J Rehabil Med 2013; 45: 192–197

ORIGINAL REPORT

ASSOCIATION OF POSTURAL CONTROL WITH MUSCLE STRENGTH, PROPRIOCEPTION, SELF-REPORTED KNEE INSTABILITY AND ACTIVITY LIMITATIONS IN PATIENTS WITH KNEE OSTEOARTHRITIS

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Objective: **To determine the association of postural control with muscle strength, proprioception, self-reported knee instability and activity limitations in patients with knee osteoarthritis.**

Methods: **A total of 284 patients with knee osteoarthritis from the Amsterdam Osteoarthritis cohort were included. Postural control was assessed using the One-Leg Stand Test (OLST), in which the patients were asked to stand on one leg for 30 s. Muscle strength (isokinetic dynamometer), proprioception (joint motion detection threshold) and self-reported knee instability (episodes of buckling, shifting or giving way) were also assessed. Activity limitations were assessed using the Get Up and Go (GUG) test, the walking up-down stairs test, and Western Ontario and McMaster University Osteoarthritis Index – Physical Function subscale. Regression analyses were used to assess the associations.**

Results: **Muscle weakness ($p = 0.02$) and proprioceptive inaccuracy ($p < 0.001$) were associated with decreased postural control. Decreased postural control was associated with less time performing the GUG test ($p < 0.001$) and the walking up-down stairs test ($p < 0.001$). These associations were found after adjustment for relevant confounders.**

Conclusion: **In patients with knee osteoarthritis, decreased postural control is associated with muscle weakness, proprioceptive inaccuracy and performance-based activity limitations. These results highlight the importance of including assessment and training of postural control in this group of patients.**

Key words: knee osteoarthritis; postural control; balance; activity limitations; knee instability; muscle strength; proprioception.

J Rehabil Med 2013; 45: 192–197

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Submitted June 5, 2012; accepted August 29, 2012

INTRODUCTION

Osteoarthritis (OA) is the most common form of arthritis associated with chronic pain and activity limitations (1). Postural control impairment (balance), defined as the capacity to maintain the centre of mass within the base of support in the upright position in diverse situations, is associated with activity limitations (2, 3). Adequate postural control allows not only the maintenance of posture when carrying out activities, but it is also essential for the prevention of serious injuries due to falls (4). Postural control involves numerous body systems, which translate into a coordinated neuromuscular response at the peripheral level (2, 4). Neuromuscular disorders, such as muscle weakness (5) and proprioceptive inaccuracy (6), as well as knee instability (7), are present in patients with OA and might contribute to decreased postural control. Subsequently, decreased postural control might lead to activity limitations (8). Some studies have documented the existence of decreased postural control in patients with OA (3, 9–11), and its association with muscle strength and proprioception (3, 12, 13). However, there is limited evidence for the association between knee instability and postural control (10). Furthermore, only a limited number of studies have reported an association of postural control with activity limitations in this group of patients (14, 15).

To measure postural control in patients with OA, previous studies have used complex and expensive equipment, which is often not available in clinical settings. In contrast, the One-Leg Stand Test (OLST) used in this study, is a quick, cheap and easy-to-perform postural control test, which has been used in various studies (2, 16–20), mainly with older adults. The OLST performance was associated with muscle strength and activity limitations in older adults (18, 21). In addition, the OLST does not require equipment for its implementation, and has shown high validity and reliability when applied in the elderly population (17, 22). To the best of our knowledge, the OLST has not been used to assess postural control in patients with knee OA.

 doi: 10.2340/16501977-1087 ISSN 1650-1977

In patients with OA, muscle weakness, proprioceptive inaccuracy and knee instability might contribute to decreased postural control, and decreased postural control might lead to activity limitations. In addition, the identification of a simple clinical test, such as the OLST, to easily assess postural control in patients with OA might be of clinical relevance. The aim of this study was therefore to determine the association of postural control with muscle strength, proprioception, self-reported knee instability and activity limitations in patients with knee OA, using the OLST as the measure of postural control.

PATIENTS AND METHODS

Subjects

A total of 284 participants of the Amsterdam Osteoarthritis (AMS-OA) cohort (184 females, 100 males) with unilateral or bilateral diagnosis of knee OA according to American College of Rheumatology (ACR) criteria (23) were included in this study (24). The AMS-OA is a cohort of patients with OA of the knee and/or hip according to the ACR criteria (23, 25), who have been referred to an outpatient rehabilitation centre (Reade, Centre for Rehabilitation and Rheumatology, Amsterdam, The Netherlands). Participants were assessed by rheumatologists, radiologists and rehabilitation physicians. Exclusion criteria were: total knee replacement, rheumatoid arthritis, or any other form of inflammatory arthritis (i.e. crystal arthropathy, septic arthritis, spondylarthropathy). Demographic, radiographic, biomechanical, clinical and psychosocial factors related to OA were assessed. All of the participants provided written informed consent before testing. The study was approved by the Slotervaart Hospital/Reade Institutional Review Board.

