Rheumatology International (2020) 40:565–571
https://doi.org/10.1007/s00296-020-04532-5

Rheumatology
INTERNATIONAL

OBSERVATIONAL RESEARCH

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Association of handgrip strength with patient-reported outcome measures after total hip and knee arthroplasty

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Received: 13 September 2019 / Accepted: 5 February 2020 / Published online: 18 February 2020

Abstract

About 33% patients with osteoarthritis undergoing total hip/knee arthroplasty are not satisfied with the outcome, warranting the need to improve patient selection. Handgrip strength (HGS) has been suggested as a proxy for overall muscle strength and may be associated with post-arthroplasty function. This study aims to assess the association of pre-operative HGS with change in hip/knee function and quality of life in patients with arthroplasty. 226 hip (THA) and 246 knee (TKA) arthroplasty patients were included in this prospective cohort study. Pre-operative HGS was assessed by means of a dynamometer and the HOOS/KOOS and SF-36 questionnaires were collected before arthroplasty and 1 year thereafter. The association of HGS with score change on each sub-domain of the included questionnaires was assessed by linear regression models, adjusting for sex, body mass index and baseline score. Mean pre-operative HGS was 26 kg for patients undergoing THA and 24 kg for those undergoing TKA. HGS was positively associated with an increased improvement score on "function in sport and recreation"-domain in hip ($\beta = 0.68$, $P = 0.005$) and knee ($\beta = 0.52$, $P = 0.049$) and "symptoms"-domain in hip ($\beta = 0.56$, $P = 0.001$). For patients with THA, HGS was associated with the "quality of life" domain ($\beta = 0.33$, $P = 0.033$). In patients with TKA, HGS was associated with the physical component score ($\beta = 0.31$, $P = 0.001$). All statistically significant effects were positive, indicating that with greater pre-operative HGS, an increased gain in 1-year post-surgery score was observed. HGS can be used as a tool to inform patients with OA who are future candidates for a prosthesis about the possible improvements of certain aspects of life after arthroplasty.

Keywords Osteoarthritis (OA) · Total hip arthroplasty (THA) · Total knee arthroplasty (TKA) · Handgrip strength (HGS) · Rehabilitation

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Introduction

Total hip arthroplasty (THA) and total knee arthroplasty (TKA) are effective procedures to improve pain and functioning in patients with osteoarthritis (OA) [1, 2]. Despite high success rates, up to one-third of persons undergoing arthroplasty are not satisfied with the outcome of surgery [3–5], warranting the need for tools to manage expectations in this patient group and to improve the selection of patients who may and may not benefit from this procedure.

Besides age, gender, physical and mental status, poor quadriceps strength was associated with worse outcomes of TKA [6–8]. Handgrip strength (HGS) may be a proxy for overall muscular strength, with only a small number of measurements with a handgrip dynamometer considered necessary to characterize an individual's overall strength status [9–11].

HGS has been demonstrated to associate with worse general health in the elderly as well as being a predictor for all-cause mortality in the elderly [12–18]. In various patient groups, HGS has been shown to be associated with disability, malnutrition and surgery complications [19–28]. Kumar et al. [29] demonstrated in patients with THA and TKA that a lower HGS is associated with increased length of hospital stay while correcting for age. Recently, Hashimoto et al. [30] demonstrated that HGS is associated with gait pattern on stairs after TKA. However, the value of HGS as a predictor for long-term outcomes on other aspects of life after lower limb arthroplasty surgery are currently unknown.

The purpose of this study is to assess the association of pre-operative HGS with the level of improvements of hip and knee function and quality of life 1 year after THA or TKA. These outcomes will be measured by means of the sub-domains of the *Hip Disability and Osteoarthritis Outcome Score* (HOOS) and *Knee Injury and Osteoarthritis Outcome Score* (KOOS) and *Short Form-36 Health Survey* (SF-36) questionnaires.

Materials and methods

Participants

This study was part of a prospective observational cohort study on the outcomes of THA and TKA performed at the department of orthopedics of the Alrijne Hospital, Leiderdorp, the Netherlands, from October 2010 to September 2013 (inclusion of patients until September 2012). The study protocol was in concordance with the Declaration of Helsinki [31] and was reviewed and approved by the local hospital Review Board of the Alrijne Hospital (registration number 11/02), which is supervised by the medical ethics committee of the Leiden University Medical Center, Leiden, the Netherlands. Informed consent was obtained from all individual participants included in the study.

