Brazilian Journal of Physical Therapy 2019;23(6):491–496

Brazilian Journal of Physical Therapy

https://www.journals.elsevier.com/brazilian-journal-of-physical-therapy

ORIGINAL RESEARCH

What are the clinical implications of knee crepitus to individuals with knee osteoarthritis? An observational study with data from the Osteoarthritis Initiative

Marcella Ferraz Pazzinatto[a,b], Danilo de Oliveira Silva[a,b], Nathálie Clara Faria[a], Milena Simic[c], Paulo Henrique Ferreira[c], Fábio Mícolis de Azevedo[a,*], Evangelos Pappas[c]

[a] *Physical Therapy Department, School of Science and Technology, Universidade Estadual Paulista ''Julio de Mesquita Filho'' (UNESP), Presidente Prudente, SP, Brazil*
[b] *La Trobe Sports and Exercise Medicine Research Centre (LASEM), School of Allied Health, La Trobe University, Bundoora, Victoria, Australia*
[c] *The University of Sydney, Discipline of Physiotherapy, Faculty of Health Sciences, Sydney, NSW, Australia*

Received 29 March 2018; accepted 6 November 2018
Available online 16 November 2018

KEYWORDS
Knee osteoarthritis;
Quality of life;
Recovery of function;
Knee

Abstract
Background: Crepitus is a common clinical feature of knee osteoarthritis. However, the importance of crepitus in the overall clinical presentation of individuals with knee osteoarthritis is unknown.
Objective(s): (A) To compare function, pain and quality of life between individuals with knee osteoarthritis with and without crepitus; (B) to compare whether individuals with knee osteoarthritis in both knees, but crepitus in just one, differ in terms of function pain, and knee strength.
Methods:: Setting: Observational study. *Participants*: (A) A total of 584 participants with crepitus who had the same Kellgren–Lawrence grade on both knees were matched for gender, body mass index and Kellgren-Lawrence grade to participants without crepitus on both knees. (B) 361 participants with crepitus in only one knee and with the same Kellgren-Lawrence grade classification on both knees were included. *Main outcome measure(s)*: A – Self-reported function, pain, quality of life, 20-m walk test and chair-stand test. B –Knee extensor and flexor strength, self-reported function and pain.

* Corresponding author at: Rua Roberto Simonsen, 305, CEP: 19060-900, Presidente Prudente, SP, Brazil.
E-mail: micolis@fct.unesp.br (F.M. Azevedo).

https://doi.org/10.1016/j.bjpt.2018.11.001
1413-3555/

Results: A – Individuals with crepitus had lower self-reported function, quality of life and higher pain compared to those without crepitus (3–11%; small effect = 0.17–0.41, respectively). No difference was found in objective function between groups. B – Self-reported function was lower in the limb with crepitus compared to the limb without crepitus (15%; trivial effect = 0.09). No difference was found in pain and knee strength between-groups.
Conclusion(s): Individuals with knee osteoarthritis and knee crepitus have slightly lower self-reported physical function and knee-related quality of life (small or trivial effect). However, the presence of knee crepitus is not associated with objective function or knee strength.

Introduction

Osteoarthritis (OA) is one of the leading causes of pain and disability worldwide only surpassed by back pain.[4] The prevalence of knee OA increases with age and affects 33.6% of women and 24.3% of men who are 60 years or older.[20] Individuals with late-stage knee OA have decreased physical function,[10,26] quality of life[2] and are commonly elect to undergo total knee arthroplasty.[11,27]

Imaging has been widely used to diagnose and grade knee OA.[6,9,12] However, the lack of association between imaging and knee OA severity have been responsible for a movement toward its diagnosis based on clinical findings.[5,8] According to the European League Against Rheumatism (EULAR), the association of risk factors for knee OA (e.g., age, gender, body mass index (BMI), occupation); their symptoms (persistent knee pain, morning stiffness and functional limitation) and physical examination (crepitus, restricted movement and bony enlargement) can guide a confident diagnosis of knee OA.[28]

