

Can Stimulating Massage Improve Joint Repositioning Error in Patients with Knee Osteoarthritis?

Hans Lund,¹ Marius Henriksen,² Else M. Bartels,² Bente Danneskiold-Samsøe,² Henning Bliddal^F

¹Institute for Sports Science and Clinical Biomechanics, University of Southern Denmark, Odense, Denmark

²The Parker Institute, Frederiksberg Hospital, Denmark

ABSTRACT

Purpose: The purpose of this study was to investigate the effect of massage applied to the thigh muscles on joint repositioning error (JRE) in patients suffering from osteoarthritis (OA). We hypothesized that stimulating massage of the muscles around an osteoarthritic knee joint, could improve the neuromuscular function and thereby optimize the positive and minimize the negative performance factors in relation to an exercise program.

Methods: In a cross-over design, 19 patients with knee osteoarthritis, mean age of 73.1 years (SD: 9.4; range 56 to 88 years), recruited from the local department of rheumatology, were randomly allocated to either receive massage and a week later, act as controls or vice versa. The applied massage consisted of stimulating massage of the quadriceps femoris, sartorius, gracilis, and hamstrings muscles for 10 min on the affected leg. Participants had their JRE measured before and immediately after the 10 min massage and control sessions. Data were analyzed by using paired t-test. **Results:** No significant change in JRE was observed (95% CI: -0.62° to 0.85° , $p=0.738$). **Conclusion:** Massage has no effect on the immediate joint repositioning error in patients with knee osteoarthritis, ie, if an improved JRE is important for improving the performance factors when exercising, stimulating massage may not be recommendable to use.

Key Words: osteoarthritis, massage, knee joint, proprioception, joint repositioning error, joint position sense

INTRODUCTION

Osteoarthritis (OA) is the most common type of arthritis and the major reason for chronic pain and disability among aging adults worldwide.¹ Knee and hip pain are the major causes of difficulty in climbing stairs and walking in the aging adults in the United States and in Europe, and as many as 40% of people over the age of 65 in the United Kingdom suffer symptoms associated with knee or hip OA.^{2,3} Recent findings indicate that the etiology and progression of OA may not be the result of changes in a single tissue, such as cartilage, but due to disease in any of the tissues of the affected joint, including the subchondral bone, synovium, capsule, periarticular muscles, and sensory nerve endings.⁴ Compared to healthy subjects, patients with knee OA have a poorer sense of joint position and

a higher threshold for detection of a passive movement (ie, a reduced proprioceptive function of the affected joint).⁵⁻⁸ The decrease in proprioception may contribute to increased load on the knee joint when walking, increased laxity of the joint, and higher energy demand during walking, which when combined reduce walking speed.⁹⁻¹¹ Decrements in proprioception could also contribute to impaired decreased postural control, which increases the risk of falling.^{12,13}

Several studies have demonstrated that decreased muscle function (especially of quadriceps femoris) is a more important determinant of pain and discomfort than the radiological alterations of the knee.¹⁴⁻¹⁹ Exercise is shown to be effective in both decreasing pain and improve function for patients with OA of the knee.^{20,21} When initiating exercise, both positive performance factors (eg, healthy muscle and connective tissue and normal range of motion) and negative performance factors (eg, pain, joint malalignment, restricted range of motion, and decrements in muscle performance) have impact on compliance and effect of exercise.²² Therapeutic interventions targeting muscles, such as massage, could therefore be a recommendable addition to an exercise treatment.

Not all patients with knee OA benefit from an exercise program, as the knee joint can be exposed to potential harmful loads if the joint is dynamically unstable (unstable due to lack of adequate muscle recruitment during movement) and/or malaligned.²³ One reason for the dynamic instability may be arthritis-related impairment of proprioception during exercise.²⁴ Impaired proprioception have been demonstrated in both aging adults and in subjects with OA of the knee.^{5-8,25-28}

