Clin Orthop Relat Res (2015) 473:70–75
DOI 10.1007/s11999-014-3650-6

Clinical Orthopaedics and Related Research®
A Publication of The Association of Bone and Joint Surgeons®

SYMPOSIUM: 2014 KNEE SOCIETY PROCEEDINGS

The KSS 2011 Reflects Symptoms, Physical Activities, and Radiographic Grades in a Japanese Population

Naoya Taniguchi MD, Shuichi Matsuda MD, PhD, Takahisa Kawaguchi MS, Yasuharu Tabara PhD, Tome Ikezoe PhD, Tadao Tsuboyama MD, PhD, Noriaki Ichihashi PhD, Takeo Nakayama MD, PhD, Fumihiko Matsuda PhD, Hiromu Ito MD, PhD

Published online: 29 April 2014

Abstract

Background Cultural and ethnic differences are present both in subjective and objective measures of patient health, but scoring systems do not always reflect these differences, and so validation of outcomes tools in different cultural settings is important. Recently, a revised version of The Knee Society Score® (KSS 2011) was developed, but to our knowledge, the degree that this tool evaluates clinical symptoms, physical activities, and radiographic grades in the general Japanese population is not known.

Questions/purposes We therefore asked: (1) how KSS 2011 reflects knee conditions and function in the general Japanese population, in particular evaluating changes with increasing patient age; (2) can objective measures of physical function be correlated with KSS 2011; and (3) does radiographic osteoarthritis (OA) grade correlate with KSS 2011?

Methods Two hundred twenty-six people in the general Japanese population, aged 35 to 92 years, with and without knee arthritis, voluntarily participated in this cross-sectional study. Residents who had no serious disease or symptoms based on a self-assessment were recruited. This study consisted of a questionnaire including self-administered KSS 2011, physical examination, and weightbearing radiographs of the knee. Leg muscle strength, Timed Up and Go test, and body mass index (BMI) were examined in all the participants. Radiographs were graded according to the Kellgren and Lawrence scale (KL grade).

Results Multivariable linear regression analysis showed that KSS 2011 correlated with age (coefficient: -0.30 ± 0.12, $p = 0.011$), BMI (coefficient: -1.47 ± 0.42, $p < 0.001$), leg muscle strength (coefficient: 0.41 ± 0.13, $p = 0.002$), and Timed Up and Go Test (coefficient: -1.96 ± 0.92, $p = 0.034$), but not sex, as independent variables by a stepwise method. KSS 2011 was also correlated with radiographic OA evaluated by KL grade (coefficient: -12.2 ± 2.9, $p < 0.001$).

Conclusions KSS 2011 reflects symptoms, physical activities, and radiographic OA grades of the knee in an age-dependent manner in the general Japanese population.

The Nagahama Prospective Genome Cohort for the Comprehensive Human Bioscience (The Nagahama Study) is composed of the following principal investigators: Fumihiko Matsuda (chairperson), Ryo Yamada, Akihiro Sekine, Shinji Kosugi, and Takeo Nakayama (Kyoto University Graduate School of Medicine and School of Public Health).

This study was supported by university grants from the Ministry of Education, Culture, Sports, Science & Technology in Japan and a research grant from the Takeda Science Foundation.

All ICMJE Conflict of Interest Forms for authors and *Clinical Orthopaedics and Related Research*® editors and board members are on file with the publication and can be viewed on request.

Each author certifies that his or her institution approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

N. Taniguchi, S. Matsuda (✉), H. Ito
Department of Orthopaedic Surgery, Kyoto University Graduate School of Medicine, 54 Kawahara-cho, Shogoin, Sakyo, Kyoto 606-8507, Japan
e-mail: smat522@kuhp.kyoto-u.ac.jp

T. Kawaguchi, Y. Tabara, F. Matsuda
Center for Genomic Medicine, Kyoto University Graduate School of Medicine, Kyoto, Japan

T. Ikezoe, T. Tsuboyama, N. Ichihashi
Human Health Sciences, Kyoto University Graduate School of Medicine, Kyoto, Japan

T. Nakayama
Department of Health Informatics, Kyoto University School of Public Health, Kyoto, Japan

Level of Evidence Level IV, diagnostic study. See Guidelines for Authors for a complete description of levels of evidence.