In individuals with Kellgren–Lawrence (KL) grade of 1–3, the presence of crepitus results in 80% possibility of being diagnosed with knee OA.[28] Lo et al.[14] reported that knee crepitus is a simple and effective assessment that is predictive of longitudinal development of symptomatic knee OA. Another study,[3] reported a significant association between radiographic OA and the presence of knee crepitus. Knee crepitus was also an indicator of osteoarthritic lesions in the patellofemoral joint identified with magnetic resonance imaging in women with knee OA.[23]

Despite being associated with the development of knee OA and structural damage, it is unknown whether knee crepitus is indicative of an overall poor clinical presentation, including lower function, strength, quality of life and higher pain.[1] As individuals with knee pain often report negative beliefs regarding crepitus,[22] it is important to investigate the importance of crepitus to the overall clinical presentation of individuals with knee OA. If crepitus is associated with poor function, this information would aid clinicians to potentially identify a clinical finding indicative of OA severity. On the other hand, if crepitus is not associated with poor function, such information could be used to manage patient's negative beliefs regarding crepitus as a component of an education intervention.

The aims of the study are to (1) compare objective and self-reported physical function, pain and knee-related quality of life between individuals with knee OA with and without knee crepitus; (2) to compare whether individuals with knee OA in both knees, but crepitus in just one, differ in terms of knee extensor and flexor strength, knee-related pain and self-reported function.

Methods

This study was performed using data from the OA Initiative (OAI), which is a multi-center, longitudinal observational study of incident and progressive knee OA in older adults (http://www.oai.ucsf.edu). The study rationale and general inclusion criteria for the OAI (e.g., male or female sex, age 45–78, presence of symptoms and/or knee radiographic OA, or risk factors for knee OA) have been published[21] and are publicly available (http://oai.epi-ucsf.org/datarelease). Participants were enrolled at five centers (Baltimore, MD; Columbus, OH; Pittsburgh, PA; Pawtucket, RI and San Francisco, CA) between 2004 and 2006 if they had symptomatic knee OA. All participants provided written informed consent and this study received ethical approval from each OAI clinical site (Memorial Hospital of Rhode Island Institutional Review Board, The Ohio State University's Biomedical Sciences Institutional Review Board, University of Pittsburgh Institutional Review Board, and University of Maryland Baltimore – Institutional Review Board), and the OAI coordinating center (Committee on Human Research at University of California, San Francisco, California, United States of America. Number 10-00532).

Participants presenting with knee symptoms (pain, aching or stiffness), associated with, at least, one of other risk factors of OA such as age >45 years, overweight, knee injury or surgery and family history were considered as having high risk of developing knee OA. All assessments were conducted using a standardized protocol at each of the centers that could be found at http://www.oai.ucsf.edu. Participants underwent an examination by trained clinicians.

In order to address our aims, this study was divided into parts A and B.

Part A: A case-control design was used to compare objective and self-reported physical function, pain, and knee-related quality of life between individuals with knee OA with and without knee crepitus.

Part B: A within-subject design was used to compare knee extensor and flexor strength, knee-related pain, and self-reported physical function in individuals with knee OA in both knees, but crepitus in only one.

Crepitus

According to the OAI guidelines, clinicians assessed for crepitus by placing the palm of their hand over the patella to evaluate the presence of a continuous grinding sensation during passive knee flexion-extension movement in the supine position. To ensure quality of data collection, all clinic staff underwent a rigorous training.

Part A — case-control design

Participants with knee OA and crepitus who had the same KL grade on both knees were matched for gender, BMI and KL grade to participants without knee crepitus on both knees. The clinical presentation of the participants was assessed using performance-based function measures and self-reported measures.