In sports medicine, massage is often used to improve performance, with the goals of optimizing positive performance factors and minimizing negative performance factors, although little clear evidence for efficacy of massage for this purpose has been found.²² Two studies did not find any effect of massage on performance, however, both involved healthy young subjects with a small possibility of improvement in function.^{29,30} Recently, a study on subjects with knee OA demonstrated improvement in level of pain and stiffness, range of motion, and walking time following massage.³¹ In addition, studies on the neuromuscular effect of massage indicate that the reduced neuromuscular excitability (measured by changes in the Hoffmann Reflex) might originate from muscle or other deep tissue mechanoreceptors.^{22,32} Other kind of physical therapy interventions such as stretching³³ and specific proprioceptive exercise³⁴ have shown positive effect on joint position sense, while another study did not find any effect of stretching.³⁵ The gentle Swedish massage techniques (stroking, effleurage, petrissage) used in most of the studies may not have been intense enough to stimulate the muscle and deep tissue mechanoreceptors. Application of these techniques more forcefully, along with the addition of more powerful techniques such as patting, chopping and tapotements, might provide afferent input sufficient to stimulate mechanoreceptors, resulting

Address correspondence to: Hans Lund, Institute of Sports Science and Clinical Biomechanics, University of Southern Denmark, Campusvej 55, DK-5230 Odense M, DENMARK +45 65 50 34 49, +45 25 72 11 25 (mobile) (hlund@health.sdu.dk).

in a higher level of proprioceptive attention to the massaged muscles. Hence, manual massage could be divided into 2 different categories, relaxing techniques using constant pressure, rhythmical strokes and applied with low frequency (0.5 Hz), or stimulating techniques, using high frequencies, nonrhythmical strokes, and constant changes in pressure.

We hypothesized that by applying stimulating massage on the muscles around the knee, we could improve the neuromuscular function. As the first step, we would like to know whether stimulating massage would improve joint position sense that may be compromised in patients with OA of the knee OA,^{5,8} similar to the effect seen in young healthy subjects.³⁶

MATERIAL AND METHODS

Subjects

Nineteen patients with symptomatic knee joint osteoarthritis were recruited from the local department of rheumatology by a random selection from the list of patients connected to the department. Eligibility criteria for participation in the study were those of the American College of Rheumatology (ACR) clinical diagnostic criteria.³⁷ All subjects had pain in one or both knees and met at least 3 of the following criteria: age above 50 years, morning stiffness lasting less than 30 minutes, crepitus on passive joint movement, joint space tenderness, presence of palpable osteophytes, and/or absence of palpable warmth corresponding to the synovial membrane. Patients were excluded from participation if they have had knee joint surgery during the last 10 years, had any major diseases affecting the lower extremity, had skin ulcers on the thigh, or had diabetes.

Sixteen women and 3 men, mean age of 73.1 years (S.D 9.4 years, range 56 to 88 years) were included in the study sample. Because pain medication might influence results of the position sense test, subjects were asked to abstain from any pain relieving medication 24 hours before each measurement. Each subject signed an informed consent before participating in the study. The procedures followed in this study were in accordance with the ethical standards of the Scientific-Ethical Committee for Copenhagen and Frederiksberg (KF 01-129/02) and with the Helsinki Declaration of 1975, as revised in 1983.

Study Design

The study was designed as a randomized crossover study, where each subject served as his or her own control, in order to minimize the number of subjects required for planned analyses. The sequence of either massage or control was randomized, with a washout period of 7 days between testing. The 7-day period between testing sessions insured that the effect of massage, estimated to last 1 to 2 days, would have no impact on subsequent control measurements, and because this period was practical for both testers and subjects.

Joint repositioning error (JRE) of the right leg was measured before and immediately after receiving either 10 minutes of stimulating massage to the thigh of the most affected leg (intervention) or 10 minutes of rest (control). With this protocol all 19 subjects were examined both as controls and as subjects exposed to massage. A trained observer, blinded to the type of intervention each subject received, collected the data. Participants wore a pair of loose-fitting long pants at every JRE measurement in order to mask changes in skin color following

massage. The massage and JRE recordings were carried out on the same massage bench.

Determination of Joint Repositioning Error

Subjects were positioned in prone on the massage bench (Figure 1), and blindfolded to avoid possible influence of visual clues during measurement. A foam rubber wedge was placed under the thigh to allow free movement of the patella during knee flexion/extension. The lower legs were placed on a cylinder-shaped cushion, which gave a resting position of approximately 15° of flexion in the knees. When subjects were comfortably and correctly positioned, 2 straps were placed around their trunk secured to the bench to minimize position change during testing.

