Journal of Rehabilitation Sciences and Research

Journal Home Page: jrsr.sums.ac.ir

Original Article

The Effect of Mulligan Mobilization Technique on Static and Dynamic Balance in Patients with Moderate to Severe Knee Osteoarthritis: A Randomized Controlled Clinical Trial

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ARTICLE INFO

Article History:
Received: 09/01/2022
Revised: 15/04/2022
Accepted: 21/05/2022

Keywords:
Balance
Knee osteoarthritis
Manual therapy

Please cite this article as: Mostamand J, Adeli M, Ahmadi HA, Hassanzadeh A. The Effect of Mulligan Mobilization Technique on Static and Dynamic Balance in Patients with Moderate to Severe Knee Osteoarthritis: A Randomized Controlled Clinical Trial. JRSR. 2023;10(1):25-30.

ABSTRACT

Background: Knee osteoarthritis is the most degenerative joint disease and can consequently cause a defect in balance control. Controlling balance is necessary to prevent physical and psychological damage. The current study investigated the effects of the Mulligan mobilization technique on static and dynamic balances in patients with moderate to severe knee osteoarthritis.
Methods: In a randomized controlled clinical trial, 31 patients with moderate to severe knee osteoarthritis were selected and then randomly assigned to two groups of treatment (16 patients) and control (15 patients). Static and dynamic balances and pain score were evaluated in these patients once before and once after 10 sessions of treatment. Independent and paired t-tests were used for statistical analysis. The level of statistical significance was set at P<0.05.
Results: Pain decreased significantly in both groups after intervention (P<0.001). The treatment group experienced significantly greater reduction in pain than the control group (P=0.005). A significant improvement was found in both static (P=0.01) and dynamic (P=0.006) balance in the treatment group after the intervention. Additionally, the improvement in static (P=0.04) and dynamic (P=0.02) balance was greater in the treatment group compared to the control group.
Conclusion: The results of the present study reveal that Mulligan mobilization technique can improve balance in patients with moderate and severe knee osteoarthritis.

Introduction

The most common joint to become entangled with osteoarthritis is the knee joint [1]. According to radiographic evidence, the prevalence rate of osteoarthritis is 34.2%, and this disease is more prevalent among women (35.3%) than men (31.2%) [2].

The symptoms of this disease are pain, joint instability, inflammation of the synovial membrane, joint stiffness, limited range of motion, muscle weakness, positional faults of the bones relative to each other, and decreased proprioception of the knee joint [3, 4]. Control of balance is a complicated process resulting from interactions among the visual, vestibular, and musculoskeletal systems [5] in both static and dynamic positions [6]. Balance disorders are among the most important causes of falls [7]. Many factors lead to balance disorders, including cardiovascular disease, metabolic disease, musculoskeletal disorders, neurological disorders, visual

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and hearing disturbances, as well as the fear of falling, surgeries, and some specific medications [8]. Among the mentioned disorders, the changes in muscle strength and joint structures seen in osteoarthritis lead to impaired proprioception, making the affected individual prone to falling [4, 9, 10]. There are mechanoreceptors of proprioception in the muscles and articular components. Sensory inputs are reported from these receptors to the central nervous system for both processing and providing the appropriate response [9, 11] in order to maintain balance [10].

One of the non-conservative treatments for knee osteoarthritis is physiotherapy [1, 4], including manual therapies [4, 12]. Mulligan mobilization is most commonly used in physiotherapy as an effective manual therapy technique [4]. Using this technique, the therapist applies a pain-free accessory motion to the joint, and while maintaining it, the patient is then asked to move the joint actively [4, 13, 14]. It has been stated that Mulligan mobilization could lead to decreased pain, increased range of motion, and improved function in patients with knee osteoarthritis by correcting the positional faults in the knee joint caused by osteoarthritis [4, 12]. Additionally, this technique affects the knee joint by improving arthrokinematics and joint proprioception [4, 15]. Some previous studies have reported that Mulligan mobilization stimulates the afferent nerves in the brain and the spinal cord [16], improves motor control, and increases balance control [17].

One study that evaluated the short-term effects of Mulligan mobilization and compared them with those of Maitland mobilization reported significant improvements in pain intensity and the duration of the Timed Up and Go (TUG) test using Mulligan mobilization in patients with knee osteoarthritis [15].

In a different clinical trial, the effects of proprioception exercises and Mulligan mobilization were evaluated in patients with knee osteoarthritis, and the results indicated this technique caused significant improvements in both proprioception variables and knee pain [4].