This prospective cohort study aimed to include all consecutive patients undergoing a primary THA or TKA because of OA, aged 18 years or older, able to read and understand Dutch and being mentally and physically able to complete questionnaires. Excluded were patients with revision of a THA or TKA, undergoing a hemi-arthroplasty of the hip and undergoing a THA or TKA because of a tumor or rheumatoid arthritis. All assessments were done pre-operatively and 12 months thereafter and consisted of HGS measurement at the hospital and the collection of questionnaires, administered personally (pre-operative assessment) or by regular mail (follow-up).

One day before surgery, upon being admitted to the hospital, information about the study was provided to all eligible patients. Patients received a response form as well as a set of questionnaires. The response form comprised statements for both patients who wished to participate (including signature) and those who did not want to participate. Each patient was asked to return the questionnaires and informed consent form and perform the HGS test on the day of surgery.

Data collection

Socio-demographic characteristics were recorded pre-operatively and included: age (years); gender, height (cm) and weight (kg) to calculate the body mass index (BMI). Age was categorized into three age groups; < 60 years, 60–70 years and aged > 70.

Isometric HGS was measured before arthroplasty using the JAMAR® hydraulic hand dynamometer (Patterson medical, Mississauga, Canada). Results were expressed in kilograms. Patients were shown the correct operation of the dynamometer prior to measurements. They were instructed to keep their shoulders adducted and neutrally rotated, their forearm in a vertical position, and wrist in a neutral position and to squeeze the grip with maximal strength. The highest result of two grip strength trials with the dominant hand in a seated or semi-seated position was used [32].

Patient-reported outcome measures (PROMs) were collected before arthroplasty surgery and at 1 year follow-up. The SF-36 questionnaire was used to assess overall quality of life and the HOOS/KOOS for joint specific PROMs measurements. The SF-36 is composed of 36 questions and standardized response choices. Summary component scores for physical health (PCS) and mental health (MCS) can be calculated from this questionnaire. In this study, scores of the Dutch general population were used to apply norm-based scoring [33]. For each of summary component score, a change score was calculated by subtracting the pre-surgery score from the 1-year follow-up score.

In patients undergoing THA, the HOOS was used to assess functioning. This questionnaire consists of 40 items divided over five dimensions: pain (P); symptoms (S); activity limitations-daily living (ADL); function in sport and recreation (SP); and hip-related quality of life (QoL). Persons with end-stage knee OA received a similar KOOS questionnaire which comprises 42 items and uses the same five subscales as the HOOS. For the present study, validated Dutch versions of the HOOS and KOOS were used [34, 35]. For each of these subscales, a change score was calculated by subtracting the pre-surgery score from the 1-year follow-up score.

Statistical analyses

Patients' socio-demographic characteristics were compared between those who did and did not complete the 1 year follow-up assessment by using unpaired Student's *t* test (for continuous variables) or Chi square test (for categorical variables).

Normality of the change scores was assessed by means of histograms, Q–Q-plot and Kolmogorov–Smirnov test. Multiple regression models were used to study the association between HGS and change scores adjusted for age group, gender, BMI and preoperative values of outcome measures. An interaction term between gender and age group was incorporated in the model to investigate possible additional different effects between males and females. These analyses were performed for THA and TKA separately.

The strength of the association of HGS with the change score was quantified by assigning the unstandardized effect sizes to one of the categories: 0–0.19 very weak, 0.2–0.39 weak, 0.4–0.59 moderate, 0.6–0.79 strong, 0.8–1.00 very strong [36].

All data were analyzed using the SPSS statistical package (version 20.0, SPSS, Chicago, Illinois). The level of statistical significance was set at $P \leq 0.05$ for all analyses.

Results

341 persons undergoing THA surgery completed the preoperative assessment of which 226 (66.3%) persons completed the 1 year follow-up. Among the 315 patients with TKA, 246 (78.1%) completed the 1 year follow-up; see also Fig. 1. Demographic characteristics of patients with end-stage OA, scheduled for either THA or TKA, are shown in Table 1. There were no statistically significant differences