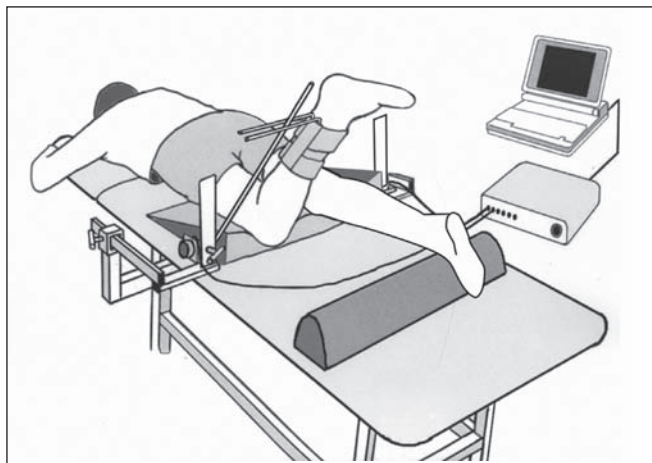


Figure 1. Illustration of the experimental set-up. A light-weight leveler arm connects the electrogoniometer and the “fork” placed on the lateral malleolus in a soft cuff. The knees rest on a wedge-shaped foam rubber pillow to allow free movement of the patella. The goniometers are carefully placed over the flexion-extension axis of the knee joint. The cylinder shaped cushion under the feet ensures a resting position of 15° of knee flexion.

An electrogoniometer (Ergotest Technology A/S, Norway, range 15°-320°) was placed at the lateral face of each knee joint (without touching the knee) with its axis positioned to match the flexion/extension axis of the knee joint. This position was verified prior to each test. The goniometer was extended by a light aluminum arm to a 10-cm fork, which was placed in a soft Velcro cuff fixed to each ankle at the lateral malleolus thereby avoiding contact with the knee joint or leg. This set up insured that any movement of the lower leg in the frontal plane would not influence measurement; such that slight sideways movements due to hip rotation would not affect knee joint angle.

In order to match the axis of the goniometer with the flexion/extension axis of the knee, a sticker was placed on the arm at fork level when the lower leg was in resting position. If the sticker and the fork were aligned during a test flexion of the knee, the axes were defined as matching. If not, the position of the subjects and/or goniometer was adjusted until alignment was achieved. After positioning was verified, the participant was allowed to try the procedure 2 or 3 times, to become familiar with the procedure. Following this, the entire set-up was re-

calibrated. The position of the goniometer was registered via the data collector onto a monitor as a numerical angle and a figure.

Angle measurements were sampled for 2 seconds at 100 Hz, and all data were converted from analogue to digital signals and recorded via MuscleLab™ (Ergotest Technology A/S, Norway, 10 bit A/D converter, sampling frequency: 100 Hz) ³⁸ and stored on the computer (IBM PC 300PL, Windows 1998). The goniometer was calibrated daily prior to each session, using carpenters level.

The subject was asked to flex his or her knee to a randomly chosen angle between 40° and 80° of knee flexion. The subject was instructed to hold the position while the joint angle was recorded. This measurement served as 'target angle.' Following this, the subject was asked to return the leg to the resting position. After a 2 to 3 second rest, the subject was asked to flex the knee to the previously held position and notify the observer when he or she felt that the 'target angle' had been replicated. The position was then recorded, again for 2 seconds, as the 'estimated angle.' The whole procedure was repeated 3 times. A recording was repeated if the legs touched each other during movement or recording, the aluminum arm fell out of the fork, or the leg and goniometer arm came into contact. Joint repositioning error was expressed as an absolute error (AE). Absolute error is the mean difference between the 'target angles' and a patient's 'estimated angles,' ignoring the direction of the error. The AE presented is the mean of the 3 repeated measurements.

Intra-rater reliability of the JRE method was tested comparing the baseline data from the 2 sessions, and an acceptable reliability was found (ICC(2.1)[average measure]:0.663).

