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Muscle strength is the main associated factor of physical performance in older people with radiographically severe knee osteoarthritis

근력이 방사선학적으로 중증인 슬관절염을 가진 노인 환자에서 신체적 기능과 연관된 주요 인자이다

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Abstract

Muscle strength is the main associated factor of physical performance in older people with radiographically severe knee osteoarthritis

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Objective: To evaluate the factors associated with physical performance in the geriatric population according to the severity of knee osteoarthritis

Design: This was an ancillary cross-sectional study to a population-based cohort study focusing on Koreans age 65 years or older. The analysis included 553 subjects with information about age, gender, body weight, knee radiographs, knee pain, muscle strength, depressive symptoms, co-morbidities, and physical performance measures using the Short Physical Performance Battery. Stepwise logistic regressions were performed with physical performance as an outcome variable and the others as independent variables, across radiographic knee osteoarthritis severity.

Results: In the minimal-to-moderate-severity group, muscle strength, knee pain, BMI, and age were related to poor performance (odds ratio (OR) [confidence interval (CI)] 0.81[0.73 – 0.90], 1.12[1.03 – 1.21], 0.87[0.79 – 0.96], 1.09[1.05 – 1.14], respectively). In the severe group, muscle strength was the only factor associated with poor performance (OR [CI] 0.72[0.58-0.89]).

Summary: Muscle strength, knee pain and BMI were important determinants of physical performance in the older population with knee osteoarthritis. In severe knee osteoarthritis patients, muscle strength is the only significant determinant.

Keywords: Osteoarthritis, Knee, Muscle Strength, Disability Evaluation, Physical Performance

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Introduction

Population aging is occurring in all developed countries and has led to great interest in promoting health and quality of life in the elderly. For older persons, preserving physical function is a key component to maintaining well-being. Knee osteoarthritis (OA) is the leading cause of disability and poor quality of life in the community-dwelling elderly individuals. (Guccione AA et al. 1994) The diagnosis of knee OA is based on various findings, including knee pain and radiographically proven degenerative changes. Knee pain can wax and wane, whereas the radiographic findings do not improve. Consequently, we often group knee OA severity according to the Kellgren-Lawrence grading system, which is based on radiographic findings. The prevalence of radiographically more severe knee OA increases with age. Therefore, understanding the physical performance of persons with severe knee OA is necessary to promote optimal quality of life in the geriatric population.

Knee OA may influence performance in many ways. Pain, structural damage, compensatory patterns, and limited range of motion caused by knee OA can negatively affect physical performance. (Maly MR et al. 2006) Anthropological properties such as body mass, (Lohmander LS et al. 2009) height, (Hunter DJ et al. 2005) and muscle strength (Hart LE. 2004) that also affect physical performance have unidirectional or bidirectional effects on knee OA. Furthermore, unmodifiable factors such as age and gender also affect both knee-OA and physical performance (Samson MM et al. 2000) These complex interactions of various factors related to knee OA and physical performance might differ in patients with severe compared with less severe knee OA. Severe knee OA patients tend to be older and heavier, and their body mechanics are usually altered more seriously. (Astephen JL et al. 2008)

Life-style modification including regular exercise is the first-line treatment for knee OA. Currently, this principle has not been applied properly to patients with severe knee OA because factors such as pain, depressive symptoms, joint deformity, and muscle weakness causing physical dysfunction may act differently in severe cases. However, the literature on physical function in severe knee OA patients is sparse. It is obvious

that physical performance in subjects with severe knee OA is poorer compared to that of comparison group. (Thomas SG et al. 2003) But the knowledge of what attributes to the disability shown in severe knee OA patients is still somewhat deficient. There is only one study that investigated the attributes of physical performance in patients with severe knee OA. It identified muscle strength, knee range of motion and BMI as significant predictors of functional tasks and proposed muscle strength as the main target of treatment for functional improvement in patients with severe knee OA. (Brown K et al. 2009) However, the data from the subjects who were waiting for surgical treatment should be applied cautiously to general severe knee OA population. Moreover, there was no comparison with normal or less severe knee OA patients. Thus, we sought the attributes of physical performance in patients with radiographically severe knee OA using the baseline data of a population-based cohort on Aging.

In this study, we compared the factors associated with physical performance in the geriatric population with radiographically severe knee OA and that in those with no or less severe OA. We hypothesized that there is an identifiable difference in the relationship between muscle strength, along with other adjustable factors, and physical performance in severe knee OA patients compared with that in patients with no or less severe OA. Understanding the relationship between the adjustable factors and performance in severe knee OA patients would provide a key basis for designing a targeted treatment program for the corresponding population.

