The Effect of Single-Session Stimulating Massage on the Knee Joint Position Sense in Healthy Older Adult Men: A Randomized Crossover Trial

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Background: Proprioception is critical for older adults to maintain their balance and prevent falling. However, massage is a convenient intervention that its beneficial effect on the proprioception is suggested.

Purpose: This study aimed to determine whether one session of stimulating massage of the muscles around the knee joint improves position sense in older adult men.

Methods: Twenty healthy older adults participated in this blind, randomized, crossover trial. The two treatment phases were massage and rest. The washout period between interventions was a 1-week interval. The massage protocol was as follows: deep effleurage, petrissage, and tapotement for 5 minutes for the anterior (tensor fascia lata, quadriceps, sartorius, and gracilis) and posterior (hamstrings) muscles of the knee (10 minutes in total).

Results: Outcome measures were absolute, constant, and variable errors (AE, CE, and VE). Participants were assessed immediately before and after the intervention by a blinded investigator. Independent *t*-tests were used for statistical analyses. Massage reduced absolute error (2.77°, p = 0.01).

Conclusion: The finding of this study confirms the beneficial impact of the massage on the joint position sense in healthy older adult men.

KEYWORDS: Massage; position sense; older adults

INTRODUCTION

Falling is a common problem among older adults that causes injuries and fractures. Its prevalence was about 20% in 2015. In addition to disability and injury, falling terribly affects independence and the quality of life in older adults. Falling also leads to spending extra costs.[1] However, in older adults, the proprioception that is so important for balance is diminished and the risk of falling is enhanced.[2,3] Proprioception is one of the systems that is involved in providing standing balance. The better the balance, the better the performance and the lower the risk of falling. Similarly, the lower the equilibrium, the lower the performance and the greater the risk of falling.[4,5] Proprioception enables an individual to sense where the body is located in space and provides important sensory feedback to maintain standing balance. On the other hand, standing balance is critically dependent on the proprioception.[6] Many studies have shown the negative effects of aging on proprioception.[4,7,8] Since balance impairments are common in older adults and they are at high risk of falling, finding methods to improve proprioception in older adults, which is ultimately expected to improve their balance, is of utmost importance. Several studies indicated that proprioception can be affected positively through external manipulation.[9,10]

It is postulated that during the massage, sensory inputs are sent to the brain and that these afferents provide more connections between muscles and the nervous system

and that more connections introduce better performance;[11-13] in fact, following the massage an improvement in gait was reported.[14] According to the model suggested, motor responses are influenced by sensory inputs.[15] In other words, without proper sensory input, movement cannot be performed efficiently. Wolpert et al.[15] considered two types of sensory signals: sensory inputs from the environment and sensory inputs produced by movements. Although the origin of these two sensory signals is distinct, they have the same channels. Massage provides multiple sensory inputs through the skin, muscles, and joints. However, it should be noted that the effects of massage are not limited to the stimulation of proprioceptive receptors and mechanoreceptors. Massage also affects pain receptors and reducing pain also helps improve movement and balance.[16]

Nowadays, older adult population and life expectancy are increasing.[17,18] In addition, the risk of falling is enhanced with aging and simultaneously the proprioception which is critical for proper balance function is weakened.[4] Massage has been suggested to improve proprioception by providing sensory input. On the other hand, improved proprioception is expected to contribute to improved balance. Joint position sense (JPS) is a component of proprioception.[6] JPS is the measurable component of proprioception. JPS is evaluated by absolute (AE), constant (CE), and variable (VE) errors. AE indicates the accuracy of the joint repositioning error. AE is determined as the difference in absolute value in degrees between the position chosen by the subject and the test-position angle. CE is the difference between the chosen position and the test-position angle; the positive relative error (CE) indicates the overshooting and negative relative error indicates undershooting the test-position angle by the subject. VE is the standard deviation of the relative error in three repetitions.[19] The purpose of this study was to examine the immediate effect of massage on knee JPS in older adult men.