Intervention

During the intervention arm of the study, subjects received 10 min of vigorous stimulating massage of the quadriceps, sartorius, gracilis, semimembranosus, semitendinosus and biceps femoris muscles. A physiotherapist specially trained for this study provided massage for all subjects. For massage, subjects were positioned in supine with approximately 45° of knee flexion, 45° of hip flexion, and between 40° and 60° of external hip rotation, depending on technique, for the massage intervention. The massage consisted of 5 different techniques that were changed every 30 seconds. The massage was given twice in a set sequence (kneading, tapotements, vibration and petrissage) to anterior thigh muscles for the initial 2.5 minutes, and to posterior thigh muscles for the remaining 2.5 minutes of the intervention session (Table 1). The force used during all of the massage sessions was intended to stimulate, and so was greater than forces typically used in relaxing massage, in order to effectively stimulate mechanoreceptors.

Kneading was performed double-handed. The muscles of the thigh were lifted with both hands and kneaded with one hand against the other. No gliding of the hands on the skin occurred during kneading; with kneading motions applied rapidly and nonrhythmically (2-5 Hz) in a semicircular motion of varying, more than gentle force. Tapotements included chopping and patting techniques. During chopping, the therapist's hands were positioned with palms facing each other, and a series of small alternating chops with hypothenar eminences were provided. Patting was also performed with both hands, using cupped palms to stroke the thigh with rapidly applied,

Table 1. Description of the Massage Procedure

Time (s)	Technique	Application area
0-30	Kneading	Anterior thigh
30-60	Chopping	Anterior thigh
60-90	Patting	Anterior thigh
90-120	Vibrations	Anterior thigh
120-150	Petrissage	Anterior thigh
150-180	Kneading	Posterior thigh
180-210	Chopping	Posterior thigh
210-240	Patting	Posterior thigh
240-270	Vibrations	Posterior thigh
270-300	Petrissage	Posterior thigh

The sequence was repeated in entirety for another 300 seconds (5 minutes), for a total of 600 seconds (10 minutes) of stimulating massage.

nonrhythmical (2-10 Hz) pats of varying force. For vibration, the therapist grasped subject's thigh with both hands, and muscles were vibrated in a semicircular manner around the femur. The vibrations were performed very rapidly, nonrhythmically (5-10 Hz), and with varying force. Petrissage was performed single- or double-handed, depending on muscle mass and size. The therapist's hands grasped the muscle tissue with somewhat straight fingers, pulled or pushed the tissue and then released the tissue again. Petrissage was performed rapidly nonrhythmically (5-10 Hz) and with varying force above the gentle level. The pressure applied and the rate and rhythm of application during the massage correspond to that used in clinical physical therapy practice.

Statistical Analysis

Absolute error (AE) was calculated as the mean difference between the 'target' and 'estimated angles' of the 3 repeated measurements. A paired t-test ($\alpha=0.05$) was used to evaluate AE before and after massage intervention sessions. Another paired t-test evaluated AE in measures taken prior to and at the end of control sessions. An un-paired t-test was used to evaluate the differences in proprioception between control and intervention sessions.

Effect size (ES) was calculated using the formula:

$$ES = (\Delta\text{Massage} - \Delta\text{Control}) / SD$$

where $\Delta\text{Massage}$ is the difference between AE before and after massage, $\Delta\text{control}$ is the difference between AE before and after control, and SD is the standard deviation of the control baseline results. To test for a possible influence of the massage given in the first session on the second session an unpaired t-test was used to evaluate differences in AE between those receiving massage in the first session and those receiving massage in the second session.

SPSS 13.0 for Windows (Wacker Drive, Chicago, Illinois) was used for these calculations.

RESULTS

Subject characteristics are presented in Table 2. A post hoc power analysis indicated that we needed 13 participants in order to detect a difference of 2° (minimal detectable change)⁸ between control and massage (SD of the difference between before and after control: 2.6°, $\alpha = 0.05$ and $\beta = 0.20$).

The Absolute Error (AE) of JRE is presented in Table 3. No significant difference between mean AE before control and before massage in first sessions versus second sessions was observed, indicating the groups had the same baseline prior to intervention ($p=0.29$). No significant difference in AE was observed before and after massage and control sessions. No significant difference was found between the differences between before and after the control sessions compared to the difference before and after the massage intervention (Effect size: 0.05, Table 3).