Introduction

TKA is used widely to relieve pain and improve functional status in patients with symptomatic knee osteoarthritis (OA) [24]. The number of TKAs performed annually has increased in the United States [27] and in other countries [10, 12]. Patient satisfaction is now recognized as an important measure of healthcare quality [4, 13, 17]. However, despite substantial advances in patient selection, surgical technique, and implant design in primary TKA, a study has indicated that 11% to 18% of the patients are still unsatisfied with the operation [5]. In other words, TKA does not perfectly achieve its goal of relieving pain and restoring function in a substantial proportion of patients. One reason is that some patients expect full recovery of the motion of the knee and the ability to participate actively in recreational and physical activities after receiving TKA [18]. To evaluate the reasons why a certain fraction of patients who undergo TKA are dissatisfied, a proper evaluation of patients undergoing TKA is needed. It is also required that the evaluation method be closely related to physical function and, possibly, radiological grade of the patient.

The Knee Society Knee Scoring System® developed in 1989 (KSS 1989) is one of the most often used methods to evaluate patients undergoing TKA [8]. This scoring system has several advantages in terms of its reliability and use, and it has been adopted worldwide [2, 11]. However, increasing importance is being placed on the subjective aspects of evaluation, which have changed from those of prior generations, and were not captured by the KSS 1989. Therefore, in 2011, the new Knee Society Knee Scoring System® (KSS 2011) was refined to better characterize the expectations, satisfaction, and physical activities of more diverse populations of patients who undergo TKA [25]. This new scoring system is based on new scales and validation work [19], and its reliability has been evaluated by our research group and by others [14, 26] with satisfactory results. However, what is an appropriate score in this scoring system in a certain age group remains to be unveiled.

In this study, we asked the following questions: (1) how KSS 2011 reflects knee conditions and function in the general Japanese population, in particular evaluating changes with increasing patient age; (2) can objective measures of physical function be correlated with KSS 2011; and (3) does radiographic OA grade correlate with KSS 2011?

Patients and Methods

We conducted a cross-sectional study of the association between KSS 2011 and clinical symptoms and physical activities in a general Japanese population. Subjects were participants in the Nagahama Prospective Genome Cohort for Comprehensive Human Bioscience (the Nagahama Study) [16]. The Nagahama Study participants were recruited from apparently healthy community residents aged older than 30 years living in Nagahama City, a largely rural city of approximately 124,000 inhabitants in Shiga Prefecture located in the center of Japan. The study has been continuously advertised in the city for residents with no serious disease or symptom based on a self-assessment, and a total of 226 residents with and without knee arthritis voluntarily participated in 2012. We did not specifically exclude patients with knee symptoms or prior knee surgery.

We translated the KSS 2011 questionnaire into Japanese. We used the self-administered questionnaire areas of the KSS 2011 questionnaire, including "symptoms," "patient satisfaction," and "functional activities." The questions on "expectations" were excluded because the participants did not plan to undergo TKA. The area "functional activities" comprises four components: "walking and standing," "standard activities," "advanced activities," and "discretionary activities." The full score of these questions is a maximum of 165 points. We supposed that participants did not have applicable answer choices for some of the questionnaire because the participants may have an impairment involving a body part other than the knee. Thus, in the area of "functional activities," we added a new answer: "I cannot do this because of a problem not related to the knee." Participants who chose this answer were excluded from the analyses. A total of 4% (nine of 224) answered this to the question about "walking and standing," 2.2% (five of 224) for "standard activities," 1.3% (three of 224) for "advanced activities," and 2.7%

Table 1. Baseline characteristics of the participants

Demographic	Mean ± SD
Number of participants	212
Female (ratio)	123 (58%)
Age (years)	60.3 ± 12.2
Height (cm)	161.4 ± 9.1
Weight (kg)	59.4 ± 11.8
BMI (kg/m^2)	22.7 ± 3.3
Leg strength (kg)	26.7 ± 10.3
Up and Go time (seconds)	6.2 ± 1.6

BMI = body mass index; Up and Go = Timed Up and Go Test.

