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Original Article

Physical functions associated with health-related quality of life in older adults diagnosed with knee osteoarthritis

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Abstract. [Purpose] The present study aimed to identify the physical functions associated with health-related quality of life in older adults with knee osteoarthritis. [Participants and Methods] A total of 132 participants were included in this study in two groups: the knee osteoarthritis group (n=66) and the control group (n=66). We compared the results of the Medical Outcomes Study 36-Item Short-Form Health Survey with the physical function measures related to health-related quality of life. In the knee osteoarthritis group, we examined the relationship between the degree of knee pain and health-related quality of life. [Results] The knee osteoarthritis group showed a significantly shorter one-leg standing time, lower maximum walking speed, and significantly longer time to complete the Sit-to-Stand-5 and Timed Up and Go tests than the control group. The knee osteoarthritis group had significantly lower 36-Item Short-Form Health Survey scores than the control group on seven subscales and significantly lower scores for physical component summary and role or social component summary. In the knee osteoarthritis group, physical component summary and role or social component summary were correlated with Sit-to-Stand-5, Timed Up and Go, and maximum walking speed. We observed a correlation between physical component summary and knee pain on joint loading. [Conclusion] In older adults with knee osteoarthritis, rehabilitation approaches aimed at achieving a smooth transition from sitting to standing may increase social participation and improve health-related quality of life.
Key words: Knee osteoarthritis, Health-related quality of life, Sit-to-stand movement

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INTRODUCTION

Knee osteoarthritis (KOA) is a multifactorial disease caused by various factors such as aging, obesity, and mechanical stress[1)]; it is the most common joint disease among older adults[2, 3)]. The prevalence of KOA in Japan is high[4)], with estimated 25.3 million people over the age of 40 years being affected by KOA, of which approximately 8 million are symptomatic cases with complaints of pain and other symptoms[5)]. Furthermore, according to the Japanese Ministry of Health, Labour and Welfare's FY2019 National Survey of Basic Living Conditions, joint diseases, including KOA, represented the fifth leading factor that contributes to the need for long-term care and the leading factor that contributes to the need for support[6)]. The number of older adults affected by KOA is assumed to continue to rise in Japan where rapid population aging is underway.

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As KOA progresses, articular cartilage damage, osteophyte formation, and stiffening of the subchondral bone occur, causing pain, a decline in physical functions, and loss of ability to perform activities of daily living (ADL)[7, 8]. Previous studies have also reported a decrease in quality of life (QoL) due to KOA[9]. QoL is considered to be equivalent to the World Health Organization's (WHO) definition of health[10]; according to the WHO Charter, "Health is defined not as the absence of disease or infirmity, but as a state of complete physical, mental, and social well-being"[11]. To determine whether a person is healthy or not, it is essential to evaluate not only the physical component but also the mental and social components of health. It is possible to assess the health status of older adults with KOA more multidimensionally by taking into account QoL, rather than focusing solely on physical functions.

Among QoL measures, health-related QoL (HRQoL) is the one that shows the influence of perceived health on QoL[10]. The Medical Outcomes Study 36-Item Short-Form Health Survey (SF-36®) is a useful measure for the evaluation of HRQoL. The SF-36® consists of eight subscales and three summary scores (physical component summary [PCS], mental component summary [MCS], and role/social component summary [RCS])[12]. It has been reported that factors related to HRQoL as measured by SF-36® in patients with KOA include the amount of joint effusion and the degree of pain[9]. It has also been reported that the PCS of SF-36® is correlated with age and that MCS is correlated with gender[13]. Furthermore, a systematic review on the HRQoL of patients with KOA revealed that the female gender, obesity, decline in physical functions, poverty, psychological distress, depression, and living alone were factors that negatively affect HRQoL of patients with KOA[14]. Although it is clear that age and gender affect the HRQoL of patients with KOA, to the best of the authors' knowledge, no previous studies have examined the HRQoL of patients with KOA in comparison with healthy controls perfectly matched for age and gender. Comparing fully age- and gender-matched KOA older adults without KOA will further clarify the characteristics of KOA older adults when the effects of age and gender are excluded. Moreover, although a decline in physical functions has been reported to adversely affect HRQoL, specific physical functions measures related to the physical, mental, and social aspects of HRQoL have not been sufficiently studied. In particular, no physical functions related to the RCS of HRQoL have been examined. It has been reported that exercise therapy is effective in improving HRQoL in patients with KOA[15]; thus, if physical functions that influence each aspect of HRQoL are identified, it will become possible to develop a rehabilitation approach that not only aims to improve physical functions but also HRQoL. Therefore, this study we compared and examined the association between physical functions and HRQoL among KOA elderly and community-dwelling elderly who were perfectly matched in terms of age and gender.