METHODS

Study Design

A randomized crossover study design was used to investigate the immediate effect of stimulating massage of the muscles around the knee of the preferred lower extremity on JPS in a group of older adult men. The two groups/phases were: (i) massage and (ii) rest. Participants were randomly allocated to a phase. Following completion of the first phase, participants were then reassigned to the other phase. A 1-week "washout period" occurred between the phases. In each session, outcome measures including AE, CE, and VE were calculated pre- and immediately post-test. Each session lasted 20 minutes.

Participants

Healthy older adult men were recruited through posters in parks around the research center. These recruitment announcements invited healthy older adult men (>65 years) to volunteer to participate in the current study.

Subjects were included if they were healthy older adult men i.e., they did not complain of any particular disease or problem and were asymptomatic and were able to walk independently at least 50 m.

Inclusion: The inclusion criteria were the capacity to understand the test procedure and perform the test and having a visual analogue scale of pain less than 3.

Exclusion: Subjects were excluded if they had received sedative drugs, manual or physical therapy in the last 4 weeks, or if they had fracture or surgery of the lower extremities in the past 3 months, or if there were open wounds in the lower extremities, or if they suffered from musculoskeletal complaints in the past 3 months. Participants were free to leave the study at any time.

Prior to commencing the study, the testing procedure was explained to all participants and all subjects signed the written consent to the study which was required by the local ethics committee. The Ethics Committee of Shahid Beheshti University of Medical Sciences approved the study protocol (IR.SBMU.RETECH.REC.1396.572).

Randomization

Each group was allocated a number from 1 to 2. The participants were randomly assigned to each group by selecting a number of a box. The participants who chose an odd number were assigned to group one (massage first session and rest second session) and the participants who

selected an even number were allocated to group two (rest first session and massage second session). Randomization occurred before the joint testing occurred.

Measurement Procedure

AE, CE, and VE were assessed for a knee extension angle of −65°. While the participant was sitting relaxed on the bed with the knee joint in 90° flexion, he was asked to extend his knee until he reached the target angle i.e., −65° knee extension. Measurements were performed by a single-camera and motion analyzer system. The test procedure was explained to the participant. The participant was asked to wear sports shorts and remove his shoes and socks so that the markers were visible. The measurements were performed in the sitting position. The participant was seated on the bed in such a way that the hip and knee were at 90° flexion. A folded towel was placed underneath the distal part of the femur to keep the alignment of the hip. Four circle markers with 3-cm diameters were applied to the lateral aspect of the preferred lower limb (the limb that was used to kick the ball) over the bony landmarks of long axes of the femur and the leg using double-sided tapes as follows: the head of the greater trochanter, lateral condyle of the femur, the head of the fibula, and the lateral malleolus.[20] A motion analyzer system (SIMI-GS108E v2, Germany), a Canon camera (Canon Basler ac A 640, Germany), four markers, a universal goniometer (model SAEHAN, Korea), a visual analogue scale (VAS) ruler, a scale, a meter, and a ball (to determine the preferred leg) were used to collect and record the data. A universal goniometer was used to check the joint angle presented by the motion analyzer system. Participants were asked to actively try to replicate the knee joint target angle with their eyes closed.

Reliability

The reliability of replication of the target knee joint angle by the motion analyzer system (SIMI-GS108E v2 made in Germany) in our study was assessed using the interclass correlation coefficient (ICC) with 95% confidence intervals (CIs). An ICC value of 0.00–0.20 is considered "poor," 0.21–0.40 "fair," 0.41–0.60 "moderate," 0.61–0.80 "substantial," and 0.81–1.00 "almost perfect."[21]

Interventions

Massage

Participants received 10 minutes of stimulating massage for the muscles surrounding the knee. Stimulating massage consisted of deep effleurage, tapotement, and palmar kneading, which were applied to all participants in the following order: deep effleurage, tapotement, petrissage, and deep effleurage. The massage was performed while the participant was in the supine position with an approximately 45° knee flexion, and a pillow was placed under the knee. The massage was started with 30 seconds of effleurage of the anterior surface of the knee up to the hip and back down. The rate of performing effleurage was two strokes per second. Moderate pressure was applied during the effleurage. In effleurage, hands applied a constant pressure to the tensor fascia lata, quadriceps, sartorius, and gracilis muscles.