Methods

Study Sample

This study was a part of a population-based longitudinal cohort study named the Korean Longitudinal Study on Health and Aging (KLoSHA). It was based on the baseline evaluation of KLoSHA which makes it a cross-sectional study. KLoSHA focuses on the general health, functional status and risk factors for geriatric disorders among Koreans aged 65 years or older. The baseline study was conducted for 13 months starting in September 2005. The subjects visited hospital twice for various examinations and questionnaires. The baseline evaluation included isokinetic muscle strength, Short Physical Performance Battery (SPPB), knee radiographs, Western Ontario McMaster University (WOMAC) index, Center of Epidemiologic Studies Depression Scale (CES-D), Charlson co-morbidity index (CCI), body weight, or body mass index (BMI). Total 690 persons participated in the baseline study. Among these, 11 hemiplegic persons were excluded due to the fact that hemiplegia directly affects muscle strength and physical performance. And 126 persons were excluded because they missed data on either isokinetic muscle strength, SPPB, WOMAC, knee radiograph, CCI, or BMI. (Figure1) Ultimately, 553 subjects (295 men and 258 women) with a mean age of 74.2 ± 7.7 years were included in the analysis. All subjects were ethnic Koreans. The Institutional Review Board of Seoul National University, Bundang Hospital approved this study in August 2005.

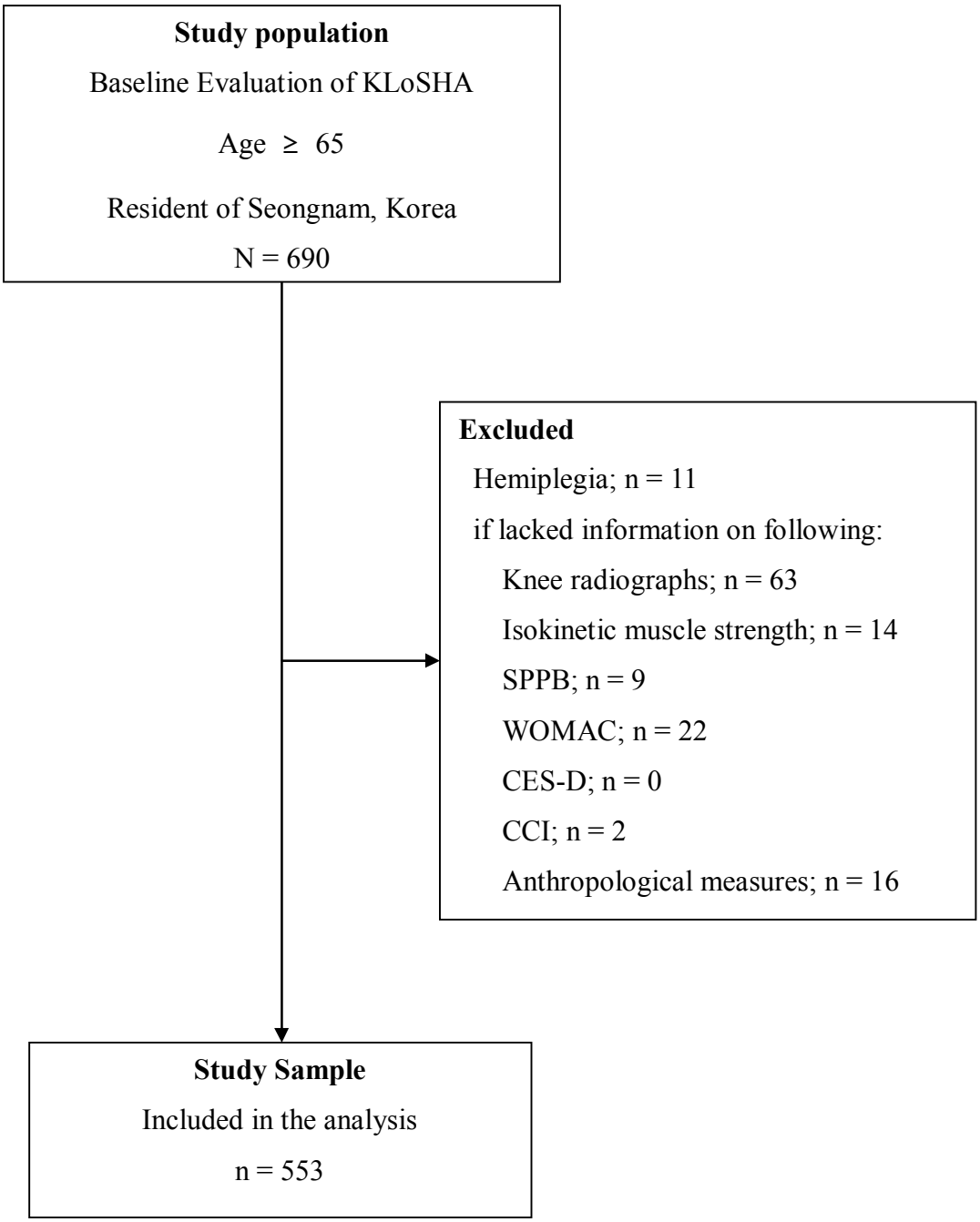

Figure 1. Flow chart of study

Measurement

Physical performance. The Short Physical Performance Battery (SPPB) is a valid measure of lower extremity mobility that is predictive of mortality and institutionalization for elderly adults. The SPPB consists of three tests: (1) three standing-balance trials (tandem, semi-tandem, and side-by-side standing), (2) five continuous chair stands, and (3) a 4-meter walk. Based on normative data, the performance times of these tasks were graded on a scale from 0–4. The sum of the three subscores gave the total SPPB score, ranging from 0 (worst) to 12 (best function). Elderly persons with an SPPB score ≤9 have a significantly higher risk of subsequent disability compared to those with an SPPB score >9. (Guralnik JM et al. 2000) Therefore, the SPPB score was converted into a binary variable by coding a score ≤9 as poor performance and one >9 as good performance.