DISCUSSION

Even though osteoarthritis is defined as a joint disease,⁴⁵ the muscles connected to the affected joint are also involved.⁴ Adequate proprioception is an important contributor to function in individuals with OA of the knee. Because the primary sources for joint reposition error (JRE) are muscle spindle and mechanoreceptors,³⁹⁻⁴¹ we hypothesized that stimulating massage of the muscles would enhance knee joint proprioception, and thus improve function. This hypothesis is supported by studies describing reduced H-reflex activity after massage, indicating an inhibition on the motor neuron activity.^{32, 42} Two different intensities of massage resulted in a dose-dependent decrease in motor neuron excitability⁴³ and manual massage influenced the reflex activity in patients with spinal cord injury.⁴⁴ These studies suggest that manual massage does affect the mechanoreceptors within the region; and support the assumption that the JRE could be also be affected.

Whatever the effect of stimulating massage on the spindles or cutaneous receptors may be, the position sense of the knee joint in our subject was not altered following massage intervention. These findings were surprising, as we previously have demonstrated that an identical stimulating massage improved joint reposition accuracy in healthy subjects.³⁶

Our primary research question was whether massage would have any effect on knee proprioception. We selected JRE as an indicator or proprioceptive function. This method tests only one component of the proprioceptive system.⁴⁶ Other techniques that provide information about other dimensions of proprioception may have been more sensitive indicators of the

effect of stimulating massage. In a study that compared JRE to detection threshold of passive movement (TDPM), no correlations between JRE and TDPM were found, indicating that JRE and TDPM measure different dimensions of proprioception.⁴⁶ If JRE is not sufficiently sensitive to identify possible effects of massage on proprioception, it might be more informative to use TDPM to evaluate pre- and postintervention differences following stimulating massage. Further support for this idea is a study conducted in our laboratory where we found no significant difference between a control group and a group of patients with knee OA in relation to JRE, but a highly significant difference in TDPM between the OA and the control group, indicating impaired knee-joint proprioception in knee OA patients.⁴⁷ The minimal detectable change found in that study was higher for JRE compared to TDPM and the variation lower, ie, JRE was 5.01° (SE: 0.92°) and for TDPM 2.41° (SE: 0.20°).⁴⁷ Given these findings, possible effects (if any) of massage on proprioception would be more easily identified using TDPM. If any intervention aiming at improving proprioception is to have clinical relevance, the effects should be of a magnitude that test methods with low resolution (such as JRE) would be able to detect.

Standardization of the intervention was difficult due to the way stimulating massage was applied. We standardized our intervention to the greatest degree possible by using a defined technical performance and equal distribution of the duration of each technique. The therapist practiced the massage protocol daily in the weeks preceding the study, and no more than 3 patients per day received massage to ensure that fatigue did not influence consistency of the therapist's performance. This was in accordance with Cawley et al⁴⁸ who suggested similar standardization be performed to enable comparisons between different massage treatment protocols.

Exercise as a treatment option for knee OA is beneficial in many ways, but not all aging adults with knee OA may tolerate exercise, due to the potentially harmful loads, if the joint is dynamically unstable and/or malaligned.²³ By improving proprioception immediately before an exercise program by means of simple physical interventions, the risk of inflicting harmful loads may be reduced. While the effect of massage is transient, an earlier study indicated that massage could be a valuable tool as a preparation to exercise.³⁶ The results of this present study do not support the notion that massage is effective as a physical intervention to improve proprioception.

The included participants was randomly selected from a list of patients connected to the local department of rheumatology and by comparing the age and gender distribution with other studies, our group seems to represent a general population of aging adults with knee OA.