Measures

Postural control. In the OLST, the commands given to the subjects were: "keep your hands at each side of your waist and your eyes open, please stand on one leg as I am doing it [*the position was demonstrated by the evaluator*]. Your goal is to try to keep this position for 30 s without using your arms or your other leg for additional support. I will start the chronometer when you are ready, and I will indicate to you when to stop". The subjects were free to choose on which leg they wanted to complete the test first. The OLST was timed in seconds, for a duration of 30 s from the time one foot was lifted from the floor (16, 26). The chronometer was stopped earlier when the elevated leg touched the ground or touched the standing leg, or when the stance foot was displaced. In order to avoid a ceiling effect, the results of the test were dichotomized as "0" if the subject stood on one leg for less than 30 s (i.e. did not complete the test) and "1" if he/she stood on one leg for 30 s (i.e. did complete the test). The OLST has been shown to be reliable and valid in high-functioning populations (17, 22).

Muscle strength. Knee muscle strength was assessed using an isokinetic dynamometer (EnKnee, Enraf-Nonius, Rotterdam, The Netherlands) (27). An initial practice attempt was used for the patients to become familiar with the movements required. The patients performed 3 maximal test repetitions to measure the strength of the quadriceps and hamstrings for each knee, at 60º/s (24, 28). Mean quadriceps and hamstring muscle strength per leg was calculated (Nm) and divided by patient's weight (kg). This measure (in Nm/kg) has an excellent intra-rater reliability (intraclass correlation coefficient (ICC) 0.93) in patients with knee OA (29).

Proprioceptive accuracy. Proprioceptive accuracy (motion sense) was assessed using a knee joint motion detection threshold (JMDT) (27). In a sitting position (semi-reclined), both lower legs were supported on two separate level arms moved to a starting position of 30º flexion. A constant angular motion of one knee at the time was initiated at a velocity of 0.3º/s in the extension direction. The subject was instructed to push the right-hand button after detecting motion of the right knee, or the left-hand button after detecting motion of the left knee. The ordering of the leg being tested was randomly selected. Interference of additional visual-auditory stimuli, and clues such as cutaneous tension, pressure or vibration, were minimized. JMDT for the knee joint was measured as the difference between the original joint position, in degrees, and the position in which the patient pushed the button indicating detection of knee motion. The mean of 3 measurements was calculated for each knee. Intra- and inter-rater reliability (ICC 0.91) for measuring motion detection in patients with knee OA was found to be excellent (30).

Knee instability. Self-reported knee instability was evaluated using a self-reported sensation of knee buckling, shifting or giving away during the past 3 months (24), based on a questionnaire from Felson et al. (31). Persons reporting knee instability were additionally asked for the number of episodes of instability, on which leg it was experienced, and whether these had resulted in a fall. This variable was dichotomized as "0" if they reported fewer than 3 episodes and "1" if they reported 3 or more episodes of instability during the past 3 months.

Laxity. Varus-valgus laxity was operationalized as the movement in the frontal plane after varus and valgus load (24). It was assessed using an electronic device (32). In a sitting position, with a knee flexion of 20º, the thigh and lower leg were fixed in order to prevent medial-lateral movements of the leg and/or pelvic rotation. A load of 1.12 kg was applied to the lower leg both medially and laterally, resulting in varus or valgus movement across the transverse axis of the knee joint. The total amount of movement (in the varus and valgus directions) was measured electronically and recorded digitally in degrees. Three consecutive measurements were made, and the mean of the 3 measurements calculated for each knee. Intra- and inter-rater reliability (ICC) for this measurement in healthy persons are 0.80 and 0.88, respectively (32).

Range of motion. Active knee flexion and extension range of motion (ROM) were measured in degrees using a goniometer (33). Measurements were taken according to Norkin & White (34) by trained movement scientists.

Activity limitations. Activity limitations were measured using two physical performance tests (i.e. Get Up and Go test (GUG) and time walking up-down stairs), and a self-reported physical function questionnaire: Western Ontario and McMaster Universities Osteoarthritis Index – Physical Function subscale (WOMAC-PF).

