-stand-test (%</td>
<td>78</td>
<td>94</td>
</tr>
<tr>
<td>completed)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20-cm step test (%</td>
<td>67</td>
<td>85</td>
</tr>
<tr>
<td>completed)</td>
<td></td>
<td></td>
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<tr>
<td>Participation restriction measures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IAP-P (median, Q1–Q3)</td>
<td>13 (8–17)</td>
<td>8 (5–13)</td>
</tr>
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<td></td>
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</tbody>
</table>

CI: confidence intervals; Q1–Q3: 25th percentile to 75th percentile; IAP-A: Activity Limitations Scale of the Aberdeen Impairment, Activity Limitation and Participation Restriction Measure; IAP-P: Participation Restrictions Scale of the Aberdeen Impairment, Activity Limitation and Participation Restriction Measure. P-values presented are for unpaired t-tests or Mann-Whitney U tests.

and HHS, include ROM. Second, many orthopaedic surgeons often consider the achieved ROM of a replaced joint to be an important measure of surgical outcomes, and discuss this with their patients. We suggest that as a measure of impairment, pre-operative ROM is of little relevance to function and the only concern should be whether knee flexion is restricted to less than 110° and, to a less extent, whether hip flexion is limited to less than 95°.

A limitation of the study which warrants acknowledgement when interpreting the results is the lack of data on the status of the homolateral hip or knee, as this may have influenced measures of function. Other weaknesses of the study were the lack of randomisation of the order of the performance tests and inclusion of patients from only one specialist orthopaedic unit. However, by including patients listed for a range of joint replacement procedures, a diverse and varied sample was achieved. Strengths of the study include the relatively large sample size, the extent of and care taken with the measures of ROM and disability, and the good inter and intra observer reliability for ROM.

In conclusion, these findings suggest that measuring ROM adds little value to assessment of impairment in patients undergoing joint replacement, unless knee flexion is restricted to less than 110° and, to a less extent, hip flexion is limited to less than 95°. We therefore recommend that ROM should not be used to assess disability in a pre-operative context. Further research is needed to explore the relationship between change in ROM and functional outcomes after joint replacement.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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