Radiographic knee OA severity. Radiographic knee OA severity can be represented by degenerative changes that include joint space narrowing, osteophyte, and subchondral sclerosis shown in a simple anterior-posterior knee x-ray (AP-knee). Among both knees, the more severe one was selected for the analysis. The AP-knee was taken with the subject standing erect with feet pointing forward in a comfortable manner. This gives information on the tibiofemoral joint space in a weight-bearing posture, a more functional posture than the supine position, and on the osteophytes on the lateral and medial sides of the femoral epicondyle and tibial condyle. All AP-knee images were acquired digitally using the picture archiving and communication system (PACS) (IMPAX; Agfa, Antwerp, Belgium) and assessed using PACS software. The radiographs were evaluated using the Kellgren–Lawrence (K/L) grading system by one rater blinded to all clinical information. The K/L grades are defined as follows: Grade 0, no features of OA; Grade 1, small osteophyte of doubtful importance; Grade 2, definite osteophyte, but an unimpaired joint space; Grade 3, definite osteophyte with moderate diminution of the joint space; and Grade 4, definite osteophyte with substantial joint space reduction and sclerosis of the subchondral bone. The K/L classification is one of the simplest, most reliable radiographic scoring systems for knee OA. However, it is

based on the presumption that osteophytes precede joint space narrowing, which is not always true. (Altman RD et al. 1987) Therefore, we considered KL grade 0/1 as 'no-or-doubtful OA', grade 2/3 as 'minimal-to-moderate OA', and grade 4 as 'severe OA'. (Petersson IF et al. 1997) This grouping was used in the analysis of OA severity.

Demographic factors & Anthropometric measurements. Patients were surveyed for demographic information and specific medical history that might be related to knee OA. Demographic information included gender, age, height, weight, and BMI, as these factors are commonly selected as candidate determinants of physical function. (McAlindon TE e al. 1993)

Muscle strength. Muscle strength was represented by normalized dynamic knee extension torque. Dynamic torque was measured on an isokinetic dynamometer (Biodex Medical Systems®, System 3, Shirley, New York, USA). Unilateral strength tests were performed in the seated position in a reclining (5˚) chair. The rotational axis of the dynamometer was aligned with the transverse knee-joint axis and connected to the distal end of the tibia using a length-adjustable lever arm. The thighs, hips, and shoulders were stabilized with safety belts. Once the test was finished on one side, it was repeated on the contralateral side. The laterality test order was not predefined. To determine the maximum dynamic torque, the subjects performed five back-to-back maximal consecutive isokinetic knee extension at a velocity of 60˚/s after several submaximal trial contractions at the same speed followed by 5minute rest. The highest of the five isokinetic extension torques (Nm) was selected as the maximum dynamic torque. The average value of the maximum dynamic knee extension torque for both knees was divided by 1/10 of the body weight to adjust for inter-individual differences of body size.

Knee pain. Pain severity was measured by the Western Ontario McMaster University (WOMAC) index. WOMAC is a well-established questionnaire rating current symptoms related with osteoarthritis and can be confined to the knee. It contains three sections; pain, stiffness and disability. Each question has five response options (none, mild, moderate, severe, and extreme) and pain section is composed of questions asking

about five different settings (walking on a flat surface, going up- or down-stairs, at night while in bed, sitting or lying, and standing upright). The pain subscale is frequently used separately as a quantitative measure of knee pain. The WOMAC is based on the symptoms of the past 48 hours. Thus, temporary pain without any organic cause which is inappropriate as knee pain caused by OA might be assessed by WOMAC. To overcome this problem activity induced knee pain was additionally assessed which was based on the symptoms of the past 4weeks. As main function of the lower limbs is locomotion and walking and climbing stairs are the two major activity components of independent locomotor function, (Keith RA et al. 1987) patients who consistently had knee pain during walking or/and using the stairs were defined as having activity induced knee pain. Activity induced knee pain data was extracted from the Knee Society scoring system. The Knee Society score embraces a relatively objective clinician-based rating of pain. (Insall JN et al. 1989)

Depressive symptoms. Depressive symptoms are associated with a decline in physical performance in community-dwelling older persons. (Penninx BW et al. 1998) The Center for Epidemiologic Studies Depression Scale (CES-D) was used to assess depressive symptoms. The CES-D is a 20-item self-report of depressive symptoms that shows good agreement with clinician interview ratings and other longer self-report scales. (Weissman MM et al. 1977) And the Korean version of CES-D is well validated. (Cho MJ et al. 1993)