Performance-based function measures: The 20-m walk test was used to measure walking speed. Participants were asked to walk at their usual walking pace, the timing began with the first footfall over the starting line and stopped with the first footfall over the finish line across 20 m. They performed two trials and the average speed was calculated. We have also used the performance on the repeated chair-stand test to assess function. Participants were asked to fold the arms across the chest and keep this position during the whole test. Then the examiner provided the following standardized instruction for all participants ''I want you to stand up five times as quickly as you can, keeping your arms folded across your chest. When you stand up, come to a full standing position each time, and when you sit down, sit all the way down each time''. The time to complete five chair rises was recorded in seconds. The test was performed twice and the mean value was used in the analysis.

Self-reported measures: To investigate self-reported function, pain and quality of life, patients were asked to complete the following three subscales of the Knee Outcome in Osteoarthritis Survey (KOOS): KOOS-pain, sport and recreational function (SRF) and knee related quality of life (QOL).

Part B — within-subject design

Participants with crepitus in only one knee and with the same KL grade classification on both knees were included in this analysis.

Performance-based function measures: The isometric strength was measured using the ''Good Strength Chair'' (Metitur Oy, Jyvaskyla, Finland). The participants were positioned sitting, with the back erect, their hip joints flexed at a 90°, and the legs hanging over the edge of the chair with their assessed knee joints flexed at 60°. A seatbelt was used to stabilize the pelvis, the thigh and upper leg of the participant. The participants were instructed to push (knee extension test) or pull (knee flexion test) as hard and as fast as they can against a pad (http://www.oai.ucsf.edu). There were two warm up trials with 50% effort and the participants performed three trials of knee flexion and three trials of knee extension. The maximal force produced during isometric contraction was recorded. All participants were encouraged for about 3 s and they rested for 30 s between trials.

Self-reported measures: To assess self-reported physical function and pain, the participants were asked to complete the Western Ontario and McMaster Universities (WOMAC) physical function and pain subscales for each knee.

Statistical analysis

All analyses were performed using the Statistical Package for the Social Sciences software program (IBM version 23, SPSS Inc., Chicago, IL) with an a priori level of significance of 0.05. All variables were assessed for normality and found to be normally distributed based on obtainment of $p > 0.05$ in the Kolmogorov—Smirnov test.

Case-control design: Between-groups differences in demographic measures, performance-based functional tests and self-reported measures (self-reported function, pain and quality of life) were assessed using paired t-tests.

Within-subject design: Between-groups differences in maximum isometric strength (knee flexion and knee extension), self-reported function and pain were assessed using paired t-tests.

In order to provide a more complete assessment of the findings in addition to *p*-values we also calculated the effect size (ES; Hedges'g) of each comparison using the Review Manager software (Version 5.3, Copenhagen, Denmark). The interpretation of the effect sizes values was guided according to Sullivan and Feinn,[25] where <0.2 (trivial effect), >0.2 (small), >0.5 (medium), >0.8 (large), and >1.3 (very large).

Results

Part A

A total of 584 participants (292 in each group) were included to the case-control design of our study (Table 1). Basic characteristics indicated that the matching produced groups with similar characteristics. Findings demonstrated that individuals with knee crepitus had lower self-reported function (11%; small effect = 0.36), knee-related quality of life (11%; small effect = 0.41) and higher self-reported pain (3%; trivial = 0.17) compared to those without knee crepitus (Table 1). There was no difference in performance-based function tests (20 m walk test and chair-stand test) between groups (Table 1).

Part B

For the within-subject analysis, a total of 361 participants were included. Of those, 178 participants (49%) had crepitus on the dominant leg, 177 (49%) of participants had crepitus on the non-dominant leg and six (2%) were ambidextrous. The mean age was 60.3 (8.9) years with a mean BMI of 28.93 (4.84), 236 (65%) were women, 156 (43%) had KL grade 0, 43

Table 1 Characteristics of individuals with knee osteoarthritis presenting no crepitus and crepitus (case-control design).