Additionally, the results of another study revealed that both function and balance control were significantly improved when the two different treatments of Mulligan mobilization and kinesiology taping were used in patients with patellofemoral pain syndrome [17].

The short-term effects of the Mulligan mobilization technique in patients with knee osteoarthritis during static balance have not been evaluated by any study to date. Additionally, the effects of this technique along with other effective treatments on both the static and the dynamic balance of patients with knee osteoarthritis has not been clearly explained in previous studies [4, 15, 17]. Therefore, the present study aimed to evaluate the effects of this technique on both static and dynamic balance in patients with moderate to severe knee osteoarthritis.

Methods

The present randomized controlled clinical trial was approved by the Ethics Committee of the Isfahan University of Medical Sciences (ethical code: IR.MUI.RESEARCH.REC.1397.044) and registered at the Iranian Registry of Clinical Trials (IRCT20181009041297N1). The recruited population were patients with moderate to severe knee osteoarthritis, selected based on their Kellgren and Lawrence [18] radiographic ranking. This ranking refers to five grades (0 to 4) of osteoarthritis, with a grade of zero indicating an absence of X-ray osteoarthritic changes, while grades 1 and 2 show doubtful and minimal changes in X-rays, respectively, and grades 3 and 4 refer to moderate and severe changes in X-rays, respectively [18]. Patients were evaluated to determine whether they met the inclusion criteria (Table 1). As the maximum pain intensity based on VAS is 10, only patients with a pain intensity higher than 3 were entered into the study [1, 6].

Participants were divided into two groups of intervention (n=16) and control (n=15). Figure 1 illustrates the recruiting process of eligible participants during different stages of the present study.

After patients received an explanation of the study details, they were asked to sign written consent forms for participation. In the first stage of the study, the patients' balance and pain intensity were evaluated and their demographic characteristics were recorded. One leg stance test was performed to evaluate static tests for all patients. In this test, patients were asked to stand on their affected leg, bend the knee up to approximately 90 degrees, and hold the position with arms by their sides. They were then asked to keep the contralateral leg off

Table 1: Inclusion and exclusion criteria for the present study

Inclusion criteria	Exclusion criteria
• Grade 3 or 4 knee osteoarthritis according to the Kellgren-Lawrence radiographic ranking [18] • Pain intensity higher than 3 based on the Visual Analog Scale (VAS) [1, 6] • Being able to stand and walk without help[6] • Having pain for most of the days during the last months [5, 6] • Not using analgesics or any medication that would affect an individual's balance 24 to 48 hours prior to the intervention [5] • Having unilateral osteoarthritis • Being able to read and write • Healthy vision and hearing systems [8]	• Active infection in knee joint [16] • Osteoarthritis in the patellofemoral joint [19] • Having knee joint surgery [5, 6] • Having any kind of neuromuscular disorder in the lower limb and lower back (any referral pain to the lower limb) [5, 6] • Having severe psychological disorders [10] • Having other rheumatic disease [1] • Knee joint replacement [16] • Having unmodified visual and vestibular disorders [5] • Rupture of tendon or knee ligament [1] • History of injection in the intended joint during the past 3 months [10] • Having any kind of sensory disorder in the feet (diabetes patients) • Having any kind of neurologic and orthopedic diseases in the lower limb that would affect individual's balance • Existence of fixed range of motion in knee • Body mass index of more than 30 • Unwillingness to participate in the study