PARTICIPANTS AND METHODS

Sixty-six participants in the KOA group were selected from older adults (60 years of age and older) diagnosed with KOA at an orthopedic hospital in Toyama City, Toyama Prefecture, and were scheduled for surgeries, including high tibial osteotomy or knee joint replacement. Of this 66 in the KOA group, 37 had bilateral knee osteoarthritis and 29 had unilateral knee osteoarthritis. The knee joints scheduled for surgery included 32 knees on the left side and 34 knees on the right side, with a femoro-tibial angle of 181.8 ± 4.6° and a Kellgren–Lawrence classification of grade 2 in 14 cases, grade 3 in 36 cases, and grade 4 in 16 cases. Sixty-six participants in the control group were selected from community-dwelling older adults (60 years and older) who attended a local social club for older people, had no symptoms of knee pain or limited range of motion, and had not been diagnosed with KOA. The study included a total of 132 participants (16 males and 50 females in each group with the mean age [± standard deviation] of 73.0 ± 5.9 years) who had scored 28 or higher on the Mini Mental State Examination and had no missing measurement data. Participants in the KOA and control groups were perfectly matched for age and gender. The participants received verbal and written explanations about the purpose of this study, and they provided written informed consent. This study was approved by the Institutional Review Boards of Sainou Hospital (approval number 016), Osaka University of Health and Sports Sciences (approval number 20-2), and Kinjo University (approval number 2020-01).

Grip strength, one-leg standing time, Sit-to-Stand-5 (SS-5), Timed Up and Go test (TUG), and maximum walking speed were used as measures of physical functions. Grip strength was measured using a digital grip strength meter (Grip D, Takei Scientific Instruments Co., Ltd, Niigata, Japan). The maximum values were recorded by measuring grip strength twice for each hand in the standing position. One-leg standing test and TUG can be used to assess the ability to maintain balance[16, 17]. The SS-5 can be used to assess lower-limb strength and the ability to perform ADL[18]. Walking speed can be used to assess the risk of falling[19]. For the one-leg standing test, the participants were instructed to maintain a single-leg stance on each leg in an upright standing position with arms folded across their chest as long as they could; the maximum value was recorded. For the SS-5, the participants were instructed to stand up from a chair and sit back down five times as quickly as possible with arms folded across their chest; the time to complete the test was measured once. For the TUG, the participants were instructed to stand up from a seated position upon command, walk 3 m, turn around, walk back to the chair, and sit down. The time to complete the TUG test was recorded. For the measurement of the maximum walking speed (m/s), the participants were instructed to walk as fast as possible on a 4 m walking path with 1 m spare sections before and after the walking path; the time to walk 4 m was measured using a stopwatch. The measurement was taken twice, and the maximum walking speed was recorded. In the KOA group, knee pain at rest and knee pain on joint loading were measured using a visual analog scale (VAS).

Body composition was measured using a body composition analyzer (MC-780A, Tanita, Tokyo, Japan) for body weight, body fat percentage, skeletal muscle mass index (SMI), and body mass index (BMI). The SF-36® was used to assess HRQoL; eight subscale scores (physical functioning [PF], role physical [RP], bodily pain [BP], general health [GH], vitality [VT], social functioning [SF], role emotional [RE], and mental health [MH]) and three summary scores (PCS, RCS, and MCS) were calculated using a web-based scoring system. Higher scores indicated better HRQoL.