Variable	No crepitus ($n = 292$)	Crepitus ($n = 292$)	Mean difference (95% confidence interval)
Demographics			
Age	61.00 (9.58)	61.14 (9.20)	0.14 (−1.39 to 1.68)
Body mass (kg)	79.91 (17.10)	80.05 (16.60)	0.14 (−1.07 to 1.22)
Height (m)	1.68 (0.97)	1.68 (0.98)	0.002 (−1.37 to 1.86)
Body mass index	27.85 (4.74)	28.03 (4.84)	0.18 (−0.95 to 1.03)
Sex (female/male)	162/130	162/130	N.A.
K–L grade			N.A.
0	129	129	N.A.
1	40	40	N.A.
2	88	88	N.A.
3	35	35	N.A.
Performance-based function measures			
20 m walk (m/s)	1.34 (0.19)	1.34 (0.21)	−0.008 (−0.04 to 0.02)
Repeated chair-stand (stands/s)	0.47 (0.18)	0.48 (0.18)	0.008 (−0.02 to 0.03)
Patient-reported measures			
KOOS-SRF	78.76 (22.50)	69.88 (26.82)	−8.88 (−12.69 to −5.08)*
KOOS-pain	86.75 (15.94)	84.02 (16.33)	−2.73 (−4.41 to −1.05)*
KOOS-QOL	75.98 (20.30)	67.33 (21.85)	−8.64 (−11.87 to −5.27)*

Abbreviations: KOOS-SRF, knee outcome in osteoarthritis survey sport and recreational function; KOOS-QOL, knee outcome in osteoarthritis survey quality of life.
* Represents $p < 0.05$.

(12%) had KL grade 1, 111 (31%) had KL grade 2 and 51 (14%) had KL 3 and no participant had KL grade 4.

Findings demonstrated that self-reported function was lower in the limb with crepitus (15%; trivial effect = 0.09) but no limb differences were detected for knee extensor or flexor strength and knee-related pain (Table 2).

Discussion

Our findings indicate that individuals with knee OA presenting knee crepitus have slightly lower self-reported function, quality of life and higher pain compared to individuals with knee OA without crepitus. However, all comparisons presented small or trivial effect sizes. In addition, the presence of knee crepitus did not influence performance-based function tests such as walking or sit-stand tasks and knee strength in individuals with knee OA.

Due to the small effect sizes and between-groups differences, our findings suggest that the presence of crepitus on self-reported function and knee-related quality of life or pain may be limited. It is important to note that even though the p values were frequently significant, the between-groups differences were small ranging from 3 to 15%. Despite previous reports that knee crepitus is a risk factor for individuals with knee OA[14] and associated with radiographic lesions,[3] knee crepitus seems not to be detrimental to the current clinical presentation of individuals with knee OA.

In both designs (case-control and within-subject), we observed lower self-reported function in the presence of crepitus, but no difference in objective function (knee strength or performance-based tests). We speculate that these findings might be explained by the negative beliefs individuals with knee pain have regarding knee crepitus.[22,24] Many individuals become fearful and insecure of the noise related to crepitus and might end with the belief that their condition is actually worse than it really is.[24] A common concern of patients in the clinical setting is about the meaning and importance of knee crepitus.[22] There is no clear evidence regarding the source of the noise, however, a large amount of asymptomatic individuals present knee crepitus.[16,24] Therefore, educating and reassuring the patients by explaining them that knee crepitus is not aggravating their condition seems to be the best avenue to avoid negative beliefs. This is important as our findings suggest that knee crepitus may have a negative effect on participants health-related perception.

Cross-sectionally, knee crepitus was associated with lower self-reported function and knee-related quality of life (small or trivial effect). However, at long term (4 years), the presence of knee crepitus was not associated with lower physical function nor poorer quality of life in individuals with knee OA.[19] Even so, it is important to note that in a specific subgroup with preexisting tibiofemoral radiographic OA and without frequent knee pain, self-reported crepitus was found to be a predictor of knee OA.[14] Further studies should investigate if there is a difference between self-reported crepitus and objective measures of crepitus as predictors of future knee OA.