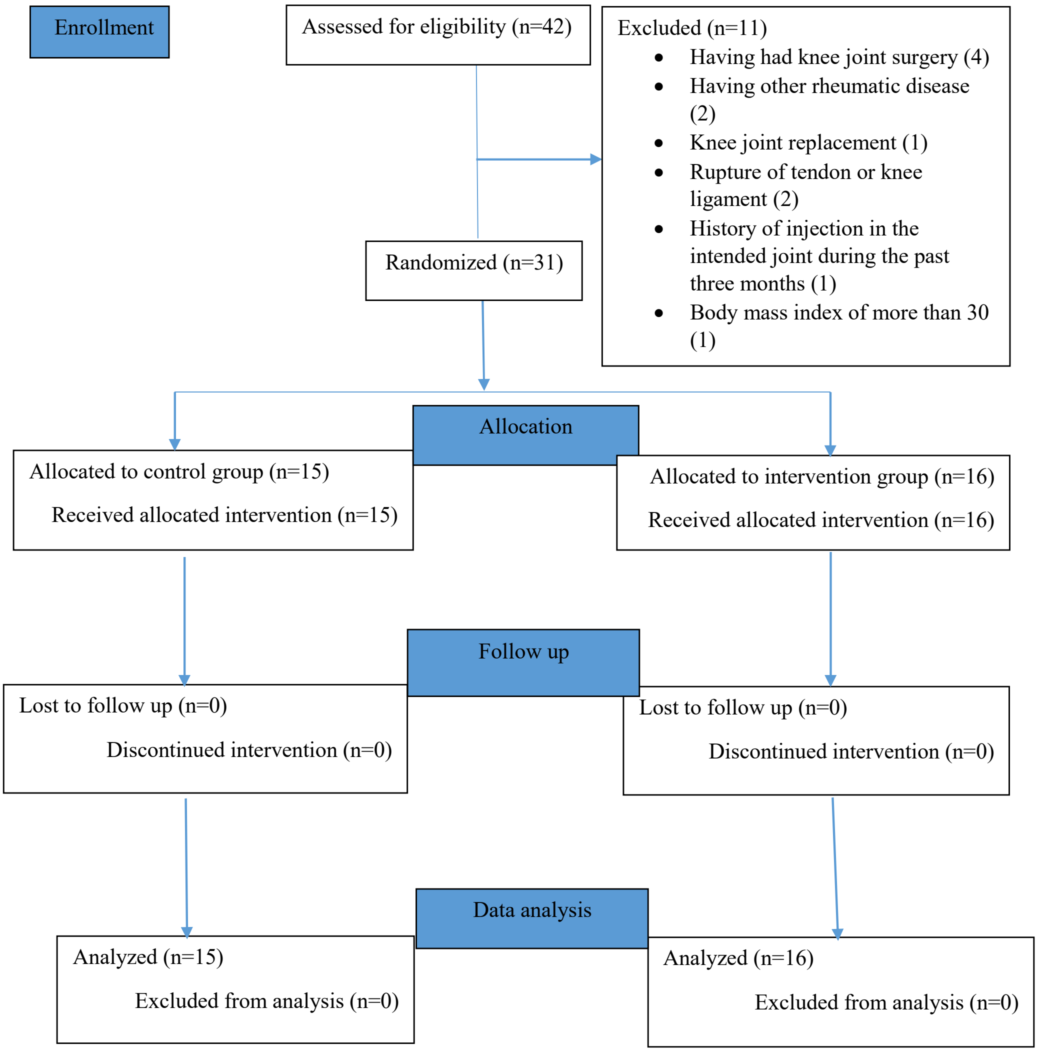

Figure 1: Flow diagram of the progress through the phases of a parallel randomized trial of 2 groups (that is, enrollment, intervention allocation, follow-up, and data analysis).

the floor and hold it as long as they could. The duration of maintaining the position in this test was recorded in seconds by the researcher using a chronometer [20]. The results of previous studies showed that this test has good validity and reliability [21].

The TUG test was used to evaluate the dynamic balance of the patients. To perform this test, patients were asked to rise from a chair without using the hand rest, then to walk the pre-determined distance of 3 meters as fast as possible, and then to return and sit on the chair again. The duration of walking this distance was recorded in seconds using a chronometer [22]. Previous studies have indicated the good validity and reliability of this test [23].

Pain intensity was evaluated using VAS in both groups [1].

It should be noted that because patients with grade 3 or 4 osteoarthritis were expected to have relatively severe pain and may not be able to perform balance tests properly, only those patients who were able to stand and walk without assistance were asked to perform the balance tests, to prevent the pain intensity from affecting the balance test results [6]. Additionally, patients were asked not to use analgesics or any medications that would affect their balance 24 to 48 hours prior to the intervention so as not to affect the test results [5].

Subsequently, both groups received 10 sessions of routine physiotherapy, including analgesic modalities and quadricep strengthening exercises, three times per week [24]. One-hour treatments with modalities of physical therapy including hot pack, transcutaneous electrical nerve stimulation (TENS), ultrasound (US), and exercise were applied on all patients. A TENS unit (Stimulator 733X, Novin Medical Engineering Company, Iran) set at a frequency of 60–100 Hz with 60 milliseconds pulse duration was used for TENS therapy. Each session lasted 20 minutes. Continuous US therapy (1-MHz, 1.5 W/cm^2, for 10 minutes) was applied on patients using Ultrasound 215 A (Novin Medical Engineering Company, Iran). Both groups also received hot packs for 20 minutes, and quadriceps setting exercises were applied to all patients for 10 minutes [24].