Then, tapotement massage techniques including hacking and cupping were used in the same area for 1 minute (each technique for 30 seconds). In tapotement massage techniques, rhythmic percussions are applied rapidly to the body. After that, petrissage was applied for 3 minutes. In petrissage, intermittent pressure is applied to the body. Then, the participant received another effleurage for 30 seconds. In this way the anterior surface of the thigh received massage for 5 minutes. In order to apply these massage techniques with the same order and intensity to the hamstrings and parts of muscles on the medial or lateral side of the thigh that had not received adequate massage during the application of massage to the anterior surface of the thigh, the participant was placed in a side-lying position and the trunk was supported with a pillow. The anterior and posterior surfaces of the thigh received massage for equal periods of time. The therapist was careful that the intensity of techniques did not exceed the participant's pain threshold. The therapist adjusted the pressure of massage techniques when needed. The massage was performed for all participants by a physical therapist experienced in manual therapy; however, no other types of manual therapy techniques were allowed.

Rest

During the rest period, the participant lay comfortably for 10 minutes (same as the duration of the massage group). The

therapist did not talk to the participant, but if the participant had a question or a conversation, he could say it.

Power Analysis

A priori power analysis was conducted using SPSS for Windows, version 16.0 (SPSS Inc., Chicago, IL, USA) for sample size estimation, based on a post hoc power analysis from the study by Lund et al., 2009 (n = 19), which compared massage to rest to improve joint repositioning error. The effect size used in the study by Lund et al. was 2° with a standard deviation (SD) of 2.6°, considered to be the minimal detectable change. With a significance criterion of $\alpha = 0.05$ and power = 0.90, the minimum sample size needed with this effect size is 20 (10 in each group) based on there being no carryover or period effects and thus being able to undertake an independent *t*-test.

Statistical Analysis

Data were analyzed by PASWSPSS16. SPSS 16 is a statistical package for social sciences and was used for all statistical analyses

The *t*-test was used for statistical analysis. However, as the number of comparisons with the *t*-test increases the probability of a type 1 error, the Bonferroni method was used to counteract the multiple *t*-test comparison problem. To obtain the Bonferroni-corrected p-value, the original alpha value was divided by the number of dependent variable analyses. The original alpha value was considered to be 0.05, and the number of dependent variable analyses was 3 (AE, CE, and VE). Therefore, we would have: p-value (0.05/3) = 0.016. A new p-value of less than 0.016 was considered statistically significant. Pre- and post-test measurements from the control group were used to calculate the ICC, standard error of measurement (SEM), and minimal detectable change (MDC). ICC, SEM, and MDC were used to examine the reliability of the test.

The Shapiro–Wilk test was used to examine the normal distribution of data. If the p-value of the Shapiro–Wilk test was more than 0.05 ($p > 0.05$) in all cases, then this confirmed normal distribution of data and parametric statistical tests including independent *t*-tests could be used for statistical analyses.

RESULTS

Twenty-seven individuals were assessed for eligibility for the study. Seven were excluded, with five not meeting the eligibility criteria and two not being interested (see Figure 1). Twenty males consented to be part of the study and all 20 participated in two sessions and completed the study (Figure 2). The Shapiro–Wilk test confirmed normal distribution of the data ($p > 0.05$) in all cases.

Demographics: The average age of the participants was 67.62 years, and the average body mass index of the participants was 26.08 kg/m^2 (see Table 1). There was no significant difference between the two groups at the beginning of the study (baseline).

Crossover study design effects: Statistical analyses indicated that there were no period effects i.e., the order of receiving the interventions, massage first or rest first, did not affect the results. Testing also indicated that there was no carryover effect, with the carryover effect for AE, CE, and VE being 0.876, 0.904, and 0.229, respectively. Due to the non-significance of the carryover and period effects ($p > 0.05$), the order of massage and rest phases did not affect the results, so an independent *t*-test was used for statistical analysis.