Table 2. Demographic data of subgroups (mean ± SD)

Demographic	30s	40s	50s	60s	70s	80s
Number of participants	17	24	47	73	42	9
Female number (ratio)	12 (70%)	15 (62%)	29 (61%)	48 (65%)	18 (43%)	1 (11%)
Height (cm)	163.4 ± 10.4	163.6 ± 9.9	165.0 ± 8.7	159.3 ± 8.3	159.1 ± 8.8	158.6 ± 7.1
Weight (kg)	60.0 ± 13.3	61.2 ± 13.3	63.4 ± 14.0	56.5 ± 10.7	59.0 ± 8.7	56.1 ± 9.1
BMI (kg/m^2)	22.1 ± 3.6	22.7 ± 3.5	23.0 ± 3.7	22.1 ± 3.3	23.2 ± 2.3	22.2 ± 4.1
Leg strength (kg)	26.4 ± 12.4	28.5 ± 9.8	29.7 ± 12.6	25.4 ± 8.4	26.7 ± 9.6	19.1 ± 6.0
Up and Go time (seconds)	5.5 ± 1.0	5.4 ± 0.9	5.7 ± 0.7	6.2 ± 1.3	6.8 ± 1.5	9.0 ± 4.1
Participants with XP (number)				49	32	6
Radiographic knee OA (number)				19	13	4

BMI = body mass index; Up and Go = Timed Up and Go test; OA = osteoarthritis; XP = Xray photography.

(six of 224) for "discretionary activities." In total, 5.4% (12 of 224) participants were excluded for this reason. The female ratio, average age, and body mass index (BMI) of the 212 participants were 58% (123 of 212), 60.3 ± 12.2 years, and 22.7 ± 3.3 kg/m^2, respectively (Table 1).

Anthropometry measurements included height and weight, which were used to calculate BMI as weight in kg/height in m^2. Quadriceps strength was measured twice on both sides during a 3-second isometric contraction of the knee extensors with a handheld dynamometer (μ-Tas F-1; Anima Co, Chofu, Japan). With the participant in a seated position, the hip and the knee were positioned at 90° angles, and the force sensor was placed 10 cm above the lateral malleolus. The average bilateral maximum muscle strength was used to represent maximum muscle strength. Participants also performed the Timed Up and Go Test [23], which measures the time it takes a participant to stand up from a chair, walk a distance of 3 m, turn, walk back to the chair, and sit down as quickly as possible.

We evaluated weightbearing AP radiographs of both knees, which were performed by experienced radiology technicians. Eighty-eight of the 124 participants who were older than 60 years agreed to the examination. Radiographs of the knee were graded according to the scale described by Kellgren and Lawrence (KL grade) [9]. Two experienced orthopaedists (NT, HI), who were blinded with regard to participant status, read the radiographs in consultation. Knee OA was defined as a KL Grade 2 or higher in either knee. Radiographic knee OA was present in 41% (36 of 87) of the participants who completed the radiographic examination (Table 2). We used the average score of both knees as the variable for analysis.

Simple linear regression analysis was used to identify correlations between the KSS 2011 and age. We divided participants into six subgroups according to age. Because only one participant was older than 90 years, we included this participant in the 80s age group. In the analysis, relationships between the KSS 2011 and physical functions and those between the KSS 2011 and other factors were examined. After excluding weight and height, a stepwise method was applied for multivariable linear regression analysis. The relationship between the KSS 2011 and KL grade was evaluated by simple linear regression analysis separately because of the limited number of participants older than 60 years with radiographic data. All data were analyzed using the statistical package R (http://www.r-project.org/).

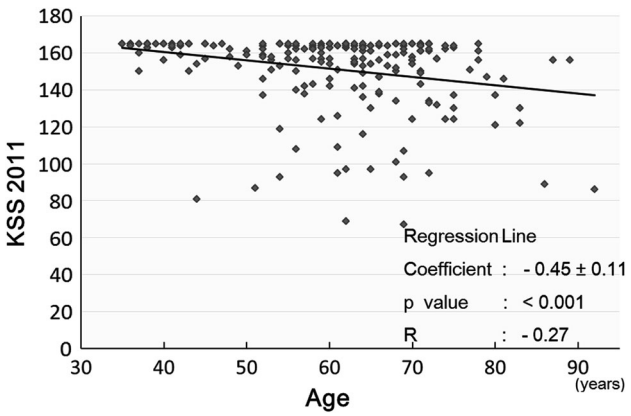

Fig. 1 Correlation of KSS 2011 and age is shown. Linear regression analysis showed a significant correlation between KSS 2011 and age.