Co-morbidity. Co-morbidity heightens the risk of disability (Verbrugge LM et al. 1989) and has a high prevalence in both geriatric and arthritic population. To evaluate the potential impact of co-morbidity, the Charlson Co-morbidity Index (CCI) was used. The CCI is a test that standardizes the weight of various coexisting illnesses to consolidate each individual condition into a single, predictive, numerical score of mortality. It includes a range of comorbid conditions such as heart disease, diabetes, cancer, etc. with a higher score indicating a greater number of and/or more severe comorbidities. (Charlson ME et al. 1987)

Statistical Analyses

One-way analysis of variance (ANOVA) was used to compare the means of interval- or ratio-type variables (age, BMI, muscle strength, CES-D and CCI), and Chi-square tests to compare the ratios of nominal-type variables (knee pain, poor performance, and female gender) across the levels of radiographic knee OA severity. Each comparison of multiple means was followed by Scheffé's method of post hoc analysis.

The subjects were divided into two groups according to muscle strength; higher and lower half in muscle strength. ANOVA and Scheffé's post hoc analysis were performed to compare mean SPPB scores across radiographic knee OA severities in both groups.

Spearman's correlation analyses between performance group and the other variables were performed in each knee OA severity group to select candidate variable to be entered in the subsequent regression analyses.

To identify the factors predicting poor physical performance, backward stepwise logistic regressions were performed in each radiographic knee OA severity group. Model fit was measured by comparing the observed and expected frequency applying the Hosmer–Lemeshow goodness-of-fit-test.

Results

Mean ± standard deviation or ratio for each variable is displayed below according to the radiographic knee OA severity (Table 1). This revealed that means or ratios differed across the levels of radiographic knee OA severity for all variables except for CES-D and CCI. The percentage of females and poor performers increased with the radiographic knee OA severity. *Post hoc* analysis using Scheffé's *post hoc* criterion for $p < 0.01$ significance indicated that muscle strength differed significantly across radiographic knee OA severity groups. The no-or-doubtful knee OA group showed lower BMI and age and higher WOMAC pain subscale score compared to other groups. However, these were not significantly different between the minimal-to-moderate and severe knee OA groups. SPPB score was lower in the severe knee OA group, but did not differ between the less severe groups.

Table1. Descriptive values according to radiographic knee-OA severity

Descriptive value		Radiographic knee OA severity (n = 553)			
		No-or-doubtful (n = 224)	Minimal-to-moderate (n = 258)	Severe (n = 71)	p-value
SPPB		9.82±2.32	9.27±2.32	7.80±2.92	< 0.001
	Post-hoc	[No-or-doubtful, Minimal-to-moderate] / Severe			
Poor performance (persons(%))		77 (34.4)	126 (48.8)	49 (69.0)	< 0.001
Age (year)		72.7 ± 7.3	74.8 ± 7.6	76.9 ± 8.4	< 0.001
	Post-hoc	No-or-doubtful / [Minimal-to-moderate, Severe]			
Female (persons (%))		71 (31.7)	129 (50.0)	58 (81.7)	< 0.001
Muscle strength (Nm/㎏)		11.60±4.17	9.76±3.54	7.50±2.78	< 0.001
	Post-hoc	No-or-doubtful / Minimal-to-moderate / Severe			
BMI (㎏/㎡)		23.5±2.9	24.6±3.1	25.1±3.3	< 0.001
	Post-hoc	No-or-doubtful / [Minimal-to-moderate, Severe]			
WOMAC pain		2.24±3.47	3.56±3.91	7.56±5.53	< 0.001
	Post-hoc	No-or-doubtful / Minimal-to-moderate / Severe			
Activity induced knee pain (persons (%))		35 (15.6)	62(24.0)	37 (52.1)	< 0.001
CES-D		31.6±8.7	31.9±8.6	33.7±9.3	0.214
CCI		0.63±0.84	0.58±0.82	0.61±0.83	0.743

SPPB Short Physical Performance Battery,BMI body mass index, WOMAC Western Ontario McMaster University index, CES-D Center of Epidemilogic Studies Depression Scale, CCI Charlson comorbidity index

Sheffé's post-hoc test is implemented to compare ground. Groups without significant difference were put within square brackets and those with significant difference were separated by forward slash.