The GUG test (14, 32) was performed with subjects seating on a high standard chair (seat height 49 cm). The subjects were instructed to stand up without the help of the arms on the command "go", and walk 15 m along an unobstructed corridor as fast as possible, without running. The chronometer was stopped when they reached the 15 m mark on the floor. All subjects were wearing walking shoes. Patients who normally used walking devices were allowed to use them during the test. A longer time taken to perform the test was considered a higher activity limitation.

In the walking up-down stairs test, subjects were instructed to climb 12 stairs without using the hand-rail, ascending one stair at the time as fast as possible, without running. Once they reached the top the chronometer was stopped while they turned around. Subsequently, and following the same instructions, after a signal the chronometer was started again and the subjected walked down the stairs. Both times (in seconds) were recorded independently and added together to calculate the time for the whole task. All subjects were wearing walking shoes. A longer time performing the test was considered a higher activity limitation. The ICC for the intra-tester and inter-tester reliability were both 0.98 (7).

The WOMAC questionnaire is used to evaluate self-reported pain, stiffness and activity limitations in subjects with OA (35). It has 5 items related to pain and 2 related to stiffness. The physical function (PF) section is composed of 17 items, each of which is scored 0 to 4, giving a possible total score of 0 to 68. Higher scores represent

greater activity limitations. A validated Dutch version of WOMAC (36) was used in this study.

Statistical analysis

The index knee was selected using the following decision tree: 1) Knee with OA diagnosis (ACR), if OA diagnosis in both knees. 2) Painful knee. 3) Highest Kellgren/Lawrence score (37). 4) Lowest degree of active knee flexion.

In participants in whom an index knee could not be defined based on these signs, a random index joint was assigned. The variables related to the index knee were used in the analyses.

Descriptive statistics were used to characterize the study population, and to characterize separately persons who completed and did not complete the OLST. Percentages were used for categorical variables, and means and standard deviations (SD) for continuous variables. χ^2 tests or Students' *t*-test were used to analyse the differences in the distribution of the variables between the two subgroups.

Associations between OLST, neuromuscular factors, self-reported knee instability and activity limitations were analysed through regression analyses. OLST dichotomized (i.e. completed vs not completed the 30 s test) was the independent factor. First, regression analyses were used to analyse the association between the OLST and neuromuscular factors (muscle strength, proprioception), self-reported knee instability and activity limitations variables (GUG, walking up-down stairs and WOMAC-PF) (crude models). Secondly, relevant confounding was defined as 10% change in the crude regression coefficient of the first determinant, after adjustment for a second variable (38). A confounding effect of other variables possibly associated with OLST, such as general patient characteristics (gender, age, body mass index (BMI), duration of knee complaints-, knee pain) and neuromuscular factors (muscle strength, proprioceptive accuracy, laxity, ROM) were determined, based on a 10% difference between crude and adjusted regression coefficient. Thirdly, fully adjusted multivariable regression models including all relevant confounding variables were analysed.

Statistical significance was accepted at p-values < 0.05. All analyses were performed using SPSS software, version 17.0 (SPSS, Chicago, IL, USA).

RESULTS

Descriptives. Almost two-thirds (65%) of the study population ($n = 284$) were women and the mean age was 61.5 years (SD 7.6). The OLST was completed for 49% of the patients ($n = 139$), and 51% of the patients ($n = 145$) did not complete the test. Further demographic and clinical characteristic data are shown in Table I. Several variables assessed were significantly different between subgroups (i.e. OLST completed vs not completed) (Table I).

Association between neuromuscular factors and postural control. Table II shows the crude and adjusted association of muscle strength and knee proprioception with the OLST. Higher muscle strength (crude regression coefficient $b = 0.23$, $p < 0.001$) and better knee proprioception (crude $b = –1.33$, $p < 0.001$) were significantly associated with completion of the OLST (better postural control). After the addition of 1 possible confounder at the time to the crude model, age, BMI, pain, muscle strength, proprioception, laxity and ROM active flexion were shown to be relevant confounders (i.e. greater than 10% change in the crude model regression coefficient for OLST). In the fully adjusted models, after adjustment for relevant confounders, higher muscle strength ($b = 0.10$, $p = 0.02$) and better proprioceptive accuracy ($b = –1.05$, $p < 0.001$) were less strongly, but still significantly, associated with better postural control in patients with knee OA.