Results

We found that increased age was correlated with decreasing scores on KSS 2011 (Fig. 1). Because age is an essential factor when deciding a therapeutic strategy, we divided the whole group into six subgroups according to their age. The total scores of the subgroups are 163.5 ± 3.7 in 30s, 158.3 ± 17.1 in 40s, 152.3 ± 18.4 in 50s, 148.0 ± 23.8 in 60s, 152.6 ± 16.1 in 70s, and 127.0 ± 25.8 in 80s (Table 3). The satisfaction component

Table 3. Details of each component in KSS 2011 in subgroups (mean ± SD)

Factor	30s	40s	50s	60s	70s	80s
Symptoms	24.7 ± 0.8	24.2 ± 2.3	22.5 ± 4.1	22.1 ± 4.3	23.3 ± 3.2	19.6 ± 4.8
Patient satisfaction	39.5 ± 1.5	37.9 ± 1.5	34.8 ± 7.0	34.4 ± 7.8	35.5 ± 7.9	31.8 ± 5.6
Walking and standing	30.0 ± 0.0	28.4 ± 5.2	29.1 ± 3.3	27.3 ± 5.5	27.5 ± 6.2	22.0 ± 6.9
Standard activities	29.8 ± 0.7	29.4 ± 1.9	28.4 ± 3.4	27.9 ± 3.8	28.8 ± 2.1	23.7 ± 6.5
Advanced activities	24.7 ± 1.0	24.0 ± 3.4	23.6 ± 2.8	22.7 ± 4.2	23.4 ± 2.6	18.8 ± 5.5
Discretionary activities	14.8 ± 0.7	14.5 ± 1.5	13.9 ± 1.9	13.5 ± 2.5	14.2 ± 2.0	11.2 ± 3.0
Sum of KSS 2011	163.5 ± 3.7	158.3 ± 17.1	152.3 ± 18.4	148.0 ± 23.8	152.6 ± 16.1	127.0 ± 25.8

KSS 2011 = 2011 The Knee Society Score®.

Table 4. Correlation analysis of KSS 2011 and other factors (simple and multivariable linear regression analysis) (mean ± SD)

Factor	Simple		Multivariable	
	Coefficient	p value	Coefficient	p value
Age	−0.45 ± 0.11	< 0.001†	−0.30 ± 0.12	0.011*
Sex	0.74 ± 2.87	0.796	Excluded by a stepwise method	
Height	0.19 ± 0.16	0.218		
Weight	−0.12 ± 0.12	0.309		
BMI	−1.22 ± 0.43	0.005*	−1.47 ± 0.42	< 0.001†
Leg strength	0.42 ± 0.14	0.003*	0.41 ± 0.13	0.002*
Up and Go	−3.42 ± 0.87	< 0.001†	−1.96 ± 0.92	0.034*

* Significant risk ratio ($p < 0.05$); †significant risk ratio ($p < 0.001$); KSS 2011 = 2011 The Knee Society Score®; BMI = body mass index; Up and Go = Timed Up and Go Test.

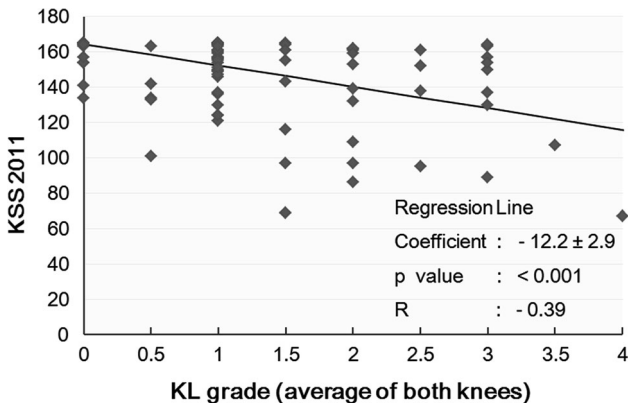

Fig. 2 Correlation between the KSS 2011 and the KL grade is shown. Linear regression analysis showed a significant correlation between KSS 2011 and KL grade.

declined steadily from ages 30s to 50s and was stable from ages 50s to 70s. The scores of people in their 80s were lower than those in the younger age groups for all components.

We found that several measures of physical function and anthropometrics correlated with the score on KSS 2011. Multivariable linear regression analysis showed that KSS 2011 correlated with age (coefficient: -0.30 ± 0.12, $p = 0.011$), BMI (coefficient: -1.47 ± 0.42, $p < 0.001$), leg muscle strength (coefficient: 0.41 ± 0.13, $p = 0.002$), and the Timed Up and Go Test (coefficient: -1.96 ± 0.92, $p = 0.034$), but not sex, as independent variables by a stepwise method (Table 4).