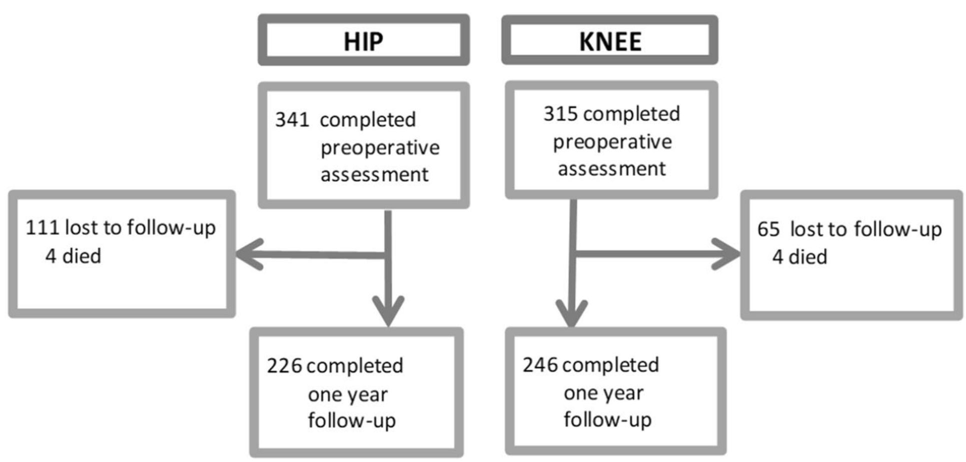

Fig. 1 Flowchart of patients completing the pre-operative and the 1-year follow up assessments

Table 1 Demographic characteristics of patients with end-stage osteoarthritis (OA), scheduled for either total hip or total knee arthroplasty

Variables		Total hip arthroplasty			Total knee arthroplasty		
		completed $N=226$	Not complete $N=115$	P*	completed $N=246$	Not completed $N=69$	P*
Sex, female	N (%)	127 (56.1%)	75 (65.2%)	0.109	176 (71.5%)	52 (75.3%)	0.531
Age, years	Mean ± SD	66.4 ± 9.5	67.8 ± 10.8	0.243	66.9 ± 9.2	68.1 ± 11.5	0.359
BMI, kg/m^2	Mean ± SD	26.9 ± 4.4	27.8 ± 4.8	0.082	29.4 ± 4.5	29.7 ± 4.7	0.675

BMI body mass index

**P* value for differences between patients with end-stage hip or knee OA who did and did not complete follow-up. Difference was calculated by means of Chi-square or unpaired Student's *T* test, as appropriate in age, gender and BMI between those who did and did not complete follow-up. Among those who completed the questionnaire, patients with TKA were significantly more often female than those who underwent THA ($P = 0.001$) and had a higher BMI ($P < 0.001$), and there was no significant difference in age between patients with THA or TKA ($P = 0.605$).

Mean HGS was 26 kg (SD = 10) for end-stage hip OA and 24 kg (SD = 10) in patients with end-stage knee OA, with males having higher scores than females in both groups: THA [mean (SD) HGS males: 34 kg (10), females: 21 kg (6)] and TKA [mean (SD) HGS males: 34 kg (10), females 19 kg (7)].

As can be seen in Table 2, for each outcome score (except MCS) a significant increase in outcome score was found. In both arthroplasty groups, the improvement in outcome for PCS was higher than the minimal clinically important difference (MCID) of ten points [37, 38]. The smallest improvement in score on the HOOS/KOOS subscales was 10.8, (KOOS-S) which is just above the MCID cutoff of ten [39, 40]. Interestingly, the final scores on the "function in sport and recreation" and "symptoms" subscales of the HOOS/KOOS were significantly (both $P < 0.001$) higher in the THA group as compared to the TKA group.

The unstandardized adjusted coefficients, showing the effect of preoperative HGS and the change on the postoperative PROMs outcome variable, are shown in Table 3 where the effect is quantified by the standardized regression coefficient (β).

In both arthroplasty groups, a significant effect of HGS on "function in sport and recreation" scale of the HOOS/KOOS (THA: $\beta = 0.68$, $P = 0.005$; TKA $\beta = 0.52$, $P = 0.049$) was found. Some evidence of an effect of HGS on the "symptoms" subscale was seen in THA ($\beta = 0.56$, $P = 0.001$), but not in the TKA group ($\beta = 0.16$, $P = 0.146$). The "quality of life"-domain as measured by HOOS/KOOS showed to have a small effect from HGS in both THA ($\beta = 0.32$, $P = 0.047$) and TKA ($\beta = 0.33$, $P = 0.033$) patients. In patients with TKA, PCS was significantly impacted by HGS ($\beta = 0.31$, $P = 0.001$) but not in THA ($\beta = 0.14$, $P = 0.052$). Again, no evidence of the effect of HGS on the MCS of the SF-36 in both the THA and TKA group was found.