Study Results (Between-Group Comparison)

The AE, CE, and VE were calculated before and immediately after each session. Following the massage, AE showed a significant decrease of 2.77 ($p = 0.01$) compared to the control group (rest) (Figure 2). No other significant changes were noticed between groups (Table 2). The p-value, as per the Bonferroni correction, was set to less than 0.016.

Reliability

This study showed very high test–retest reliability for ICC with 95% CIs of the motion analyzer system in healthy older adult men trying to replicate the target joint angle. The ICCs with 95% CI, SEMs, and MDC in 10 subjects before and after taking rest for 10 minutes are shown in Table 3.

DISCUSSION

This study investigated the immediate effects of stimulating massage of

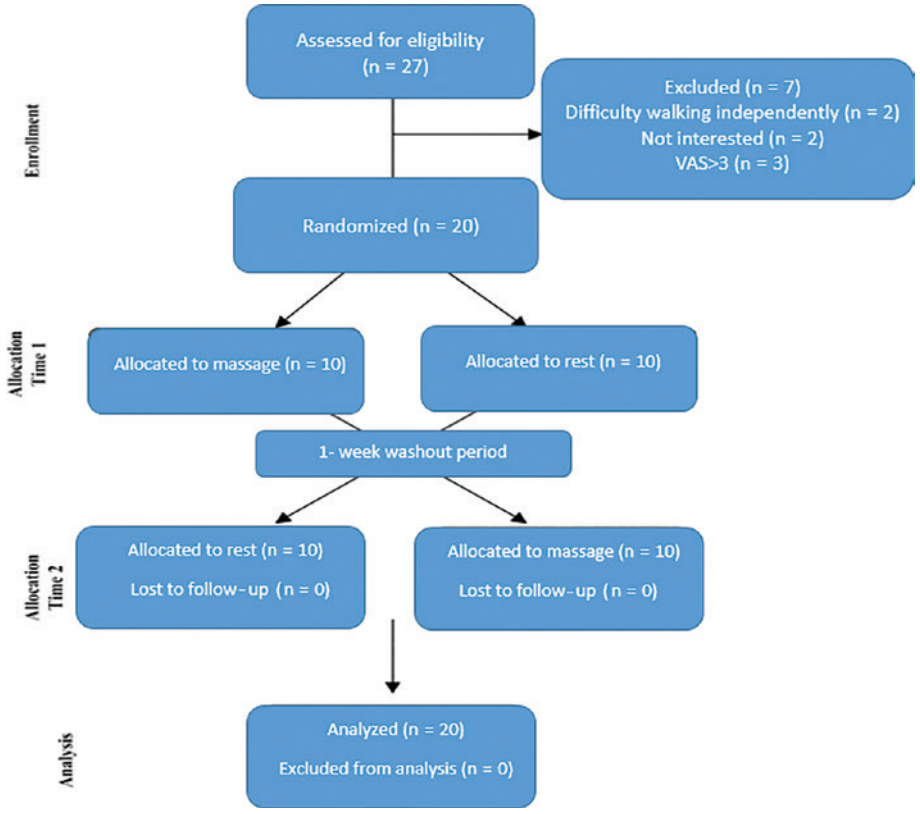

Figure 1. Test procedure flowchart.