The presence of radiographic arthritis was associated with lower KSS 2011 scores. We found a moderate correlation between the KSS 2011 score and KL grade (Fig. 2). The regression line using the KSS score as an outcome variable (y) and KL grade as a predictor variable (x) was $y = -9.8x + 158.9$ (coefficient: -9.8 ± 2.5, $p < 0.001$, $R = -0.39$).

Discussion

KSS 2011 was designed primarily to evaluate the results of TKA. However, knee function and physical activities vary among patients and are influenced by age and sex, so what should be expected as a desirable score in KSS 2011 after TKA remains unclear. To have a clearer idea about this, some population-derived normative data are important, and it is important that these normative data be determined from relevant national, cultural, and ethnic populations. We found in this study from the general Japanese population, including patients with and without arthritis of the knee, that (1) as age increased, KSS 2011 decreased; (2) objective measures of physical function correlated well with KSS 2011; and (3) the presence of radiographic arthritis was moderately correlated with lower KSS 2011.

This study has several limitations. First, sampling bias certainly exists in many ways in this study. Community residents voluntarily participated in this study and motivated residents would be inclined to participate. Also, residents with a concern or symptoms in their knees may tend to participate. Furthermore, the protocol stipulated

that the radiographic examination was limited to participants older than 60 years, and only two-thirds of these participants agreed to receive this examination. Participants with a higher grade of radiographic OA may have agreed with radiographic examination. Therefore, some sampling bias likely influenced the results. Second, any physical function-related comorbidity may affect the results. Based on this speculation, excluded were patients who had disability unrelated to the knee that could influence patients' scores on KSS 2011; a small percentage (5.4% [12 of 224]) of participants were excluded because they had such disability. Conversely, this also demonstrates that the questionnaire can be answered by most patients without influence from other kinds of disabilities. Third, the component related to "patient expectation" was unavailable in this study because the participants had no plans to receive surgery. However, it is important to point out that patients' expectations about surgery affect their satisfaction with TKA [17], and the results of this study may differ from those in patients who undergo TKA. Fourth, because there is a clear ceiling effect in the KSS 2011, parametric techniques should be cautiously used in statistical analyses. We tested the correlations with a nonparametric analysis and obtained similar results, indicating simple and multiple regression analyses with a general linear model are usable. Also, regression lines by Torbit model are similar to those in the general linear model, supporting the results obtained in this study. Even so, the results obtained here should be handled with the greatest caution. Finally, we used a Japanese version of the questionnaire, but the translated version has not been validated by the cultural adaptation method. Even minor changes in question content can influence patients' estimation of knee pain and disability [21]. A validation study of the translated version is underway.

As expected, KSS 2011 declined with age, which is consistent with other reports [3]. In a previous study, knee function declined gradually with age, and the rate of decrease accelerated in people older than 85 years [18]. Our results are consistent with these previous findings. Collectively, older patients, especially in their 80s, can set much lower goals after TKA compared with younger patients.

It is noteworthy that the KSS 2011 scores correlated with BMI, leg muscle strength, and the Timed Up and Go Test in both the simple and multivariable liner regression analyses (Table 4). These correlations raise several issues. First, greater BMI is associated with knee pain and prevalence of radiographic OA [1, 29] and substantially limits physical activities. This study confirmed that the KSS 2011 score reflects the effects of BMI. Second, a previous study found that lower knee extension strength was associated with knee pain [22, 29]. The strong associations of KSS 2011 with leg muscle strength and the Timed Up and Go Test along with other reports [7, 22] collectively suggest that increased strength can improve the KSS 2011 as well as symptoms and satisfaction. Finally, the simple test of quadriceps strength and the Timed Up and Go Test were well tolerated; these tests are representative tests of knee functions as well as symptoms and satisfaction [29]. These relationships are worth investigating further.