Possible limitations of this study could be the choice of measurement for testing proprioception, and that we may have

Table 2. Characteristics of the Participants

Female Gender, n(%)	16 (84.2%)
Age in years, mean (SD)	73.1 (9.4)
Height in cm, mean (SD)	167.1 (7.5)
Weight in kg, mean (SD)	68.5 (12.0)
Duration of knee osteoarthritis, in years, mean (SD)	13.9 (11.4)
Participants with bilateral knee osteoarthritis, n(%)	14 (74)
Knee pain at baseline, in mm on VAS, mean (SD)	27.9 (26.7)

Table 3. Joint Repositioning Error Expressed as Absolute Error (AE) for 19 Subjects

Control Sessions				Intervention Sessions				Control-Intervention Difference	
Pretest mean (SE)	Posttest mean (SE)	P	95% CI pre-post difference	Pretest mean (SE)	Posttest mean (SE)	P	95% CI pre-post difference	P	Effect size
5.20° (0.58°)	5.30° (0.64°)	0.85	-1.25° to 1.04°	4.45° (0.36°)	5.08° (0.47°)	0.25	-1.73° to 0.48°	0.74	0.05

included participants with no limited proprioception, even though patients with knee OA often have decreased proprioception. In a future study we would recruit participants with a known decrease in proprioception and add other measures of proprioception such as TDPM.

CONCLUSION

Massage has been found to have no beneficial effect on sense of joint position, as measured by JRE, in patients with knee OA, with the clinical implications that pre-exercise stimulating massage may not be beneficial. However, future studies should evaluate whether massage or interventions alike, would be able to improve other aspects of proprioception, such as threshold to detection of passive movements.

ACKNOWLEDGMENTS

The authors wish to thank The Oak Foundation, Sygekassernes Helsefond and Danish Physiotherapist Practice foundation for financial support, physiotherapist students Søren Henriksen, Rikke M Pedersen and David del Castillo for assistance in carrying out the project, laboratory technician Inger Wätjen for assistance in test sessions and Arne Elkjær for the illustrations.