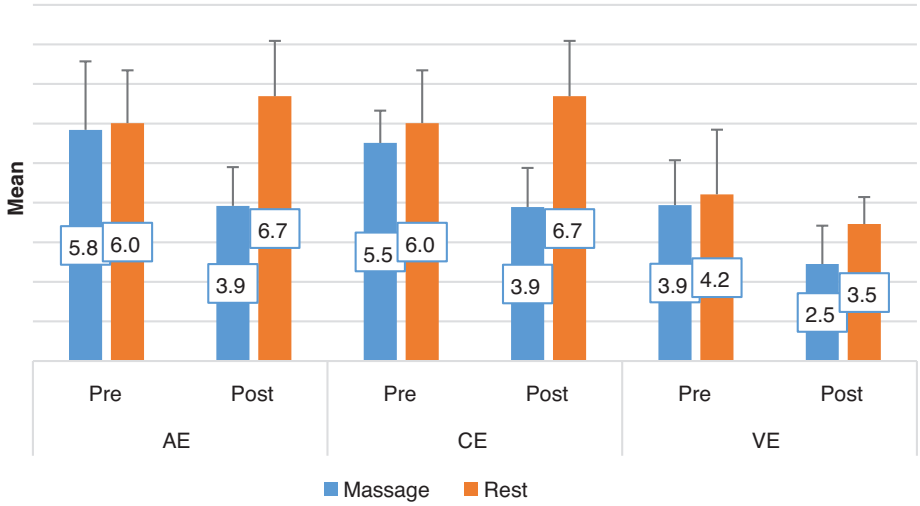

Figure 2. AE, CE, and VE in degrees in the massage and rest groups. A significant difference was observed in AE (p = 0.01).
Figure 2 shows that after receiving the massage, there is a trend to reduce all three types of errors (AE, CE, and VE) in the massage group. However, this error reduction was only significant for absolute error (AE). Meanwhile, no significant changes were noticed in the rest group.
This is an Excel chart and the lines have no special meaning (only for display).

the muscles around the knee on JPS and showed that stimulating massage applied to the muscles around the knee improved knee JPS and AE in a group of healthy older adult men compared to rest. Proprioception is weakened in older adults.[3,22] Therefore, older adults need to receive more information to compensate

for weak proprioception and to perform a task more accurately. It is possible that the participants in our study tried to acquire more sensory information from the moving parts and receptors by performing the knee movement in a greater range of motion in order to be able to adjust the task of replication of the knee target angle and consequently, they overshot the target angle. The study did not find a significant difference in CE and we postulate that this might be due to the capacity of massage to improve proprioception regardless of the error vector. Further research could investigate if massage has greater efficacy related to the vector i.e., undershooting or overshooting the target.

The result of the present study aligns with previous research that shows a beneficial effect of massage on JPS.[12,23,24] While massage has shown to be beneficial in previous studies, not all studies have investigated older individuals. Henriksen et al.,[12] and Shin and Sung[23] investigated the effect of massage on young people. The benefits of a reduced AE and improved proprioception in different age groups have different outcomes with older cohorts potentially decreasing their risk of fall with increased proprioception, whereas a younger cohort could see improvements in sporting/athletic performance and/or improvements or restoration of sensorimotor function.[25] A number of previous studies on older adults provided a combined treatment intervention (massage and ankle mobilization) and found the treatment group had better postural control than those who did not receive this intervention.[19,26] A limitation of the combined treatment is that the massage-specific effect was not able to be determined. Our findings provide some evidence of the "massage" effect and suggest that massage alone, in male older adults, can improve the sense of knee joint position. This is important as it implies that the sense of touch (massage) can be impactful, as evidenced in studies with younger participants and that aging does not appear to impact the effectiveness of massage for improving JPS.

Despite the many positive research findings for massage and the sense of joint position, not all research studies find beneficial evidence of massage. Lund[27] reported that massage had no beneficial effects on proprioception in older adults with knee osteoarthritis (OA). The massage techniques used in this study i.e., squeezing, lifting, or beating the soft tissues such as the skin, fascia, ligaments, and muscles may affect the multiple receptors found in these structures, which monitor changes in muscle length, muscle tension, and pressure distribution and contribute to the body's development of proprioception.[19] Arthritis is a disease that causes irreversible degenerative changes to the articular cartilage of the knee which can affect proprioception. We postulate that OA, and the degenerative changes that occur with it, might disrupt the activation of multiple receptors found in the skin, fascia, ligaments, and muscle and therefore

TABLE 1. Demographic Characteristics of Participants (n = 20)

Variable	*Mean*	*SD*	*Minimum*	*Maximum*
Age (year)	67.26	3.6	65	75
Weight (kg)	76.45	11.29	58	98
Height (cm)	171.30	7.15	152	181
BMI (kg/m^2)	26.08	3.11	20.91	30.59

BMI = body mass index; SD = standard deviation.