Association between self-reported knee instability and postural control. Table III shows a significant association between self-reported knee instability and the OLST (crude odds ratio (OR)

Table I. *Study group characteristics*

Characteristics	Total group ($n = 284$)	OLST completed ($n = 139$)	OLST not completed ($n = 145$)
Female gender, *n* (%)	184 (65)	96 (69)	88 (61)
Age, years, mean (SD)	61.5 (7.6)	59.3 (7.1)	63.6 (7.5)*
Body mass index, kg/m^2, mean (SD)	29.3 (5.4)	27.8 (4.7)	30.7 (5.7)*
Duration of knee complaints, years, mean (SD)	11.1 (9.9)	10.1 (9.2)	12.0 (10.6)
Severity of knee pain at the moment (0–10), mean (SD)	3.8 (2.7)	3.3 (2.6)	4.2 (2.8)*
OA diagnostic (ACR), *n* (%)			
One knee	83 (29)	47 (34)	36 (25)
Both knees	201 (71)	92 (66)	109 (75)
Radiographic OA ≥ K/L score 2, *n* (%)	199 (70)	91 (66)	108 (75)
Muscle strength, Nm/kg, mean (SD)	0.8 (0.4)	1.0 (0.4)	0.7 (0.4)*
Laxity, degrees, mean (SD)	6.9 (3.3)	6.6 (3.1)	7.2 (3.5)
Proprioceptive accuracy, degrees, mean (SD)	2.9 (2.3)	2.3 (1.5)	3.6 (2.7)*
ROM active extension, degrees, mean (SD)	–4.9 (4.9)	–4.8 (4.5)	–5.0 (5.2)
ROM active flexion, degrees, mean (SD)	121.9 (12.5)	125.1 (9.0)	118.9 (14.4)*
Walk up-down a lap of 12 stairs, s, mean (SD)	15.6 (11.2)	11.6 (3.8)	19.5 (14.3)*
GUG test, s, mean (SD)	11.1 (3.3)	9.8 (1.7)	12.4 (3.9)*
WOMAC pain score (0–20), mean (SD)	7.9 (3.7)	7.2 (3.4)	8.6 (3.8)*
WOMAC stiffness score (0–8), mean (SD)	3.8 (1.7)	3.5 (1.7)	4.2 (1.7)*
WOMAC physical function (0–68), mean (SD)	28.4 (12.9)	25.6 (12.4	31.0 (12.8)*
Self-reported knee instability (previous 3 months) ≥3 episodes, *n* (%)	81 (28)	32 (23)	49 (34)*
Fall due to episode of knee instability, *n* (%)	19 (7)	5 (4)	14 (10)*

*Significant difference between subgroups ($p < 0.05$).

OLST: One-Leg Stand Test; ACR: American College of Rheumatology; WOMAC: Western Ontario and McMaster University Osteoarthritis Index; OA: osteoarthritis; K/L: Kellgren/Lawrence; ROM: range of motion; SD: standard deviation.

Table II. *Association between postural-control and neuromuscular factors*

	Muscle strength, Nm/kg			Proprioception, degrees		
	b	95% CI	*p*-value	*b*	95% CI	*p*-value
Crude model, OLST	0.23	0.14 to 0.32	<0.001	–1.33	–1.83 to –0.82	<0.001
Adjusted models						
OLST+age	0.22	0.13 to 0.32	<0.001	–1.05[a]	–1.57 to –0.53	<0.001
OLST+BMI	0.17[a]	0.08 to 0.26	0.001	–1.34	–1.87 to –0.82	<0.001
OLST+pain at the moment	0.19[a]	0.10 to 0.28	<0.001	–1.39	–1.90 to –0.87	<0.001
OLST+muscle strength	–	–	–	–1.22	–1.75 to –0.68	<0.001
OLST+proprioception	0.21	0.11 to 0.30	<0.001	–	–	–
OLST+laxity	0.20[a]	0.11 to 0.29	<0.001	–1.34	–1.86 to –0.83	<0.001
OLST+ROM active flexion	0.17[a]	0.08 to 0.26	0.001	–1.32	–1.84 to –0.80	<0.001
Fully adjusted model, OLST	0.10[b]	0.02 to 0.19	0.02	–1.05[c]	–1.57 to –0.53	<0.001

Linear regression analysis using One-Leg Stand Test (OLST) index leg as independent factor, and muscle strength and proprioception as dependent variables. Adjusted model for factors affecting the crude coefficient 10% or more. Fully adjusted model for factors affecting the crude coefficient 10% or more.