One-way ANOVA was used separately in both higher and lower half in muscle strength to test for physical performance differences among radiographic knee OA severities. Physical performances differed significantly across three knee OA severity groups in those with lower muscle strength, $F(2,293) = 5.228$, $p = 0.006$. Scheffe's post-hoc comparisons of the three groups indicate that severe group (M = 7.31, 95% CI [6.55, 8.06]) showed significantly lower physical performance than no-or-doubtful (M = 8.52, 95% CI [8.01, 9.03]) or minimal-to-moderate group (M = 8.46, 95% CI [8.07, 8.85]). However, in those with higher muscle strength, no-or-doubtful (M = 10.67, 95% CI [10.37, 10.98]), minimal-to-moderate (M = 10.35, 95% CI [10.03, 10.68]) and severe (M = 10.25, 95% CI [9.20, 11.30]) knee OA groups showed no difference between each other. (Figure 2)

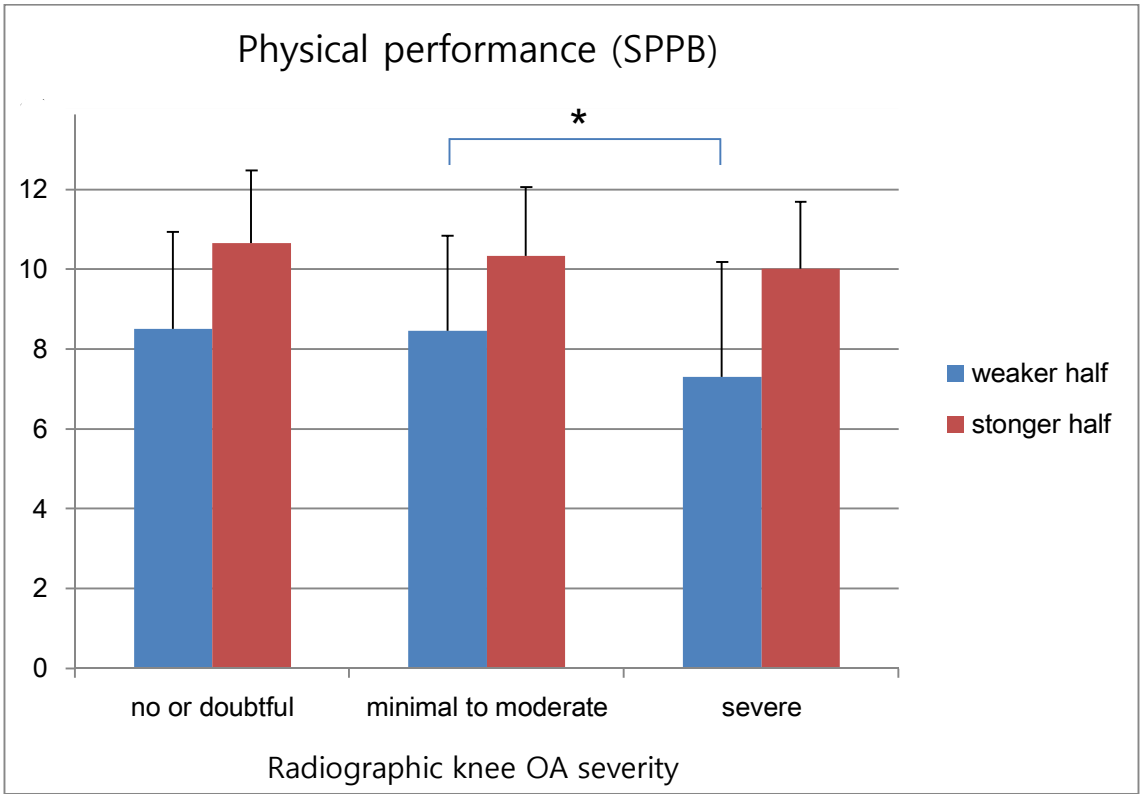

Figure 2.Mean SPPB scores by muscle strength level and radiographic knee OA severity.

* indicates statistical difference between groups

Mean ± standard deviation or ratio for each variable is displayed below according to the physical performance group (Table 2). Poor performance group showed higher proportion of severe knee OA patients, females and persons with activity induced knee pain. This group was older, had weaker muscle strength, lower BMI, more knee pain and depressive symptoms. The co-morbidity index did not differ between the two performance groups.

Table 2. Descriptive values according to physical performance group

	Physical performance group		
	Poor	Good	p-value
	N = 252	N = 301	
Severe radiographic knee OA (persons(%))	49 (19.4)	22 (7.3)	<0.001
Age (year)	77.4±8.1	71.6±6.2	<0.001
Female (persons(%))	145 (57.5)	113 (37.5)	<0.001
Muscle strength (Nm/㎏)	8.23±3.49	11.88±3.54	<0.001
BMI (㎏/㎡)	23.91±3.32	24.43±2.93	0.052
WOMAC pain	5.03±5.10	2.29±3.01	<0.001
Activity induced knee pain (persons(%))	86 (34.1)	48 (15.9)	<0.001
CES-D	33.74±10.11	30.57±7.11	<0.001
CCI	0.65±0.86	0.56±0.81	0.207

SPPB Short Physical Performance Battery,BMI body mass index, WOMAC Western Ontario McMaster University index, CES-D Center of Epidemilogic Studies Depression Scale, CCI Charlson comorbidity index

Correlation analysis between performance group and other variables are shown in table 3. Most variables showed a tendency of correlation ($p < 0.1$) with physical performance group. CCI was not correlated with performance group regardless of knee OA severity group. Gender was not correlated with performance group in minimal-to-moderate knee OA group and BMI and activity induced knee pain showed no significant correlation in severe knee OA group.