Our findings that crepitus does not have any impact on knee strength, objective function and pain of individuals with knee OA are in accordance with recent reports.[17,18] De Oliveira Silva et al. reported that crepitus did not

Table 2 Limb-specific characteristics of individuals with knee osteoarthritis presenting crepitus in one knee (within-subject design).

Variable	No crepitus knee ($n = 361$)	Crepitus knee ($n = 361$)	Mean difference (95% confidence interval)
Demographics			
K-L grade			
0	156	156	N.A.
1	43	43	N.A.
2	111	111	N.A.
3	51	51	N.A.
Strength measures			
Knee extensor torque (N/kg)	4.14 (6.76)	4.12 (7.37)	−0.02 (−9.05 to 6.03)
Knee flexor torque (N/kg)	1.75 (0.80)	1.71 (0.78)	−0.04 (−5.25 to 1.74)
Limb-specific function measures			
WOMAC-physical function	7.00 (9.39)	8.24 (10.47)	1.24 (0.36 to 2.12)*
WOMAC-pain	2.13 (2.91)	2.40 (3.11)	0.27 (−0.03 to 0.58)

Abbreviation: WOMAC, Western Ontario and McMaster Universities.
* Represents $p < 0.05$.

influence knee extensor strength, objective function, psychological factors neither is associated with pain in young individuals with knee pain.[17,18] Commonly, people associate the presence of crepitus with the need of future total knee replacement,[22] however, Pazzinatto et al. investigated a large cohort and did not find any association within a 3 years period.[19] According to previous research,[22] crepitus is poorly understood and affects negatively patient's beliefs, altering movement pattern in an attempt to not hear the noise and can be responsible for the lack of adherence to exercise therapy.[22] Thus, further education about crepitus should be tested as a component of knee OA treatment in order to educate patients that knee crepitus does not affect objective physical function or knee strength. Additionally, what still remains unclear is the potential influence of evidence-based treatments (e.g. bracing, exercise, diet)[15] on knee crepitus.

Study limitations and future research

We evaluated only individuals with knee OA or at high risk of developing knee OA, therefore, the first limitation is the lack of a group with no knee OA which prevents us from drawing broader conclusions for the importance of crepitus in the general asymptomatic population. Secondly, the lack of a group with severe knee OA (KL grade 4) prevented testing if function is lower among those with end stage knee OA. Thirdly, despite the high prevalence of patellofemoral OA in people older than 30 years,[13] the KL grade of the OAI was not used to evaluate the patellofemoral joint. The large sample size may limit selection bias, however, at the same time, spurious statistically significant findings (type I error) could be present.[7]

Future research should address these limitations by including a control group and performing a longitudinal follow-up. A longitudinal study can determine if the presence of knee crepitus is associated with a quicker functional decline in individuals with established disease or associated with development of knee OA in healthy individuals. Also, based on our findings further research could investigate the effect of education about crepitus on patient self-reported outcomes.

Conclusion

The presence of knee crepitus in individuals with knee OA indicates lower self-reported function, knee-related quality of life and higher pain that are of small or trivial effect sizes with limited clinical importance. Moreover, the presence of knee crepitus is not related with deficits in objective function and knee extensor or flexor strength.

Funding source

The authors would like to acknowledge the Sao Paulo Research Foundation (scholarships process numbers: 2015/10631-3 and 2015/11534-1). The financial sponsor played no role in the design, execution, analysis and interpretation of data, or writing of the study.

Conflicts of interest

The authors declare no conflict of interest.