The following items were included in the statistical analysis: grip strength, one-leg standing time, SS-5, TUG, maximum walking speed, body composition data, SF-36® scores (eight subscale items and three summary scores) for both groups. The unpaired t-test was used for the items for which normality was found in the measurement results. The Mann–Whitney U-test was used for items for which normality was not found. Subsequently, the relationship between physical functions and HRQoL (three summary scores) was examined in the KOA and control groups. Furthermore, the relationship between VAS and HRQoL (three summary scores) was also examined but only for the KOA group. After the normality test, the Pearson product-moment correlation coefficient was used for the items for which normality was found, and the Spearman's rank correlation coefficient was used for the items for which normality was not found. The statistical software used was SPSS Statistics 26 (Advanced ANALYTICS Co., Ltd, Tokyo, Japan). The statistical significance was determined at the 5% level.

RESULTS

The results of body composition measurements for the two groups are shown in Table 1. The KOA group had a significantly higher body weight and BMI than the control group ($p<0.01$). There were no significant differences in body fat percentage and SMI between the two groups. The VAS score for knee pain at rest was 18.9 ± 20.6 mm, and that of knee pain on joint loading was 44.3 ± 25.4 mm in the KOA group.

Physical functions measurements and SF-36® results for the two groups are shown in Table 2. First, with regard to the physical functions, the KOA group showed significantly shorter one-leg standing time ($p<0.01$), significantly lower maximum walking speed ($p<0.01$), and significantly longer time required to complete the SS-5 ($p<0.01$) and TUG ($p<0.01$) in comparison with the control group. On the SF-36®, the KOA group showed significantly lower scores in seven of the eight subscales (PF [$p<0.01$], RP [$p<0.01$], BP [$p<0.01$], GH [$p<0.01$], VT [$p<0.01$], SF [$p<0.01$], and RE [$p<0.01$]), excluding MH, in comparison with the control group. With regard to the three summary scores, the KOA group showed significantly lower PCS ($p<0.01$) and RCS ($p<0.05$) scores in comparison with the control group, but there was no significant difference in the MCS scores.

Table 3 shows the findings pertaining to the relationship between physical functions and HRQoL in the KOA and control groups. In the KOA group, PCS had weak negative correlations with SS-5 ($\rho=-0.30$, $p<0.05$), time to complete TUG ($\rho=-0.32$, $p<0.01$), knee pain on joint loading ($\rho=-0.33$, $p<0.01$), and a moderate positive correlation with maximum walking speed ($\rho=0.40$, $p<0.01$). Furthermore, RCS had weak negative correlations with SS-5 ($\rho=-0.26$, $p<0.05$), time to complete TUG ($\rho=-0.24$, $p<0.05$), and a weak positive correlation with maximum walking speed ($\rho=0.25$, $p<0.05$). In contrast, in the control group, MCS had weak positive correlations with body weight ($\rho=0.36$, $p<0.01$), BMI ($\rho=0.36$, $p<0.01$), and body fat percentage ($\rho=0.32$, $p<0.01$). RCS had weak positive correlations with one-leg standing time ($\rho=0.28$, $p<0.05$) and maximum walking speed ($\rho=0.25$, $p<0.05$), whereas PCS had no correlation with any of the physical functions measures.

DISCUSSION

In comparison with community-dwelling older adults, older adults with KOA showed significant differences in one-leg standing time, SS-5, TUG, maximum walking speed, and seven subscales (PF, RP, BP, GH, VT, SF, and RE), as well as PCS and RCS scores on the SF-36®. In the present study, which compared the physical functions of older adults with KOA and community-dwelling older adults who were perfectly matched for gender and age, older adults with KOA exhibited lesser ability to maintain balance[16, 17], lower-limb muscle strength, and lesser ability to perform ADL[18]. These results which may

Table 1. Body composition measurements for the KOA and control groups

	KOA group	Control group
Body weight (kg)**	60.90 ± 10.12	55.84 ± 9.73
BMI (kg/m^2)**	25.31 ± 3.51	23.12 ± 2.93
Body fat percentage (%)	31.52 ± 8.70	29.12 ± 7.41
SMI (kg/m^2)	7.24 ± 1.23	6.80 ± 0.91

Mean ± standard deviation.
**$p<0.01$.
KOA group: knee osteoarthritis group; Control group: community-dwelling elderly group; BMI: body mass index; SMI: skeletal muscle mass index.
The KOA group had a significantly higher body weight and BMI than the control group.