Table 3. Correlation analysis with poor physical performance group

Subgroup		Age	Gender	Muscle strength	BMI	WOMAC pain	Activity induced knee pain	CES-D	CCI	Radiographic knee OA severity
Total	r_s	0.38	0.2	-0.49	-0.08	0.28	0.21	0.14	0.05	0.22
	p-value	<0.01	<0.01	<0.01	0.08	<0.01	<0.01	<0.01	0.23	<0.01
No or doubtful	r_s	0.32	0.23	-0.54	-0.13	0.19	0.18	0.12	0.04	na
	p-value	<0.01	<0.01	<0.01	0.05	<0.01	<0.01	0.08	0.51	
Minimal to moderate	r_s	0.40	0.05	-0.38	-0.15	0.19	0.18	0.11	0.07	na
	p-value	<0.01	0.46	<0.01	0.02	<0.01	<0.01	0.08	0.25	
Severe	r_s	0.22	0.23	-0.43	-0.07	0.32	0.09	0.21	0.01	na
	p-value	0.06	0.05	<0.01	0.57	<0.01	0.46	0.07	0.91	

r_sSpearman correlation coefficient, SPPB Short Physical Performance Battery, BMI body mass index, WOMAC Western Ontario McMaster University index, CES-D Center of Epidemilogic Studies Depression Scale, CCI Charlson comorbidity index

Variables that showed p < 0.1in the correlation analysis with performance group in a certain knee OA severity group were entered in the regression analysis of the corresponding group. The possible multicollinearity between covariates using correlation analysis and collinearity statistics (tolerance and variance inflation factor tests) were evaluated, as suggested for logistic regression. There was no significant collinearity between any covariates. Stepwise logistic regression with poor performance as an outcome yield was repeated in total subjects and within each knee OA severity group. (Table 4) In the analysis on total subjects, radiographic knee OA severity was also included as an independent variable. Significant predictors of poor performance in total subjects were age (OR 1.07), knee pain (OR 1.10), BMI (OR 0.92) and muscle strength (OR 0.79). In the no-or-doubtful group, they were age (OR 1.05), depressive symptoms (OR 0.76) and muscle strength (OR 0.74). In the minimal-to-moderate group, age (OR 1.09), knee pain (OR 1.12), BMI (OR 0.87) and muscle strength (OR 0.81) were related to poor physical performance. By contrast, in the severe group, muscle strength was the only significant factor (OR 0.72). No significant interaction effect was detected between SPPB and muscle strength. None of the models was rejected for goodness-of-fit due to *p*-values over 0.05 according to the Hosmer–Lemeshow test. The frequency of poor performance predicted by the model can be considered close to the observed frequency, as the *p*-value in the Hosmer–Lemeshow test indicated good fit to the model.

Table 4. Stepwise logistic regression model on poor physical performance (SPPB ≤ 9) by radiographic knee-OA severity

	OR	95% CI	p-value
Total (74.9%)			
Age	1.07	1.04 – 1.10	< 0.001
WOMAC pain	1.10	1.05 – 1.16	< 0.001
BMI	0.92	0.86 – 0.98	0.013
Muscle strength	0.79	0.73 – 0.84	< 0.001
No-or-doubtful knee-OA (81.7%)			
Age	1.05	1.00 – 1.11	0.032
CES-D	1.04	1.00 – 1.08	0.051
Muscle strength	0.74	0.66 – 0.83	< 0.001
Minimal-to-moderate knee-OA (72.1%)			
Age	1.09	1.05 – 1.14	.000
WOMAC pain	1.12	1.03 – 1.21	.007
BMI	0.87	0.79 – 0.96	.007
Muscle strength	0.81	0.73 – 0.90	.000
Severe knee-OA (74.6%)			
Muscle strength	0.72	0.58 – 0.89	0.002

SPPB Short Physical Performance Battery, WOMAC Western Ontario McMaster University index, BMI body mass index, CES-D Center of Epidemilogic Studies Depression Scale

Discussions

Physical performance was lower in severe knee OA group compared to the others. However, when we subdivide the population according to muscle strength, in the subgroup with higher muscle strength, the physical performance of the severe knee OA group does not differ from that of the less severe groups. Which implements that good muscle strength can prevent the fall in physical performance shown in severe knee OA patients. The KLoSHA data show that the determinant profile of physical performance in subjects with radiographically severe knee OA differ from that of subjects with less severe OA. Many factors were related with physical performance, however, muscle strength was the only factor that was related to physical performance irrespective of radiographic knee OA severity. In other word, the protective effect of muscle strength on physical function appears to be important regardless of knee OA severity, whereas, other factors showed some variability in significance according to knee OA severity.