REFERENCES

1. Peat G, McCarney R, Croft P. Knee pain and osteoarthritis in older adults: a review of community burden and current use of primary health care. *Ann Rheum Dis*. 2001;60:91-97.
2. Dunlop DD, Manheim LM, Song J, Chang RW. Arthritis prevalence and activity limitations in older adults. *Arthritis Rheum*. 2001;44:212-221.
3. Dawson J, Linsell L, Zondervan K, et al. Epidemiology of hip and knee pain and its impact on overall health status in older adults. *Rheumatology (Oxford)*. 2004;43:497-504.
4. Brandt KD, Radin EL, Dieppe PA, van de PL. Yet more evidence that osteoarthritis is not a cartilage disease. *Ann Rheum Dis*. 2006;65:1261-1264.
5. Barrett DS, Cobb AG, Bentley G. Joint proprioception in normal, osteoarthritic and replaced knees. *J Bone Joint Surg*. 1991;73B:53-56.
6. Sharma L, Pai YC, Holtkamp K, Rymer WZ. Is knee joint proprioception worse in the arthritic knee versus the unaffected knee in unilateral knee osteoarthritis? *Arthritis Rheum*. 1997;40:1518-1525.
7. Koralewicz LM, Engh GA. Comparison of proprioception in arthritic and age-matched normal knees. *J Bone Joint Surg Am*. 2000;82-A:1582-1588.
8. Garsden LR, Bullock-Saxton JE. Joint reposition sense in subjects with unilateral osteoarthritis of the knee. *Clin Rehabil*. 1999;13:148-155.
9. Stauffer RN, Chao EY, Gyory AN. Biomechanical gait analysis of the diseased knee joint. *Clin Orthop Relat Res*. 1977:246-255.
10. Marks R, Percy JS, Semple J, Kumar S. Quadriceps femoris activation changes in genu varum: a possible biomechanical factor in the pathogenesis of osteoarthrosis. *J Theor Biol*. 1994;170:283-289.
11. Carpenter JE, Blasier RB, Pellizzon GG. The effects of muscle fatigue on shoulder joint position sense. *Am J Sports Med*. 1998;26:262-265.
12. Valeriani M, Restuccia D, DiLazzaro V, Franceschi F, Fabbriani C, Tonali P. Central nervous system modifications in patients with lesion of the anterior cruciate ligament of the knee. *Brain*. 1996;119:1751-1762.
13. Marks R. Exercise, joint position sense, and knee osteoarthritis. *NZ J Physiotherapy*. 2001;29:32-40.
14. Brandt KD, Heilman DK, Slemenda C, et al. A comparison of lower extremity muscle strength, obesity, and depression scores in elderly subjects with knee pain with and without radiographic evidence of knee osteoarthritis. *J Rheumatol*. 2000;27:1937-1946.
15. Van Baar ME, Dekker J, Lemmens JA, Oostendorp RA, Bijlsma JW. Pain and disability in patients with osteoarthritis of hip or knee: the relationship with articular, kinesiologic, and psychological characteristics. *J Rheumatol*. 1998;25:125-133.
16. Steultjens MP, Dekker J, Van Baar ME, Oostendorp RA, Bijlsma JW. Muscle strength, pain and disability in patients with osteoarthritis. *Clin Rehabil*. 2001;15:331-341.
17. Slemenda C, Brandt KD, Heilman DK, et al. Quadriceps weakness and osteoarthritis of the knee. *Ann Int Med*. 1997;127:97-104.
18. McAlindon TE, Cooper C, Kirwan JR, Dieppe PA. Determinants of disability in osteoarthritis of the knee. *Ann Rheum Dis*. 1993;52:258-262.
19. Hurley MV, Scott DL, Rees J, Newham DJ. Sensorimotor changes and functional performance in patients with knee osteoarthritis. *Ann Rheum Dis*. 1997;56:641-648.
20. Fransen M, McConnell S. Exercise for osteoarthritis of the knee. *Cochrane Database of Systematic Reviews 2008, Issue 4*. Art. No.: CD004376. DOI: 10.1002/14651858.CD004376.pub2.
21. Zhang W, Moskowitz RW, Nuki G, et al. OARSI recommendations for the management of hip and knee osteoarthritis, Part II: OARSI evidence-based, expert consensus guidelines. *Osteoarthritis Cartilage*. 2008;16:137-162.
22. Weerapong P, Hume PA, Kolt GS. The mechanisms of massage and effects on performance, muscle recovery and injury prevention. *Sports Med*. 2005;35:235-256.
23. Sharma L, Dunlop DD, Cahue S, Song J, Hayes KW. Quadriceps strength and osteoarthritis progression in malaligned and lax knees. *Ann Intern Med*. 2003;138:613-619.
24. Brandt KD. Neuromuscular aspects of osteoarthritis: a perspective. *Novartis Found Symp*. 2004;260:49-58.
25. Hurley MV, Rees J, Newham DJ. Quadriceps function, proprioceptive acuity and functional performance in healthy young, middle-aged and elderly subjects. *Age Ageing*. 1998;27:55-62.
26. Kaplan FS, Nixon JE, Reitz M, Rindfleisch L, Tucker J. Age-related changes in proprioception and sensation of joint position. *Acta Orthop Scand*. 1985;56:72-74.
27. Pai YC, Rymer WZ, Chang RW, Sharma L. Effect of age and osteoarthritis on knee proprioception. *Arthritis Rheum*. 1997;40:2260-2265.
28. Petrella RJ, Lattanzio PJ, Nelson MG. Effect of age and activity on knee joint proprioception. *Am J Phys Med Rehabil*. 1997;76:235-241.