In the current study, 41% (36 of 87) of participants had radiographic knee OA; this percentage agrees with previous reports on the prevalence of OA in the general population [6, 20, 28]. This implies that the participants in this study can be regarded as representative of the general population. The present study showed that KSS 2011 declines with increasing KL grade, which suggests that the severity of radiographic knee OA correlates with knee symptoms and functions and patient satisfaction. However, previous studies showed that the degree of radiographic OA does not correlate strongly with knee pain [15, 20, 29], and symptoms have been more emphasized in therapeutic strategies for OA [24]. Those and this study collectively indicate that KSS 2011 is more suitable than a radiological evaluation when deciding therapeutic strategies.

In summary, this is the first study to our knowledge to apply the KSS 2011 in the general (Japanese) population. The present study has three key findings: (1) In the general population, the KSS 2011 score declined with age. (2) The KSS 2011 score correlated independently not only with age, but also with BMI, the Timed Up and Go Test, and leg muscle strength but not with sex. (3) The KSS 2011 score correlated significantly with KL grade in people older than 60 years. Because TKA is one of the most prevalent operations worldwide, KSS 2011 should be tested in correlation with many aspects of symptoms and functions in a variety of ethnicity, nationality, belonged society, and lifestyle to set an appropriate goal for a patient who undergoes TKA.

Acknowledgments We thank Dr Yoshihiko Kotoura for his tremendous effort for this study. We also thank Drs Furu Moritoshi, Shinichi Kuriyama, Masahiro Ishikawa, Masayuki Azukizawa, Yosuke Hamamoto, Hiroyuki Tsukiyama, and Tatsuya Sueyoshi for their valuable help. We are extremely grateful to the Nagahama City Office and the nonprofit organization Zeroji Club for their help in performing the Nagahama Study.

References

1. Anderson JJ, Felson DT. Factors associated with osteoarthritis of the knee in the first National Health and Nutrition Examination Survey (HANES I). Evidence for an association with overweight, race, and physical demands of work. *Am J Epidemiol.* 1988;128:179–189.
2. Bach CM, Nogler M, Steingruber IE, Ogon M, Wimmer C, Göbel G, Krismer M. Scoring systems in total knee arthroplasty. *Clin Orthop Relat Res.* 2002;399:184–196.