Physical function concerned with the knee is determined by neuromusculoskeletal factors such as body weight, (Creamer P et al. 2000) range of motion (ROM), (van Dijk GM et al. 2010) muscle strength, muscle activation and proprioception. (Hurley MV et al. 1997) The severe knee OA group shows particularly poorer physical performance (Table 1) which is distinct from the tendency of muscle strength or BMI. Although we lack information on ROM or neuromuscular control, this finding implements the peculiarity of physical performance in severe knee OA patients. (There may be couple of possible explanations for this. The grouping of severe knee OA might have been far more severe and more homogenous than the other groups. Or muscle strength might have a threshold beneath which physical performance rapidly declines. Maybe the negative effect of decline of muscle strength on physical performance is amplified as knee OA gets severe.) However, it is difficult to know by intuition what variable attributes to physical performance in this population because there is a similarity among variables in the order of means or ratios according to the severity group. For example, better performance in the less severe knee OA group might be partially due to younger age or lower female portion. This similarity implies that there is a close

interrelation among all variables. The logistic regression analysis revealed the factors that remained as significant determinants even after controlling of other factors.

BMI was not correlated with physical performance in the no-or-doubtful and severe knee OA group (Table 2). As higher body weight brings about larger energy consumption during the same activity, it may seem reasonable that overweight is associated with functional declines of the lower extremity. (Woo J et al. 2007) However, in elderly people, BMI might not effectively reflect obesity. Both muscle and fat mass contribute to body mass, and weight loss is accompanied by loss of muscle mass, particularly in older adults. (Newman AB et al. 2005) Sarcopenia is an early characteristic of knee OA (Toda Y et al. 2000) and is closely related to physical dysfunction. (Janssen I et al. 2002) Moreover, knee malalignment which is related with knee OA progression might have a mediating role in the relationship between obesity and physical function. (Sharma L et al. 2000, 2001) In short, the effect of BMI on physical performance might differ according to knee OA severity. .

Knee pain was not significantly associated with physical performance in no-or-doubtful and severe knee OA groups. In the no-or-doubtful knee OA group the amount of knee pain might have been too small to have an influence. The mean WOMAC pain score was 2.24 in the no-or-doubtful knee OA group which is lower than the usual criteria of knee OA. (Goggins J et al. 2005) In the severe group, a plausible explanation may be that the effect of pain on physical performance might be indirect. The indirect influence might act via muscle strength. Henriksen et al. conducted a human experiment that showed that induction of knee pain reduced muscle strength. (Henriksen M et al. 2011) So it can be speculated that the deterioration in physical performance in patients with pain is not a result of pain itself but that of decrement of muscle strength caused by pain. One minor finding that supports this speculation in our study is that logistic regression not including muscle strength reveals pain as a significant correlate of physical performance in the minimal-to-moderate severity group.

In the correlation analysis, gender was not significantly correlated with physical performance of less severe OA group. (Table 3) In male subgroup, the proportion of

poor performers in no-or-doubtful/minimal-to-moderate/severe knee OA group was 0.27/0.47/0.46, and in women, it was 0.51/0.51/0.74. There might be a gender difference in the threshold where radiographic severity affects physical performance. Women basically have lower performance levels compared to men. Thus, the male group has lower proportion of poor performers in no-or-doubtful knee OA group, Male shows different proportions of poor performers between no-or-doubtful and minima-to-moderate group whereas females show it between minimal-to-moderate and severe group. Although the grading is done with same criteria, radiographic knee OA severity might have different effect on function depending on gender. (Kim I et al. 2010) The opposite effect of basic gender difference in physical performance and the different effect of OA severity on physical performance according to gender made gender not correlated with physical performance in the minimal-to-moderate knee OA group.

WOMAC pain and activity induced knee pain extracted from knee society score (KSS) showed different results. WOMAC pain was a significant attribute of physical performance whereas activity induced knee pain was not. (Table 4) WOMAC is based on the symptoms of the last 48hours whereas KSS is based on that of last 4weeks. Activity induced knee pain assessed by KSS can be that of a few weeks ago which would have little relation with performance at the evaluation point. On the other hand, WOMAC pain efficiently represents the knee pain at the time of evaluation.

There have been few studies of how to improve physical performance with conservative treatment in patients with severe knee OA. Many clinicians tend to rely on more aggressive approaches, such as total arthroplasty, when treating such patients. (Hochberg MC et al. 1995) Additionally, physical performance in severe knee OA patients has been regarded simply as one of the domains that can be corrected by surgical management, along with knee pain and joint deformity. However, performance measure is a comprehensive variable that integrates health and function (Studenski S et al. 2003) and are associated with the QoL, (Schroll M et al. 2002) which should be considered as an outcome variable that clinicians should aim to improve by other means, such as weight reduction, pain control, and exercise. In a population-based

cohort study, only 8% of the people who reported knee symptoms had K/L grade 4 knee OA. (Jordan JM et al. 2007) The relative scarcity of people with severe knee OA makes it hard to investigate the effects of conservative management in such patients. Of 21 randomized clinical trials of exercise intervention in knee OA patients, only one gave special consideration to severe knee OA, and seven excluded severe radiographic knee OA (K/L grade 4). (Escalante Y et al. 2010)

