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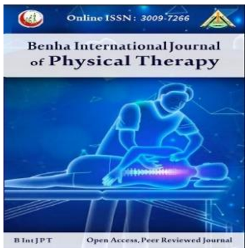

Original research

Effect of vibrating foam roller on hamstring flexibility, pain and function in chronic osteoarthritis of knee: a randomized controlled trial.

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Abstract

Background Osteoarthritis (OA) is a cause of major disability, primarily affecting the knee joint with the hamstring muscle's shortening, tightening, and loss of muscle flexibility. Foam rollers improve flexibility, decrease pain intensity, and regulate muscle imbalance. Vibrating foam rollers (VFR) add the component of vibration therapy to traditional foam rollers. **Purpose:** to examine the effect of VFR on hamstring flexibility, pain intensity level, and functional disability of knee joint score in patients with chronic knee OA**. Methods:** 42 patients, ranging in age from 40 to 60 years, of both genders with mild to moderate unilateral chronic knee OA were randomly assigned into two groups of twenty-one patients each. Groups (A) and (B) received a conventional physical therapy program involving strengthening and stretching for muscles in the lower limbs for four weeks or three workouts per week. Group (B), additionally, received a VFR training program on the hamstring, three sessions per week for four weeks. The active knee extension test (AKE), visual analog scale (VAS), and Arabic version of the Western Ontario Osteoarthritis Index (ArWOMAC) were used to measure hamstring flexibility, pain intensity level, and knee joint functional disability, respectively. **Results:** There was a significant improvement ($P<0.05$) in hamstring flexibility, pain intensity level, and functional disability of the knee score joint in group (B) more than group (A). **Conclusions:** VFR improves hamstring flexibility, pain intensity level, and functional disability of the knee joint in patients with unilateral chronic knee OA.

Keywords: ArWOMAC score, Hamstrings flexibility, Knee osteoarthritis, , Strengthening exercises, Vibrating foam roller.

Introduction

Osteoarthritis (OA) is a disabling disease that produces severe morbidity reducing physical activity[1]. According to World Health Organization, OA is regarded as major public health problem. It is the major causes for impaired function that decreases quality of life worldwide [2]. The knee is the most common weight-bearing joint affected by OA, with an estimation of 45% of all adults at risk of developing knee OA in their lifetime[3]. Muscle flexibility decline with age and lack of muscle flexibility can lead to alteration in joint function

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and may be risk factor for injuries during activities that require a full range of motion[4]. Along with quadriceps flexibility, the hamstring flexibility also more affected as the hamstring muscle have tendency to shorten and tighten in patients with chronic knee OA[5].

Thereby performing regular stretching exercises increase muscle flexibility, ROM and provide functional benefits for patients with chronic knee OA and may delay the need for surgical interventions like total knee replacement. Knee OA usually is developed when cartilage wears occur naturally with increasing degeneration as aging progresses[6].

Physical therapy interventions for patients with chronic knee OA concluded that exercise and weight loss reduce pain and improve physical function[7]. Foam roller, which are particularly useful for the relaxation of myofascial, serve to apply pressure by using the limb weight of the patient. Foam roller is thought to improve muscular performance and flexibility as well as to alleviate muscle fatigue and soreness[8].

Vibrating foam roller (VFR) adds the component of vibration therapy with foam roller. This type of foam roller has been in the spotlight recently due to low treatment cost. Currently, vibrating foam roller has been shown to increase ankle ROM, passive hip and knee flexion, pain pressure tolerance, dynamic balance and pain perception indicating a greater benefit in pain tolerance[9].

It has also been suggested that VFR might have a more pronounced effect on muscle flexibility and muscle mechanical property parameters than of non-vibrating foam roller (NVFR)[10]. However, stretching is a crucial part in physical therapy treatment protocol for chronic knee OA. It may not be comfortable enough, more painful and may be avoided in some situations as when knee OA is combined with radicular pain so VFR can solve these issues and decrease adverse effects of stretching.

Thus, the purpose of this study was to fill the gap of the effect of the vibrating foam roller in chronic knee OA patients through examining the effect of vibrating foam roller on hamstring flexibility, Knee pain intensity level and knee functional disability in patients with unilateral chronic knee OA.

Methods

The Ethics Review Committee of Cairo University's Faculty of Physical Therapy, Egypt, Approved this study (No:P.T.REC/012/003326). This study was conducted from December 2022 to July 2023 at the Outpatient Clinic of Faculty of Physical Therapy, Pharos University, Alexandria, Egypt.

Study Design

Repeated measurements pretest-post-test randomized controlled study.

Participants

The sample size for this study was 42 patients divided randomly into two groups (n=21 in each group). Sample size calculation was based on power analysis done using G* power software (version 3.1.9.2, Franz Faul, Uni Kiel, Germany) program. It was based on t-test, the type I error significance rate set at 5% (alpha-level 0.05). The expecting r=0.5 and type II error rate was at 80% power. The sample was randomly divided into two groups (A) and (B) using opaque, sealed envelopes, each containing the name of one of the groups.

Group (A): went through a conventional physical therapy program including stretching and strengthening exercises of the lower limb muscles[11].

Group (B): went through a conventional physical therapy program in addition to vibrating foam roller[12].

Each participant was diagnosed and referred by Orthopedists as unilateral. After inclusion in the study, each participant signed a consent form, personnel data, past medical history, were collected at the beginning of the study. Measurements were conducted before and after four weeks (three sessions per week) of the intervention.