In addition to the routine physiotherapy, the intervention group received the Mulligan mobilization technique. Patients of this group were asked to lay supine, while the therapist, stood near the patient's affected knee and held the proximal part of their tibia with both hands wrapped around the leg to provide internal tibial rotation. The patients were then asked to bend their affected knees into their full range of motion actively, while the therapist applied an over pressure into their internally rotated tibia. This technique was applied on patients during each session for 3 sets of 10 repetitions [4] (Figure 2).

Figure 2: Internal rotation of tibia during Mulligan mobilization technique

Table 2: Demographic and clinical characteristics of participants

Variables	Mulligan group		Control group		P value
	Mean	Standard deviation	Mean	Standard deviation	
Age (year)	59.56	8.28	59.14	9.39	0.90
Height (cm)	159.19	8.25	157.20	7.25	0.48
BMI (kg/m^2)	27.09	1.89	27.36	2.23	0.72
Knee pain (cm)	4.23	3.28	5	3.51	0.55

*BMI: body mass index

Table 3: Pain score before and after intervention

Time	Pain in Mulligan group (cm)		Pain in Control group (cm)		P value*
	Mean	Standard deviation	Mean	Standard deviation	
Before intervention	8.12	1.36	8.80	1.37	0.18
After intervention	3.75	2.18	6.07	1.94	0.005
P value**	P<0.001		P<0.001		---

*P value: Independent samples t-test; **P value: Paired sample t-test

Table 4: Mean values of dynamic and static balance tests

Variables	Group	Before intervention		After intervention		P value*	Changes		P value**
		Mean	Standard deviation	Mean	Standard deviation		Mean	Standard deviation	
TUG test (second)	Mulligan	11.7	4.7	9.8	2.9	0.006	-1.9	0.6	0.02
	Control	11.4	4.9	11.1	6.01	0.47	-0.3	0.4	
OLS test (second)	Mulligan	12.8	9.5	19.9	15.4	0.01	7.1	2.4	0.04
	Control	13.4	8.6	15.5	10.01	0.25	2.1	1.7	

*P value: Paired samples t-test; **P value: Independent samples t-test; TUG: Timed up; OLS: One leg stance

After the end of the 10 therapeutic sessions, the balance test and pain intensity of all patients were re-measured for the last time.

Results

Data from the study was analyzed using SPSS software, version 22. Considering the normal distribution of the data according to the Kolmogorov-Smirnov test, both independent t test and paired t test were used to compare intergroup and intragroup data, respectively. Demographic and clinical characteristics of the patients are provided in Table 2. The results of the independent t test showed no significant difference between the two groups in terms of these variables (P>0.05).

As shown in Table 3, the results of the independent t test showed no significant difference between the two groups in the mean value of knee pain before the intervention (P=0.18). However, this variable was significantly lower in the intervention group compared to the control group at the end of all treatment sessions (P=0.005). The results of the paired t test revealed that the mean value of knee pain was significantly lower in both study groups control after the end of treatment sessions; however, this reduction was significantly more in the intervention group (P<0.001).

The paired t test was performed to evaluate patients' static and dynamic balance before and after the treatment sessions in both study groups. The results showed that the duration of the dynamic balance test was significantly shorter in the intervention group after the intervention (P=0.006). However, the duration of static balance test was observed to be significantly longer after the intervention (P=0.01) compared to before the intervention. Nevertheless, both mean duration of dynamic test (P=0.47) and duration of maintaining static balance (P=0.25) in the control group indicated no significant difference before and after routine physiotherapy.

The results of the independent t test showed that the mean values of changes in the duration of dynamic balance were significantly lower in the intervention group compared to the control group (P=0.02), while similar means of changes in the duration of static balance in the intervention group were significantly higher (P=0.04) than those of the control group (Table 4).

Discussion

Because of the lack of investigations on the effects of the Mulligan mobilization technique on static balance in patients with knee osteoarthritis and the importance of maintaining balance in these patients, the present study aimed to evaluate the effects of the Mulligan mobilization technique on the static and dynamic balance of patients with moderate and severe knee osteoarthritis.

The results of the present study indicated a greater improvement in pain among those patients receiving Mulligan mobilization in comparison with the control group. This result is in line with those of Lulnunpuii et al. [1], who revealed that applying Mulligan mobilization was more effective on decreasing pain and increasing the knee range of motion [1]. The study conducted by Lulnunpuii et al. [1] differed from the present study in that Lulnunpuii et al. recruited only patients with grade II osteoarthritis, their patients received no physiotherapy modalities, and their treatment was composed of therapeutic exercises as well as mobilization.