TABLE 2. Comparisons of Pre-intervention and Post-Intervention Values for AE, CE, and VE in Both Groups (n = 10)

Group	*AE*		*CE*		*VE*	
	Pre	*Post*	*Pre*	*Post*	*Pre*	*Post*
Rest	6.01 ± 1.33	6.69 ± 1.4	6.01 ± 1.33	6.69 ± 1.4	4.21 ± 1.63	3.46 ± 0.68
Massage	5.84 ± 1.73	3.92 ± 0.98	5.51 ± 0.81	3.89 ± 0.98	3.94 ± 1.13	2.45 ± 0.97
p-value		p = 0.01*		p = 0.04		p = 0.58

*Indicates statistically significant difference (independent *t*-test).
AE = absolute error; CE = constant error; VE = variable error.
The p-value was set less than 0.016. According to this p-value (p = 0.016), only changes in AE were statistically significant.

TABLE 3. ICC of Reliability of Knee Joint Repositioning Angle Errors in Healthy Older Adult Men (n = 10)

Variable	*ICC*	*CI for ICC*	*SEM*	*MDC*
Absolute error	0.85	0.72–0.93	1.58	4.38
Constant error	0.85	0.72–0.93	1.58	4.38
Variable error	0.85	0.64–0.93	0.98	2.72

ICC = interclass correlation coefficient; CI = confidence intervals; SEM = standard error of measurement; MDC = minimal detectable change.
An ICC value of 0.00–0.20 is considered "poor," 0.21–0.40 "fair," 0.41–0.60 "moderate," 0.61–0.80 "substantial," and 0.81–1.00 "almost perfect."

disrupt the mechanisms which massage utilizes to increase participants' sense of knee joint position. Further research could investigate the effectiveness of massage on the sense of joint position in different cohorts such as those with knee replacements, knee OA, individuals with different body weights, multiple sclerosis, etc.

LIMITATIONS

A limitation of the present study was that a balance assessment was not performed which would have provided information about the individual's risk of fall. This study provided a one-time application of treatment and assessment, which does not last (as shown by the lack of a period effect), and future research could examine the effect of repeated doses of massage on improving the sense of knee joint position. The study only recruited healthy males and therefore the study findings might not be transferable to women or men who have compromised health.

CONCLUSION

The present findings indicated that stimulating massage, compared to rest, was beneficial to healthy older adult men and significantly improved AE. It did not improve CE or VE. Massage is a simple, low-cost, and available method. Therefore, stimulating massage of the muscles around the knee is an option for healthy older adult men to counter problems caused by weakening proprioception due to aging. However, more studies are needed in this field.

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CONFLICT OF INTEREST NOTIFICATION

The authors declare there are no conflicts of interest.

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REFERENCES

1. Carter ND, Kannus P, Khan K. Exercise in the prevention of falls in older people: a systematic literature review examining the rationale and the evidence. *Sports Med*. 2001;31(6):427–438.
2. Xiao F, Maas H, van Dieën JH, Pranata A, Adams R, Han J. Chronic non-specific low back pain and ankle proprioceptive acuity in community-dwelling older adults. *Neurosci Lett*. 2022;786:136806.
3. Ferlinc A, Fabiani E, Velnar T, Gradisnik L. The importance and role of proprioception in the elderly: a short review. *Mater Sociomed*. 2019;31(3):219–221.
4. Baczkowicz D, Szczegielniak J, Proszkowiec M. Relations between postural stability, gait and falls in elderly persons--preliminary report. *Ortop Traumatol Rehabil*. 2008;10(5):478–485.
5. Hinman R, Bennell K, Metcalf B, Crossley K. Balance impairments in individuals with symptomatic knee osteoarthritis: a comparison with matched controls using clinical tests. *Rheumatology (Oxford)*. 2002;41(12):1388–1394.
6. Riemann BL, Lephart SM. The sensorimotor system, part II: the role of proprioception in motor control and functional joint stability. *J Athl Train*. 2002;37(1):80–84.
7. Valeriani M, Restuccia D, Di Lazzaro V, Franceschi F, Fabbriciani C, Tonali P. Central nervous system modifications in patients with lesion of the anterior cruciate ligament of the knee. *Brain*. 1996;119(5):1751–1762.
8. Marks R. Exercise, joint position sense, and knee osteoarthritis. *N Z J Physiother*. 2001;29(3):32–41.