References

1. Briani RV, Pazzinatto MF, De Oliveira Silva D, Azevedo FM. Different pain responses to distinct levels of physical activity in women with patellofemoral pain. *Brazilian J Phys Ther*. 2017;21(2):138–143, http://dx.doi.org/10.1016/j.bjpt.2017.03.009.
2. Briani RV, Ferreira AS, Pazzinatto MF, Pappas E, De Oliveira Silva D, Azevedo de FM. What interventions can improve quality of life or psychosocial factors of individuals with knee

osteoarthritis? A systematic review with meta-analysis of primary outcomes from randomised controlled trials. *Br J Sports Med*. 2018;52(16):1031–1038, http://dx.doi.org/10.1136/bjsports-2017-098099.
3. Crema MD, Guermazi a, Sayre EC, et al. The association of magnetic resonance imaging (MRI)-detected structural pathology of the knee with crepitus in a population-based cohort with knee pain: the MoDEKO study. *Osteoarthr Cartil*. 2011;19(12):1429–1432, http://dx.doi.org/10.1016/j.joca.2011.09.003.
4. Cross M, Smith E, Hoy D, et al. The global burden of hip and knee osteoarthritis: estimates from the Global Burden of Disease 2010 study. *Ann Rheum Dis*. 2014;73(7):1323–1330, http://dx.doi.org/10.1136/annrheumdis-2013-204763.
5. Culvenor AG, Øiestad BE, Hart HF, Stefanik JJ, Guermazi A, Crossley KM. Prevalence of knee osteoarthritis features on magnetic resonance imaging in asymptomatic uninjured adults: a systematic review and meta-analysis. *Br J Sports Med*. 2018;(i):1–12, http://dx.doi.org/10.1136/bjsports-2018-099257.
6. Duncan R, Peat G, Thomas E, Hay EM, Croft P. Incidence, progression and sequence of development of radiographic knee osteoarthritis in a symptomatic population. *Ann Rheum Dis*. 2011;70(11):1944–1948, http://dx.doi.org/10.1136/ard.2011.151050.
7. Field A. *Discovering Statistics Using IBM SPSS Statistics*. 4th ed. London; 2013.
8. Finan PH, Buenaver LF, Bounds SC, et al. Discordance between pain and radiographic severity in knee osteoarthritis: findings from quantitative sensory testing of central sensitization. *Arthritis Rheum*. 2013;65(2):363–372, 10.1002/art.34646.Discordance.
9. Hart DJ, Spector TD. Kellgren & Lawrence grade 1 osteophytes in the knee – doubtful or definite? *Osteoarthr Cartil*. 2003;11(2):149–150, http://dx.doi.org/10.1053/joca.2002.0853.
10. Huang K-H, Hsieh R-L, Lee W-C. Pain, physical function, and health in patients with knee osteoarthritis. *Rehabil Nurs*. 2015:1–8, http://dx.doi.org/10.1002/rnj.234.
11. Kahn TL, Schwarzkopf R. Does total knee arthroplasty affect physical activity levels? Data from the Osteoarthritis Initiative. *J Arthroplasty*. 2015;30(9):1521–1525, http://dx.doi.org/10.1016/j.arth.2015.03.016.
12. Kellgren JH, Lawrence JS. Radiological assessment of osteoarthrosis. *Ann Rheum Dis*. 1956;16(3):494–503.
13. Kobayashi S, Pappas E, Fransen M, Refshauge K, Simic M. The prevalence of patellofemoral osteoarthritis: a systematic review and meta-analysis. *Osteoarthr Cartil*. 2016;24(10):1697–1707, http://dx.doi.org/10.1016/j.joca.2015.02.968.
14. Lo GH, Strayhorn MT, Driban JB, Price LL, Eaton CB, McAlindon TE. Subjective crepitus as a risk factor for incident symptomatic knee osteoarthritis: data from Osteoarthritis Initiative. *Arthritis Care Res*. 2018;70(1):53–60, http://dx.doi.org/10.1002/acr.23246.