Table 2. Comparison of physical function and SF-36® scores between the KOA and control groups

	KOA group	Control group
Grip strength (kg)	25.10 ± 7.50	27.20 ± 7.73
One-leg standing time (s)**	25.12 ± 30.21	58.01 ± 38.70
Time to complete the SS-5 (s)**	16.24 ± 6.12	7.92 ± 2.10
Time to complete the TUG (s)**	10.83 ± 4.53	6.14 ± 1.02
Maximum walking speed (m/s)**	1.11 ± 0.34	1.93 ± 0.34
PF**	47.10 ± 21.10	88.10 ± 13.00
RP**	56.20 ± 25.30	83.00 ± 21.60
BP**	43.10 ± 17.30	70.70 ± 22.00
GH**	56.50 ± 15.70	67.70 ± 15.90
VT**	59.00 ± 22.70	70.20 ± 17.30
SF**	74.10 ± 24.70	88.10 ± 20.20
RE**	71.60 ± 25.60	86.70 ± 22.60
MH	71.30 ± 21.10	78.60 ± 16.80
PCS**	27.40 ± 10.00	47.60 ± 8.60
MCS	58.00 ± 10.20	57.40 ± 8.30
RCS*	45.60 ± 12.50	49.40 ± 11.40

Mean ± standard deviation.
*p<0.05, **p<0.01.
SF-36®: MOS 36-Item Short-Form Health Survey; KOA group: knee osteoarthritis group; Control group: community-dwelling elderly group; SS-5: Sit-to-Stand-5; TUG: Timed Up and Go test; PF: physical functioning; RP: role physical; BP: bodily pain; GH: general health; VT: vitality; SF: social functioning; RE: role emotional; MH: mental health; PCS: physical component summary; MCS: mental component summary; RCS: role/social component summary.
The KOA group showed significant differences in one-leg standing time, maximum walking speed, SS-5 and TUG compared with the control group. On the SF-36®, the KOA group showed significant differences in seven of the eight subscales, excluding MH, and two of the three summary score, excluding MCS, compared with the control group.

Table 3. Correlations between physical function and SF-36® component scores in the KOA and control groups

	KOA group			Control group		
	PCS	MCS	RCS	PCS	MCS	RCS
Body weight (kg)	−0.13	0.09	−0.04	0.13	0.36**	−0.09
BMI (kg/m^2)	−0.18	0.03	−0.14	−0.07	0.36**	−0.14
Body fat percentage (%)	−0.09	−0.07	−0.05	−0.15	0.32**	0.03
SMI (kg/m^2)	−0.20	0.06	−0.01	0.18	0.19	−0.17
Grip strength (kg)	−0.08	0.17	0.15	0.17	0.15	−0.07
One-leg standing time (s)	0.13	−0.08	0.15	0.12	0.14	0.28*
Time to complete the SS-5 (s)	−0.30*	−0.05	−0.26*	−0.10	−0.01	−0.04
Time to complete the TUG (s)	−0.32**	0.03	−0.24*	−0.15	0.10	−0.13
Maximum walking speed (m/s)	0.40**	−0.01	0.25*	0.19	−0.04	0.25*
Pain at rest (mm)	−0.09	−0.02	−0.08			
Pain on joint loading (mm)	−0.33**	−0.07	−0.03			