The mechanism of pain reduction by Mulligan mobilization has not yet been clearly identified, but it seems that two biomechanical and neurophysiologic mechanisms act in this regard [1, 14]. Many researchers have agreed that Mulligan mobilization decreases pain biomechanically by correcting the position faults of the joints and joint alignment [1, 4, 14, 25]. In fact, the changes in articulation that may occur due to arthritis lead to incongruity of the joint surfaces, then cause joint arthrokinematic disorder, stimulate the tissue, and consequently may lead to limited range of motion and pain [14, 16]. In addition, it has been shown that Mulligan mobilization decreased pain by modifying articulation and creating appropriate congruity of the joint surfaces [1, 14, 16]. Additionally, this technique seems to decrease pain perception by activating pain controlling mechanisms in the central nervous system [26]. In fact, by performing mobilization, stimulating the joint's proprioceptors, and increasing the sensory inputs to the central nervous system, the opioid receptors in the dorsal horn of the spinal cord are activated because of the presence of enkephalin. Thereafter, following the related changes, the receptors and descending pain pathways are inhibited, leading to reduced pain [4, 15].

The current results showed a significant reduction in pain as well as significant improvement in static (P=0.04) and dynamic (P=0.02) balance in the intervention group compared with the control group. These results confirm the hypothesis of the present study, and are also in line with the results achieved by Bhagat et al. [25]. Bhagat et al. [25] evaluated the effects of Mulligan mobilization on pain and TUG test results of patients with knee osteoarthritis. In their study [25], patients in the intervention group showed significant improvements in pain and TUG test results compared with patients in the control group who received sham Mulligan mobilization. Although the control group in Bhagat's study [25] showed a significant decrease in pain, no significant alteration was observed in the duration of the TUG test. Correspondingly, these results were similar to those of the control group in the present study.

There were some differences between the methods of the current study and the study conducted by Bhagat et al. [25]. First, the present study evaluated static balance as well as pain and dynamic balance. Secondly, Bhagat et al. [25] evaluated the short-term effects of Mulligan mobilization in just one session compared to the 10 sessions applied in the current study. Finally, patients in the present study had grade III or IV unilateral osteoarthritis; however, in Bhagat's study [25], all patients had grades I to III of bilateral osteoarthritis; it may be possible that the pain in the opposite knee affected the results of the TUG test.

The results of the present study are also in agreement with those of Rao et al. [15], who evaluated the short-term effects of Mulligan mobilization in comparison with those of Maitland mobilization on patients with knee osteoarthritis. In their study [15], the possible effective mechanisms of Mulligan mobilization on TUG test results were reported as decreasing muscle inhibition by decreasing pain, improving knee joint proprioception, decreasing joint stiffness, and modifying joint movements. The results of the present study provide more evidence than the study of Rao et al. [15], as their patients were evaluated immediately after performing the intervention, and no evaluation of the long-term effects of Mulligan mobilization was performed.

Patients with knee osteoarthritis experience symptoms including reduced knee proprioception, muscular weakness, and positional faults of the bones relative to each other [3, 4]. As decreased proprioception is known to cause disrupted balance, its improvement would decrease the risk of falling by increasing balance maintenance [5, 10].

Heggannavar et al. [4] reported improved proprioception using Mulligan mobilization. Because patients with knee osteoarthritis experience decreased function and power in the quadriceps muscle, its increased activity would be effective on improving the stability and performance of the joint [27, 28]. Although the muscles of the knee joint are strong, modification of the articulation is of great importance for improving the joint performance and stability. Modification of articulation will consequently lead to the transmission of correct proprioception information to the central nervous system [29]. In addition, this would increase the activity of the knee muscles and their interaction with other joint components, which would eventually cause increased joint stability [28, 29]. Therefore, it can be stated that in the intervention group of the present study, joint performance was improved because of the modification of articulation by Mulligan mobilization. Furthermore, this improvement in joint performance also increased knee proprioception, leading to better and more stimulation of knee muscles, increased knee stability, and improved balance maintenance in patients with knee osteoarthritis.

The lack of follow up with patients, no evaluation of the possible mechanisms of the Mulligan mobilization technique, and the small sample size were some limitations of the current study.

Conclusion

Although the results of the present study reveal that Mulligan mobilization can improve balance in patients with moderate or severe knee osteoarthritis, the mechanisms related to this effectiveness require more investigations.

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Acknowledgment

This study was supported by the Vice-Chancellery of Research of Isfahan University of Medical Sciences, Isfahan, Iran.

Funding

This study was financially supported by Isfahan University of Medical Sciences.

Conflict of Interest: None declared.

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