All observed effects were positive, indicating that with increased handgrip strength a larger improvement of the outcome score occurs after arthroplasty surgery.

Discussion

This study demonstrates that there is a strong, positive, association between HGS and the improvement of outcome score on the "function in sport and recreation" domain of the HOOS/KOOS questionnaire in patients with THA or TKA. This was also found for the "symptoms" subscale and some evidence for a smaller effect on "quality of life" of the HOOS in patients with THA. These findings may be useful in a clinical setting to inform patients with end-stage OA who are future candidates for a prosthesis about which improvements to expect from THA or TKA.

Our findings are in agreement with current research where low HGS before surgery is associated with adverse outcome scores. The association of HGS with increased improvement of the score for physical measures (reflected in "function in sports and recreation", "symptoms" and PCS)

Table 2 Outcome score at baseline and 1 year follow-up

Outcome	Total hip arthroplasty $N = 226$			Total knee arthroplasty $N = 246$		
	Baseline Mean ± SD	1 year FU Mean ± SD	P*	Baseline Mean ± SD	1 year FU Mean ± SD	P*
SF-36						
PCS	40.2 ± 7.5	53.3 ± 7.7	< 0.001	40.6 ± 7.3	52.1 ± 8.9	< 0.001
MCS	52.1 ± 10.5	53.4 ± 8.4	0.096	52.8 ± 10.1	52.0 ± 9.35	0.115
HOOS/KOOS						
ADL	45.2 ± 17.8	84.8 ± 16.9	< 0.001	50.1 ± 18.1	84.2 ± 16.4	< 0.001
Pain	43.2 ± 18.5	88.2 ± 14.7	< 0.001	43.0 ± 16.5	85.0 ± 17.0	< 0.001
QoL	35.7 ± 10.3	54.8 ± 17.1	< 0.001	35.2 ± 9.9	54.2 ± 17.1	< 0.001
SP	21.6 ± 19.3	63.8 ± 26.6	< 0.001	14.0 ± 16.0	47.1 ± 28.8	< 0.001
Symptoms	38.2 ± 18.9	80.5 ± 19.8	< 0.001	45.0 ± 13.5	55.8 ± 12.0	< 0.001

SF-36 Short Form 36 questionnaire, *PCS* physical component score of the SF-36 questionnaire, *MCS* mental component score of the SF-36 questionnaire, *HOOS/KOOS* hip disability/knee injury Osteoarthritis Outcome Score, *ADL* activities of daily life–domain of the HOOS/KOOS questionnaire, *QoL*: quality of life–domain of the HOOS/KOOS questionnaire, *SP* function in sport and recreation–domain of the HOOS/KOOS questionnaire

*P value for Wilcoxon test assessing difference in outcome score at baseline and 1 year follow-up

Table 3 Outcome of multiple regression models for the association between HGS and change score

Outcome	Total hip arthroplasty $N=226$			Total knee arthroplasty $N=246$		
	β (SE)	95% confidence interval	P*	β (SE)	95% confidence interval	P*
SF-36						
PCS	0.136 (0.069)	[−0.001–0.273]	0.052	0.305 (0.086)	[0.135–0.476]	0.001
MCS	0.074 (0.065)	[−0.054–0.202]	0.257	−0.022 (0.086)	[−0.192–0.148]	0.802
HOOS/KOOS						
ADL	0.253 (0.147)	[−0.037–0.543]	0.087	0.308 (0.150)	[0.012–0.604]	0.042
Pain	0.270 (0.129)	[0.015–0.524]	0.038	0.188 (0.156)	[−0.119–0.496]	0.229
QoL	0.317 (0.159)	[0.005–0.630]	0.047	0.327 (0.152)	[0.026–0.628]	0.033
SP	0.681 (0.239)	[0.209–1.153]	0.005	0.520 (0.263)	[0.001–1.039]	0.049
Symptoms	0.564 (0.170)	[0.228–0.900]	0.001	0.159 (0.109)	[−0.056–0.373]	0.146

SF-36 Short Form 36 questionnaire, *PCS* physical component score of the SF-36 questionnaire, *MCS* mental component score of the SF-36 questionnaire, *HOOS/KOOS* hip disability/knee injury Osteoarthritis Outcome Score, *ADL* activities of daily life domain of the HOOS/KOOS, *QoL* quality of life domain of the HOOS/KOOS, *SP* function in sport and recreation domain of the HOOS/KOOS