15. McAlindon TE, Bannuru RR, Sullivan MC, et al. OARSI guidelines for the non-surgical management of knee osteoarthritis. *Osteoarthr Cartil*. 2014;22(3):363–388, http://dx.doi.org/10.1016/j.joca.2014.01.003.
16. McCoy GF, McCrea JD, Beverland DE, Kernohan WG, Mollan RAB. Vibration arthrography as a diagnostic aid in diseases of the knee. *J Bone Jt Surg*. 1987;69(2):288–293.
17. De Oliveira Silva D, Barton C, Crossley K, et al. Implications of knee crepitus to the overall clinical presentation of women with and without patellofemoral pain. *Phys Ther Sport*. 2018;33:89–95, http://dx.doi.org/10.1016/j.ptsp.2018.07.007.
18. De Oliveira Silva D, Pazzinatto MF, Priore Del LB, et al. Knee crepitus is prevalent in women with patellofemoral pain, but is not related with function, physical activity and pain. *Phys Ther Sport*. 2018;33:7–11, http://dx.doi.org/10.1016/j.ptsp.2018.06.002.
19. Pazzinatto MF, De Oliveira Silva D, Azevedo FM, Pappas E. Knee crepitus is not associated with the occurence of total knee replacement in knee osteoarthritis – a longitudinal study with data from the Osteoarthritis Initiative. *Brazilian J Phys Ther*. 2018, http://dx.doi.org/10.1016/j.bjpt.2018.09.009 [Epub ahead of print].
20. Pereira D, Peleteiro B, Araújo J, Branco J, Santos RA, Ramos E. The effect of osteoarthritis definition on prevalence and incidence estimates: a systematic review. *Osteoarthr Cartil*. 2011;19(11):1270–1285, http://dx.doi.org/10.1016/j.joca.2011.08.009.
21. Peterfy CG, Schneider E, Nevitt M. The osteoarthritis initiative: report on the design rationale for the magnetic resonance imaging protocol for the knee. *Osteoarthr Cartil*. 2008;16(12):1433–1441, http://dx.doi.org/10.1016/j.joca.2008.06.016.
22. Robertson CJ, Hurley M, Jones F. People's beliefs about the meaning of crepitus in patellofemoral pain and the impact of these beliefs on their behaviour: a qualitative study. *Musculoskelet Sci Pract*. 2017;28:59–64, http://dx.doi.org/10.1016/j.msksp.2017.01.012.
23. Schiphof D, Van Middelkoop M, De Klerk BM, et al. Crepitus is a first indication of patellofemoral osteoarthritis (and not of tibiofemoral osteoarthritis). *Osteoarthr Cartil*. 2014;22(5):631–638, http://dx.doi.org/10.1016/j.joca.2014.02.008.
24. Song SJ, Park CH, Liang H, Kim SJ. Noise around the knee. *CiOS Clin Orthop Surg*. 2018;10(1):1–8, http://dx.doi.org/10.4055/cios.2018.10.1.1.
25. Sullivan GM, Feinn R. Using effect size – or why the p value is not enough. *J Grad Med Educ*. 2012;4(3):279–282, http://dx.doi.org/10.4300/JGME-D-12-00156.1.
26. Tanaka R, Hirohama K, Ozawa J. Can muscle weakness and disability influence the relationship between pain catastrophizing and pain worsening in patients with knee osteoarthritis? A cross-sectional study. *Brazilian J Phys Ther*. 2018, http://dx.doi.org/10.1016/j.bjpt.2018.08.011.
27. Umehara T, Tanaka R. Effective exercise intervention period for improving body function or activity in patients with knee osteoarthritis undergoing total knee arthroplasty: a systematic review and meta-analysis. *Brazilian J Phys Ther*. 2018;22(4):265–275, http://dx.doi.org/10.1016/j.bjpt.2017.10.005.
28. Zhang W, Doherty M, Peat G, et al. EULAR evidence-based recommendations for the diagnosis of knee osteoarthritis. *Ann Rheum Dis*. 2010;69(3):483–489, http://dx.doi.org/10.1136/ard.2009.113100.