Correlation coefficient.
*p<0.05, **p<0.01.
SF-36®: MOS 36-Item Short-Form Health Survey; KOA group: knee osteoarthritis group; Control group: community-dwelling elderly group; PCS: physical component summary; MCS: mental component summary; RCS: role/social component summary; BMI: body mass index; SMI: skeletal muscle mass index; SS-5: Sit-to-Stand-5; TUG: Timed Up and Go test.
In the KOA group, PCS was correlated with SS-5, TUG, knee pain on joint loading, and maximum walking speed. Furthermore, RCS was correlated with SS-5, TUG, and maximum walking speed. In the control group, MCS was correlated with body weight, BMI, and body fat percentage. RCS was correlated with one-leg standing time and maximum walking speed.

indicate a higher risk of falling[19], as suggested in previous studies[20–23]. The findings pertaining to HRQoL in this study are similar to those reported in previous research[9, 24], although there was no significant difference in MCS between the two groups. This suggests that the older adults with KOA who participated in this study were able to maintain their MH because they were patients on the waiting list for surgery who wished to be active again after the operation.

Analysis of physical functions measures related to HRQoL in older adults with KOA revealed that PCS and RCS were negatively correlated with the time to complete SS-5 and TUG while being positively correlated with maximum walking speed. In contrast, in community-dwelling older adults, RCS was positively correlated with one-leg standing time and maximum walking speed, but no correlation was established with SS-5 and TUG. These findings indicate that SS-5 and TUG are characteristic physical functions measures related to HRQoL in older adults with KOA. SS-5 and TUG include standing up from a chair as a common movement between the two measures of physical functions. KOA makes it difficult to go up and down the stairs or stand up from a chair due to pain and limited range of motion[21, 22]. The negative correlation between PCS and knee pain on joint loading established in the present study clearly indicates that knee pain on joint loading had a negative impact on knee flexion and extension involved in activities such as standing up from a seated position or going up and down the stairs. Factors associated with HRQoL in patients with KOA have been reported to be pain9 and decreased physical activity[25]. Patients with KOA tend to avoid physical activity due to pain and discomfort in the knee joint, as well as due to the notion that increased activity can worsen their symptoms[25]. Standing up from a seated position is an important movement that serves as a starting point for subsequent walking and locomotion. Older adults with KOA are expected to gradually lose their ability to stand up as the pain and limited range of motion will hinder their ability to perform this movement. This is likely to lead to a decline in physical activity in their daily life, which in turn is likely to lead to activity restrictions and fewer opportunities for interaction with others and social participation, which may result in decreased motivation for activities and exacerbation of anxiety. The findings of this study indicate that the sit-to-stand movement may have an unfavorable impact not only on physical but also on social aspects of HRQoL in older adults with KOA.

This study has four limitations. First, although we were able to elucidate physical functions measures related to RCS in older adults with KOA, we were not able to actually measure the amount of physical activity and evaluate daily social activities. Since factors related to RCS have not been examined in previous studies, it is necessary to further investigate other factors related to RCS. Second, this study included older adults with advanced KOA who were eligible for surgery. To elucidate the characteristics of older adults with KOA, it is necessary to also examine whether HRQoL decreases with the severity of the disease, whether HRQoL changes depending on disease severity, and whether the relationship between physical functions and HRQoL differs depending on disease severity. Third, the proportion of female participants was disproportionately high. In future research, it is necessary to equalize the proportion of male and female participants. Fourth, in the comparison of HRQoL between older adults with KOA and community-dwelling older adults, we could not establish the reason why only MCS did not show any significant difference. It was surmised that the older adults with KOA who participated in this study were able to maintain their MH because they were on the waiting list for surgery and wished to be active again after the operation. That is, it is possible that the reason why only MCS showed no significant difference was due to a sampling bias. Sample size should be increased in future research, and further studies should examine whether HRQoL increases with improvement in physical functions following surgery in the same participants.

This study examined physical functions related to HRQoL in older adults with KOA. The findings suggest that the sit-to-stand movement and knee pain on joint loading affect the physical and social aspects of HRQoL in older adults with KOA. In the rehabilitation of older adults with KOA, approaches aimed at reducing knee pain on joint loading during the sit-to-stand movement and achieving smooth transition from sitting to standing may increase engagement in ADL and social participation, thereby improving HRQoL.

Conflicts of interest

The principal investigator and the co-investigators have no conflicts of interest to declare in relation to this study.

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