29. Hunter AM, Watt JM, Watt V, Galloway SD. Effect of lower limb massage on electromyography and force production of the knee extensors. *Br J Sports Med.* 2006;40:114-118.
30. Barlow A, Clarke R, Johnson N, Seabourne B, Thomas D, Gal J. Effect of massage of the hamstring muscles on selected electromyographic characteristics of biceps femoris during sub-maximal isometric contraction. *Int J Sports Med.* 2007;28:253-256.
31. Perlman AI, Sabina A, Williams AL, Njike VY, Katz DL. Massage therapy for osteoarthritis of the knee: a randomized controlled trial. *Arch Intern Med.* 2006;166:2533-2538.
32. Morelli M, Seaborne DE, Sullivan SJ. H-reflex modulation during manual muscle massage of human triceps surae. *Arch Phys Med Rehabil.* 1991;72:915-919.
33. Ghaffarinejad F, Taghizadeh S, Mohammadi F. Effect of static stretching of muscles surrounding the knee on knee joint position sense. *Br J Sports Med.* 2007;41:684-687.
34. Jan MH, Tang PF, Lin JJ, Tseng SC, Lin YF, Lin DH. Efficacy of a target-matching foot-stepping exercise on proprioception and function in patients with knee osteoarthritis. *J Orthop Sports Phys Ther.* 2008;38:19-25.
35. Larsen R, Lund H, Christensen R, Rogind H, Danneskiold-Samsøe B, Bliddal H. Effect of static stretching of quadriceps and hamstring muscles on knee joint position sense. *Br J Sports Med.* 2005;39:43-46.
36. Henriksen M, Hojrup A, Lund H, Christensen L, Danneskiold-Samsøe B, Bliddal H. The Effects of Stimulating Massage of Quadriceps, Gracile, Sartorial and Hamstring muscles on Knee Joint Position Sense. Healthy Participants. *Adv Physiother.* 2004;6:29-36.
37. Altman R, Asch E, Bloch D, et al. Development of criteria for the classification and reporting of osteoarthritis - Classification of osteoarthritis of the knee. *Arthritis Rheum.* 1986;29:1039-1049.
38. Bosco C, Belli A, Astrua M, et al. A dynamometer for evaluation of dynamic muscle work. *Eur J Appl Physiol.* 1995;70:379-386.
39. Dekker J, Boot B, van der Woude LH, Bijlsma JW. Pain and disability in osteoarthritis: a review of biobehavioral mechanisms. *J Behav Med.* 1992;15:189-214.
40. McCloskey DI. Kinesthetic sensibility. *Physiol Rev.* 1978;58:763-820.
41. Matthews PB. Proprioceptors and their contribution to somatosensory mapping: complex messages require complex processing. *Can J Physiol Pharmacol.* 1988;66:430-438.
42. Sullivan SJ, Williams LRT, Seaborne DE, Morelli M. Effects of massage on alpha motoneuron excitability. *Phys Ther.* 1991;71:555-560.
43. Goldberg J, Sullivan SJ, Seaborne DE. The effect of two intensities of massage on H-reflex amplitude. *Phys Ther.* 1992;72:449-457.
44. Goldberg J, Seaborne DE, Sullivan SJ, Leduc BE. The effect of therapeutic massage on H-reflex amplitude in persons with a spinal cord injury. *Phys Ther.* 1994;74:728-737.
45. Poole AR, Howell DS, Moskowitz RW, et al. Etiopathogenesis of osteoarthritis. *Osteoarthritis - Diagnosis and Medical/Surgical Management.* 3rd ed. Philadelphia, PA: W.B. Saunders Company; 2001:29-47.
46. Grob KR, Kuster MS, Higgins SA, Lloyd DG, Yata H. Lack of correlation between different measurements of proprioception in the knee. *J Bone Joint Surg Br.* 2002;84:614-618.
47. Lund H, Juul-Kristensen B, Hansen K, et al. Movement detection impaired in patients with knee osteoarthritis compared to healthy controls: A cross-sectional case-control study. *J Musculoskelet Neuronal Interact.* 2008;8:391-400.
48. Cawley N. A critique of the methodology of research studies evaluating massage. *Eur J Cancer Care Engl.* 1997;6:23-31.

Become a Certified Exercise Expert for Aging Adults (CEEAA)

The Section on Geriatrics, believing that physical therapists are most qualified to design and provide exercise options for aging adults, across the wellness-frailty spectrum, offers a series of evidence-based courses leading to certification as an Exercise Expert for Aging Adults.

- | | |
|------------------|---|
| Course 1: | Introduction and Examination/
Tests and Measures |
| Course 2: | Exercise Prescription, Consensus
Guidelines |
| Course 3: | Special Populations,
Complementary Exercises,
Motivation, Drug and Nutritional
Considerations, Marketing |

Montgomery, AL

Course 1: March 28–29, 2009
Course 2: August 29–30, 2009
Course 3: October 17–18, 2009

San Marcos, CA

Course 1: July 18–19, 2009
Course 2: December 5–6, 2009
Course 3: CSM 2010

Montgomery, AL

Course 1: November 21–22, 2009
Course 2: April 10-11, 2010
Course 3: PT 2010

Courses provide formal didactic education, supervised and mentored skill development, followed by home-based reflection and critical thinking. Mastery is assessed by home-based examination (Courses 1-3) and onsite skills test for the content of the first 2 courses during Course 3.

For further information, visit <http://geriatricspt.org> or contact the Section on Geriatrics Office at geriatrics@apta.org.