9. Elangovan N, Tuite PJ, Konczak J. Somatosensory training improves proprioception and untrained motor function in Parkinson's disease. *Front Neurol*. 2018;9:1053.
10. El Shemy SA. Effect of treadmill training with eyes open and closed on knee proprioception, functional balance and mobility in children with spastic diplegia. *Ann Rehabil Med*. 2018;42(6):854–862.
11. Dekker J, Boot B, van der Woude LH, Bijlsma J. Pain and disability in osteoarthritis: a review of biobehavioral mechanisms. *J Behav Med*. 1992;15(2):189–214.
12. Henriksen M, Højrup A, Lund H, Christensen L, Danneskiold-Samsøe B, Bliddal H. The effect of stimulating massage of thigh muscles on knee joint position sense. *Adv Physiother*. 2004;6(1):29–36.
13. Matthews PB. Proprioceptors and their contribution to somatosensory mapping: complex messages require complex processing. *Can J Physiol Pharmacol*. 1988;66(4):430–438.
14. Manella C, Backus D. Gait characteristics, range of motion, and spasticity changes in response to massage in a person with incomplete spinal cord injury: case report. *Int J Ther Massage Bodywork*. 2011;4(1):28–39.
15. Wolpert DM, Ghahramani Z, Jordan MI. An internal model for sensorimotor integration. *Science*. 1995;269(5232):1880–1882.
16. Fadlalmola HA, Mohammed AA, Abedelwahed HH, Mohammed AA, Taha AAE, Ali RA, et al. Efficacy of massage on pain intensity in post-Cesarean women: a systematic review and meta-analysis. *Int J Ther Massage Bodywork*. 2023;16(3):44–63.
17. Kun LG. Telehealth and the global health network in the 21st century. From homecare to public health informatics. *Comput Methods Programs Biomed*. 2001;64(3):155–167.
18. Nejati V, Ashayeri H. Health related quality of life in the elderly in Kashan. *Iran J Psychiatry Clin Psychol*. 2008;14:56–61.
19. Willems T, Witvrouw E, Verstuyft J, Vaes P, De Clercq D. Proprioception and muscle strength in subjects with a history of ankle sprains and chronic instability. *J Athl Train*. 2002;37(4):487–493.
20. Stillman BC. *An Investigation of the Clinical Assessment of Joint Position Sense* [PhD thesis]. Melbourne: Australia: School of Physiotherapy, The University of Melbourne; 2000.
21. McHugh ML. Interrater reliability: the kappa statistic. *Biochem Med (Zagreb)*. 2012;22(3):276–282.
22. Henry M, Baudry S. Age-related changes in leg proprioception: implications for postural control. *J Neurophysiol*. 2019;122(2):525–538.
23. Shin M-S, Sung Y-H. Effects of massage on muscular strength and proprioception after exercise-induced muscle damage. *J Strength Cond Res*. 2015;29(8):2255–2260.
24. Vaillant J, Vuillerme N, Janvey A, Louis F, Braujou R, Juvin R, et al. Effect of manipulation of the feet and ankles on postural control in elderly adults. *Brain Res Bull*. 2008;75(1):18–22.
25. Winter L, Huang Q, Sertic JVL, Konczak J. The effectiveness of proprioceptive training for improving motor performance and motor dysfunction: a systematic review. *Front Rehabilit Sci*. 2022;3:830166.
26. Vaillant J, Rouland A, Martigné P, Braujou R, Nissen MJ, Caillat-Miousse JL, et al. Massage and mobilization of the feet and ankles in elderly adults: effect on clinical balance performance. *Man Ther*. 2009;14(6):661–664.
27. Lund H, Juul-Kristensen B, Hansen K, Christensen R, Christensen H, Danneskiold-Samsoe B, et al. Movement detection impaired in patients with knee osteoarthritis compared to healthy controls: a cross-sectional case-control study. *J Musculoskelet Neuronal Interact*. 2009;4:391–400.

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