[a]Factor affects the coefficient 10% or more; [b]Adjusted for body mass index (BMI), pain at the moment, laxity and range of motion (ROM) active flexion; [c]Adjusted for age.

b: regression coefficient; CI: confidence interval.

0.57, $p=0.04$). After the addition of one possible confounder at the time to the crude model, BMI, pain, muscle strength and ROM active flexion were identified as relevant confounders (i.e. greater than 10% change in the crude model regression coefficient for the OLST). Self-reported knee instability was no longer associated with postural control measured with the OLST (OR 0.77, $p=0.38$), after adjustment for relevant confounders.

Association between postural control and activity limitations. Table IV shows the crude and adjusted association of the OLST with the GUG, the time walking up-down stairs and WOMAC-PF. Completion of the OLST (better postural control) was significantly associated with less time (s) performing the GUG test (crude $b=-2.67$, $p<0.001$) and less time walking up-down stairs (crude $b=-7.86$, $p<0.001$), and with lower WOMAC-PF score (crude $b=-5.46$, $p<0.001$). After the addition of 1 possible confounder at the time to the crude model, BMI, pain, muscle strength, laxity and ROM active flexion were identified as relevant confounders (i.e. greater than 10% change in the crude model regression coefficient for the OLST). In the fully adjusted models, adjusted for all the relevant confounders, better postural control was still strongly associated with less time performing the GUG ($b=-1.32$, $p<0.001$) and walking up-down stairs ($b=-3.13$, $p<0.001$) tests, while the association with lower WOMAC-PF score was no longer significant ($b=-0.51$, $p=0.69$).

Table III. *Association between postural-control and self-reported knee instability*

	Self-reported knee instability		
	OR	95% CI	*p*-value
Crude model, OLST	0.57	0.34 to 0.96	0.04
Adjusted models			
OLST+BMI	0.63	0.37 to 1.09	0.10
OLST+pain at the moment	0.65	0.38 to 1.11	0.12
OLST+muscle strength	0.69	0.40 to 1.20	0.19
OLST+ROM active flexion	0.65	0.37 to 1.12	0.12
Fully adjusted model, OLST[a]	0.77	0.43 to 1.37	0.38

Logistic regression analysis (index knee) using OLST (One-Leg Stand Test) as independent factor and self-reported knee instability as dependent variable. Adjusted models for factors affecting the crude coefficient 10% or more. Fully adjusted model for factors affecting the crude coefficient 10% or more.

[a]Adjusted for body mass index (BMI), pain at the moment, muscle strength and range of motion (ROM) active flexion.

OR: odd ratio; CI: confidence interval.

DISCUSSION

This study investigated the association of postural control with muscle strength, proprioception, self-reported knee instability and activity limitations in a group of patients with knee OA. More than half (51%) of the patients studied had decreased postural control (i.e. did not complete the OLST). Concerning the hypothesis that neuromuscular disorders and knee instability contribute to decreased postural control, we indeed found that muscle weakness and proprioceptive inaccuracy were associated with decreased postural control. However, self-reported knee instability was not associated with decreased postural control after adjustment for relevant confounders. We also hypothesized that decreased postural control may lead to activity limitations. The results of the present study showed an association between decreased postural control and performance-based activity limitations in this group of patients, but not between decreased postural control and self-reported activity limitations. The found associations of postural control with neuromuscular factors and activity limitations imply that postural control may represent an important and complementary target for assessment and treatment in patients with knee OA. In addition, this study suggests that the OLST may be used as practical clinical test to easily assess postural control in this group of patients.

Muscle weakness and proprioceptive inaccuracy were highly associated with decreased postural control. This finding supports the results of previous studies, which found an association between those neuromuscular factors and postural control in patients with knee OA (12, 13). The interaction between muscle weakness and proprioceptive inaccuracy may affect postural control. Patients with