3. Badley EM, Tennant A. Changing profile of joint disorders with age: findings from a postal survey of the population of Calderdale, West Yorkshire, United Kingdom. *Ann Rheum Dis.* 1992;51:366–371.
4. Bayley KB, London MR, Grunkemeier GL, Lansky DJ. Measuring the success of treatment in patient terms. *Med Care.* 1995;33(Suppl):AS226–235.
5. Bourne RB, Chesworth BM, Davis AM, Mahomed NN, Charron KDJ. Patient satisfaction after total knee arthroplasty: who is satisfied and who is not? *Clin Orthop Relat Res.* 2010;468:57–63.
6. Dickstein R, Heffes Y, Shabtai EI, Markowitz E. Total knee arthroplasty in the elderly: patients' self-appraisal 6 and 12 months postoperatively. *Gerontology*. 1998;44:204–210.
7. Imoto AM, Peccin MS, Trevisani VEM. Quadriceps strengthening exercises are effective in improving pain, function and quality of life in patients with osteoarthritis of the knee. *Acta Ortop Bras.* 2012;20:174–179.
8. Insall JN, Dorr LD, Scott RD, Scott WN. Rationale of the Knee Society Clinical Rating System. *Clin Orthop Relat Res.* 1989;248:13–14.
9. Kellgren JH, Lawrence JS. Radiological assessment of osteoarthrosis. *Ann Rheum Dis.* 1957;16:494–502.
10. Koh IJ, Kim TK, Chang CB, Cho HJ, In Y. Trends in use of total knee arthroplasty in Korea from 2001 to 2010 knee. *Clin Orthop Relat Res.* 2013;471:1441–1450.
11. Kreibich DN, Vaz M, Bourne RB, Rorabeck CH, Kim P, Hardie R, Kramer J, Kirkley A. What is the best way of assessing outcome after total knee replacement? *Clin Orthop Relat Res.* 1996;331:221–225.
12. Kurtz SM, Ong KL, Lau E, Widmer M, Maravic M, Gómez-Barrena E, De Fátima De Pina M, Manno V, Torre M, Walter WL, De Steiger R, Geesink RGT, Peltola M, Röder C. International survey of primary and revision total knee replacement. *Int Orthop.* 2011;35:1783–1789.
13. Mahomed NN, Liang MH, Cook EF, Daltroy LH, Fortin PR, Fossel AH, Katz JN. The importance of patient expectations in predicting functional outcomes after total joint arthroplasty. *J Rheumatol.* 2002;29:1273–1279.
14. Matsuda S, Kawahara S, Okazaki K, Tashiro Y, Iwamoto Y. Postoperative alignment and ROM affect patient satisfaction after TKA knee. *Clin Orthop Relat Res.* 2013;471:127–133.
15. McAlindon TE, Snow S, Cooper C, Dieppe PA. Radiographic patterns of osteoarthritis of the knee joint in the community: the importance of the patellofemoral joint. *Ann Rheum Dis.* 1992;51:844–849.
16. Nakayama T. Implementation of a genomic epidemiology and public health activities in a community: establishing a 'rule' for the protection and utilization of individual information. *Jap J Genet Counsel.* 2010;31:117–121.
17. Noble PC, Conditt MA, Cook KF, Mathis KB. The John Insall Award: Patient expectations affect satisfaction with total knee arthroplasty. *Clin Orthop Relat Res.* 2006;452:35–43.
18. Noble PC, Gordon MJ, Weiss JM, Reddix RN, Conditt MA, Mathis KB. Does total knee replacement restore normal knee function? *Clin Orthop Relat Res.* 2005;431:157–165.
19. Noble PC, Scuderi GR, Brekke AC, Sikorskii A, Benjamin JB, Lonner JH, Chadha P, Daylamani DA, Scott WN, Bourne RB. Development of a new Knee Society scoring system. *Clin Orthop Relat Res.* 2011;470:1–13.
20. Odding E, Valkenburg HA, Algra D, Vandenouweland FA, Grobbee DE, Hofman A. Associations of radiological osteoarthritis of the hip and knee with locomotor disability in the Rotterdam Study. *Ann Rheum Dis.* 1998;57:203–208.
21. O'Reilly SC, Muir KR, Doherty M. Screening for pain in knee osteoarthritis: which question? *Ann Rheum Dis.* 1996;55:931–933.
22. O'Reilly SC, Muir KR, Doherty M. Effectiveness of home exercise on pain and disability from osteoarthritis of the knee: a randomised controlled trial. *Ann Rheum Dis.* 1999;58:15–19.
23. Podsiadlo D, Richardson S. The Timed 'Up and Go': a test of basic functional mobility for frail elderly persons. *J Am Geriatr Soc.* 1991;39:142–148.
24. Richmond J, Hunter D, Irrgang J, Jones MH, Snyder-Mackler L, Van Durme D, Rubin C, Matzkin EG, Marx RG, Levy BA, Watters WC III, Goldberg MJ, Keith M, Haralson RH III, Turkelson CM, Wies JL, Anderson S, Boyer K, Sluka P, St Andre J, McGowan R. American Academy of Orthopaedic Surgeons clinical practice guideline on the treatment of osteoarthritis (OA) of the knee. *J Bone Joint Surg Am.* 2010;92:990–993.
25. Scuderi GR, Bourne RB, Noble PC, Benjamin JB, Lonner JH, Scott WN. The new Knee Society Knee Scoring System. *Clin Orthop Relat Res.* 2012;470:3–19.
26. Van Der Straeten C, Witvrouw E, Willems T, Bellemans J, Victor J. Translation and validation of the Dutch new Knee Society Scoring System©. *Clin Orthop Relat Res.* 2013;471:1–7.
27. Weinstein AM, Rome BN, Reichmann WM, Collins JE, Burbine SA, Thornhill TS, Wright J, Katz JN, Losina E. Estimating the burden of total knee replacement in the United States. *J Bone Joint Surg Am.* 2013;95:385–392.
28. Yoshimura N, Muraki S, Oka H, Mabuchi A, En-Yo Y, Yoshida M, Saika A, Yoshida H, Suzuki T, Yamamoto S, Ishibashi H, Kawaguchi H, Nakamura K, Akune T. Prevalence of knee osteoarthritis, lumbar spondylosis, and osteoporosis in Japanese men and women: the Research on Osteoarthritis/Osteoporosis Against Disability Study. *J Bone Miner Metab.* 2009;27:620–628.
29. Zhai G, Blizzard L, Srikanth V, Ding C, Cooley H, Cicuttini F, Jones G. Correlates of knee pain in older adults: Tasmanian older adult cohort study. *Arthritis Care Res (Hoboken).* 2006;55:264–271.