*P value; potential confounder age group, sex, BMI and baseline outcome

post-surgery is also discussed in Savino et al. [41], where the authors show that HGS is associated with walking recovery after hip fracture surgery. In the same type of patients, Visser et al. have shown that a decline in HGS post-surgery is associated with less recovery of mobility and Beloosesky et al. have demonstrated that HGS can be used to predict motor functioning at 6 months post-surgery [42, 43]. Similarly, Hashimoto et al. [30] showed that HGS is associated with stairs ascent and decent in females who underwent TKA. Although we used a more generic outcome measure in a slightly different patient group with a longer follow-up, these findings are in line with published literature.

The association of HGS with "function in sport and recreation" was more pronounced in patients with THA than patients with TKA and the "symptoms" subscale was only associated with HGS in patients with THA, not in patients with TKA. A systematic review by Skoffer et al. [44] found that muscle strength training in THA is effective to improve QoL after surgery, whereas for TKA this is not demonstrated. These outcomes, together with the present study, suggest that the association of muscle strength with surgery outcome is dependent on the joint site; however, the mechanism is yet to be elucidated. Patients with TKA were, at baseline, more overweight than patients with THA, which may play a role. Indeed, it has been reported that obesity is negatively associated with functional score and quality of life after TKA, but not in THA [45]. However, our results were corrected for BMI; nevertheless, we do find different results for both joints.

The mean HGS values found in our study (THA: males: 34 kg, females: 21 kg; TKA: males: 34 kg, females 19 kg) were lower than the reference values as reported by Leong et al. [46] for males (HGS = 42 kg) and females (HGS = 26 kg) aged 61–70 years from North America and Europe. These lower values may be explained by the fact that our patients have end-stage osteoarthritis, while the reference values were obtained in healthy adults.

Clinicians were instructed to include patients with primary THA or TKA because of OA and to exclude patients who had other rheumatic diseases. However, no registration was made of the presence of other rheumatic diseases; therefore, it is possible that there were patients who had a lower HGS because they had another rheumatic disease, a limitation of the study.

This study suffers from a high rate of loss to follow-up (THA: 33.7% and TKA: 21.9%). Although we did not find any statistically significant differences in age, sex or BMI, those who did not complete follow-up tend to be older and have a higher BMI. As increased age and BMI are associated with worse outcomes, this is a major limitation to our study leading to underestimated results. The high rate of loss of follow-up could be due to the observatory nature of the study in which patients were not motivated to complete the questionnaires they received by post; however, future studies should aim to reduce these dropout rates. This may be done by administering the follow-up questionnaire in a face-to-face setting instead of deliver them at home by mail.

Since the guidelines on indication for THA or TKA are based on limited evidence [47, 48], the application of HGS as a tool to identify patients with end-stage OA who may experience less improvement in function may contribute to optimize patient-specific care. HGS could be applied to manage patient expectations and include patients in the shared decision-making process.

In conclusion, a rather easily applicable measurement such as HGS could provide clinicians as well as patients with OA who are future candidates for a prosthesis with an indication of the improvement in function that is to be expected after THA or TKA on certain aspects of life.

Author contributions All authors participated either in drafting of the work or revised the work critically and approved the final version of the manuscript and agree to be accountable for all aspects of the work. JMTAM and MF made substantial contributions to the analysis of data and the interpretation of the data. RLT made substantial contributions to the conception and design of the work, and together with AS and SHMV contributed to the acquisition of data. PES helped with the interpretation of the data for the work. TPMVV and RGHHN made substantial contributions to the conception and design of the work, the analysis of data and the interpretation of the data. All (co-)authors take full responsibility for the integrity of the study and the final manuscript. No abstracts of this work have been published in congresses.

Funding No funding was obtained for this study.

Compliance with ethical standards

Conflict of interest Each author certifies that he or she has no commercial associations (eg, consultancies, stock ownership, equity interest, patent/licensing arrangements) that might pose a conflict of interest in connection with the submitted article. There is no financial or non-financial conflict of interest to be reported for any of the authors.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee (Review Board of the Alrijne Hospital (registration number 11/02) and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Ethical review committee statement The medical ethic board of the Alrijne Hospital, which is supervised by the medical ethics committee of the LUMC, approved this study (# 11/02).

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