Table IV. *Association between postrual- control and activity limitations*

	GUG Test (s)			Walking up-down stairs (s)			WOMAC-PF score (0–68)		
	b	95% CI	*p*-value	*b*	95% CI	*p*-value	*b*	95% CI	*p*-value
Crude model, OLST	–2.67	–3.38 to –1.97	<0.001	–7.86	–10.32, –5.40	<0.001	–5.46	–8.42, –2.50	<0.001
Adjusted models									
OLST+BMI	–2.01	–2.68 to –1.34	< 0.001	–5.96	–8.38 to –3.55	<0.001	–3.34	–6.27 to –0.40	0.03
OLST+pain at the moment	–2.36	–3.04 to –1.67	< 0.001	–7.16[a]	–9.68 to –4.69	<0.001	–2.90	–5.32 to –0.47	0.02
OLST+muscle strength	–1.66	–2.27 to –1.05	<0.001	–5.36	–7.36 to –3.37	<0.001	–2.51	–5.40 to 0.39	0.09
OLST+laxity	–2.41[a]	–3.09 to –1.73	<0.001	–6.26	–8.12 to –4.41	<0.001	–4.93	–7.96 to –1.90	0.002
OLST+ROM active flexion	–2.13	–2.81 to –1.44	<0.001	–4.84	–6.97 to –2.72	<0.001	–3.78	–6.74 to –0.82	0.01
Fully adjusted model, OLST	–1.32[b]	–1.91 to –0.73	<0.001	–3.13[c]	–4.74 to –1.53	<0.001	–0.51[d]	–2.98 to 1.97	0.69

Linear regression analysis using One-Leg Stand Test (OLST) index leg as independent factor and Get Up and Go test (GUG), time walking up and down a lap of 12 stairs and Western Ontario and McMaster University Osteoarthritis Index – Physical Function subscale (WOMAC-PF) as dependent variables. Adjusted model for factors affecting the crude coefficient 10% or more. Fully adjusted model for factors affecting the crude coefficient 10% or more.

[a]Factor does not affect the coefficient 10% or more; [b]Adjusted for BMI, pain at the moment, muscle strength and ROM active flexion; [c]Adjusted for BMI, muscle strength, laxity and ROM active flexion; [d]Adjusted for BMI, pain at the moment, muscle strength, laxity and ROM active flexion. *b*: regression coefficient; CI: confidence interval; BMI: body mass index; ROM: range of motion.

muscle weakness may have less muscle mass, incomplete muscle activation, decreased muscle spindle sensitivity, and fewer sensory units (i.e. reduction in the number of mechanoreceptors), which might affect proprioceptive accuracy (14, 39–41).

Self-reported knee instability was not associated with decreased postural control, after controlling for relevant confounders. In contrast, a previous study found that knee instability was related to decreased postural control in patients with OA (10). This inconsistency may be due to differences in measurements, analyses and the number of patients. Using objective postural control measurements to analyse the association with knee instability in both studies, the difference in the results might be explained by the objective knee instability measurement (3D knee joint acceleration) used in the previous study compared with the subjective measurement (self-reported knee instability) used in our study. Moreover, the previous study controlled the outcome only for BMI, while the present study controlled the crude model for a number of relevant confounders (i.e. BMI, pain, muscle strength and ROM active flexion). These results suggest that the association between self-reported knee instability and postural control is influenced by additional factors. Finally, the previous study analysed data from a smaller group ($n=20$) compared with the larger population of this study ($n=284$).

In this study, it was found that patients with decreased postural control have greater activity limitations. This finding is consistent with previous studies, which also showed associations between postural control and activity limitations in patients with knee OA (14, 15). However, after adjusting for relevant confounders the associations with postural control were significant only for performance-based activity limitation, and not for self-reported activity limitations (WOMAC-PF). This might be due to the influence of additional psychosocial factors potentially involved in a self-reported measure such as WOMAC-PF.

We hypothesized that muscle weakness, proprioceptive inaccuracy and knee instability might contribute to decreased postural control, and that decreased postural control may lead to activity limitations. However, the cross-sectional design of the present study can only show that associations exist, but not establish the causality underlying them. Longitudinal studies are required in order to confirm our hypotheses. A key strength of our study is the use of the OLST as an evaluation tool, as this represents a simple clinical test to assess postural control in patients with knee OA. Another strength of this study is the large number of patients with knee OA studied compared with most of the previous studies of postural control in this group of patients (3, 4, 11, 15).

From a clinical perspective, our results suggest that improvement in muscle strength and proprioceptive accuracy achieved through training may result in an improvement in postural control. Thus, improvement in postural control, secondary to improvements in neuromuscular factors and postural control training *per se*, may lead to a reduction in activity limitations in patients with knee OA. Nevertheless, further intervention research is needed to confirm this.

In conclusion, in patients with knee OA, decreased postural control is associated with muscle weakness, proprioceptive inaccuracy and performance-based activity limitations. The results of this study suggest that the assessment and training of postural control should be included in the care of this group of patients.

ACKNOWLEDGEMENTS

The authors would like to thank the patients for their participation in the study. This study was funded by the European Commission, through the Erasmus Mundus Joint Doctorate Move-age programme. The study sponsor had no involvement in the study.

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