Previous studies of severe knee OA patients recruited their subjects from patients waiting for knee arthroplasty/replacement surgery. A few focused on various factors associated with preoperative performance but did not make comparisons with less severe OA. Barker et al. investigated the associations among radiographic findings, self-reported function, observer-rated performance, pain, and lower extremity power. (Barker K et al. 2004) All were significantly correlated with each other except for the radiographic findings, which were not significantly correlated with any other factors. Moreover, only lower extremity power was strongly correlated with performance, whereas the other variables showed moderate correlations. Brown et al. studied the predictors of various modules of functional tasks of the lower extremity.[9] Age, BMI, pain, lower extremity strength and ROM, and perceived functional ability were investigated as determinants of functional tasks. Strength was a significant correlate irrespective of the modality of the functional task. The regression equations identified strength as the most significant predictor of the performance out of all functional tasks, accounting for 24–45% of the variance in a specific functional task, whereas age, BMI, and ROM were significant only in some tasks, accounting for only 3–9% of the variance. Despite the difference in performance assessment tools, the results of previous investigators are similar to ours. However, lack of comparison with a less-severe knee OA group may fail to identify the factors that clinicians should focus on in patients with severe knee OA. The cohort design enabled us to compare the determinants of physical performance in severe and less-severe knee OA, whereas the designs of studies that recruited their subject from surgery waiting lists limited the subjects to those with severe knee OA.

Some studies conflict with our results. Kauppila et al. evaluated disability and associated factors in 60- to 80-year-old patients with advanced knee OA. (Kauppila AM et al. 2009) The linear regression model for the WOMAC function score showed that knee flexion/extension strength was not a significant indicator, whereas pain was. This may be due to the fact that self-reported physical functioning is influenced more by pain than are performance-based measures of physical functioning in knee OA patients. (Terwee CB et al. 2006) Additionally, previous studies have defined severe knee OA patients as those awaiting knee surgery, whereas we focused on patients with radiographically severe knee OA. Consequently, there are some limitations when comparing our study with others.

Our study has some shortcomings. First, it might have failed to identify other meaningful predictors due to the small sample size of severe-OA patients (n = 69). Larger sample size would have identified other meaningful variables. However, the sample was sufficient to suggest that weak muscle strength was a significant predictor of poor performance. Second, the conclusion cannot be extended to all knee OA patients, as the study subjects were limited to elderly individuals. Moreover, our conclusions may not extend to other ethnic groups. Third, no causal relationships can be drawn because of the cross-sectional study design. The modifiable variables that truly contribute to maintaining good physical performance remain to be revealed by a longitudinal study. The second wave evaluation of the parent cohort study, KLoSHA, is in process. The relation between muscle strength and the change in physical performance after some time period along with other variables in the severe knee OA group will reveal more detailed information on the true determinants of physical performance in the corresponding group.

Summary

The factors of physical performance in the geriatric population differ according to the radiographic knee OA severity. Among the modifiable factors, muscle strength is the only factor that is related with physical performance irrespective of radiographic knee OA severity. Therefore, to improve the physical performance of severe OA patients, the strategy used must differ from that for patients with less severe OA. Muscle strengthening in severe OA patients should be emphasized as a targeted treatment program.

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국문 초록

근력이 방사선학적으로 중증인 슬관절염을 가진 노인 환자에서 신체적 기능과 연관된 주요 인자이다

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연구 목적: 노인 인구에서 방사선학적으로 중증인 슬관절염을 가진 군과 중증이 아닌 슬관절염을 가진 군에서 신체적 기능을 결정하는 인자를 비교하기 위함.

연구 설계: 65세 이상을 대상으로 하는 지역 기반 코호트 연구의 일부로서 진행되었다. 분석에는 총 553명이 포함되었고 연령, 성별, 몸무게, 슬관절 방사선 사진, 슬관절 통증, 근력, 우울 정도, 동반 질환과 Short Physical Performance Battery를 이용하여 측정한 신체적 기능의 인자가 이용되었다. 신체적 기능을

종속인자로 하고 여타 인자를 독립인자로 하여 단계별 로지스틱 회귀 분석을 슬관절염의 방사선학적 중등도에 따라 나뉜 군별로 각각 시행하였다.

결과: 경도에서 중등도의 슬관절염을 가진 군에서는 근력, 통증, 비만지수, 연령이 불량한 신체적 기능과 연관이 있었다. (오즈비(95%신뢰구간)가 각각 0.81(0.73 - 0.90), 1.12(1.03 - 1.21), 0.87(0.79 - 0.96), 1.09(1.05 - 1.14)) 중증의 슬관절염을 가진 군에서는 근력만이 불량한 신체적 기능과 연관이 있었다. (오즈비(95%신뢰구간) 0.72(0.58-0.89))

결론: 슬관절염을 가진 노인 인구에서 근력과 통증, 비만지수가 신체적 기능과 연관이 있다. 하지만 중증인 슬관절염을 가진 노인 인구에서 봤을 때는 근력만 유의한 연관인자이다.