Inclusive Criteria

Age - 40 to 60 years patients of unilateral chronic knee OA, patient with unilateral chronic knee OA grade II-III Kellgren and Lawrence (K/L), patients with normal Body mass index (BMI) 18.5-24.9 kg/m^2[13], patients who are able to walk with painful chronic knee OA without assistive devices and patients with knee pain intensity level at least >3 cm on a 10 cm VAS scale in activities such as going up-and downstairs, sitting and squatting were included in the study.

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Exclusion Criteria

Patient with Radiated pain from low back pain, Patients with no radiographic evidence of knee OA or with doubtful OA (grade I according to K/L classification) or with severe OA (grade IV according to K/L classification), Loss of joint play in tibiofemoral and patellofemoral articulations, Lower extremity fracture and surgery or trauma to the knee joint, Neurological deficit or movement disorder related to lower limb, Those who were athletes or who had been treated with physiotherapy or pain and anti-inflammatory medications during the previous 6 weeks, Those who could not apply vibration stimuli and Those who had severe varicose veins.

Instrumentations

Instrumentations for Measurements:

Health weight scale for weight and height measurements: was used to calculate BMI. (BMI= weight (kg) / [height (m)^2]) [14]. Digital absolute axis goniometer: (Baseline 12-1027, china) was used to measure the range of motion of the knee joint extension in degrees[15].Visual analogue scale (VAS): a 10-cm line that represents a continuum between “no pain” and “worst pain” was used for pain intensity level measurements[16]. Western Ontario and McMaster Universities Osteoarthritis index for the Arab community (ArWOMAC): 17-item physical function subscale to evaluate knee joint functional disability[17].

Instruments for Treatment:

Sand bags and elastic bands: (theraband, UK) for resistance. Vibrating Foam Roller: (LIVE PRO MODEL NO. LP8236, china) produces uniform oscillations with medium intensity 2400 rpm 40 Hz for treatment (Figure 1).

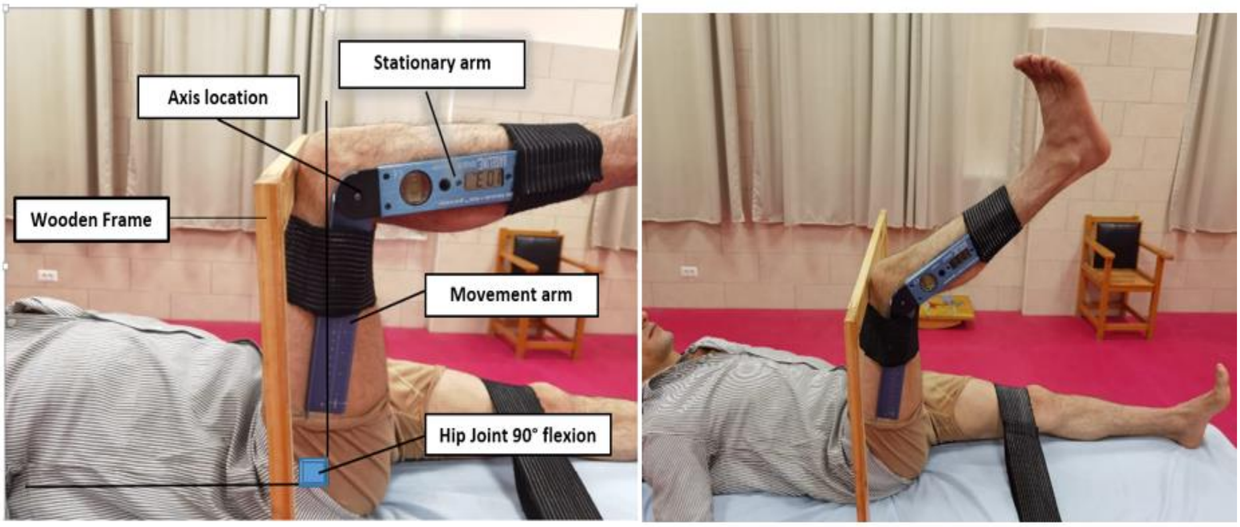
Figure 1: LIVE PRO Vibrating Foam Roller

Procedures for Measurements

Measurements were conducted for each participant prior to and following to the treatment period of time .

Measurement of Hamstring Muscle Flexibility

Participants were instructed to lay supine on the table, facing the wooden frame. The tested limb was flexed until the thigh touch the wooden frame, fixed at 90° with the table. The contralateral limb was fully extended and stabilized in neutral rotation by a belt (Figure 2.A). With the foot at neutral position and the knee flexed at 90°, the digital absolute axis goniometer was placed over the lateral femoral condyle, with one arm aligned along the thigh in direction to the greater trochanter, and the other arm aligned over the leg in direction to the lateral malleolus (Figure 2.B). From this position, and without any prior warm-up, subjects were instructed to extend the knee until they felt a strong resistance, holding this final position for 2-3 sec., allowing the goniometric reading[18].



A: Starting position **B**: Ending position

Figure 2: Measurement of hamstring flexibility with active knee extension test

The result recorded corresponded to the amplitude, in degrees, of the knee extension movement, starting from the initial test position (knee flexed at 90° which corresponded to the goniometric 0°). After the goniometric reading, the tested leg will resume to the resting position for one minute, after which the same procedures executed for the second trial [18]. AKE has an excellent intrarater reliability for the use in subjects with flexibility deficits[19].

Measurement of Pain Intensity Level:

The VAS is self-completed by the participant. The participant is asked to place a line perpendicular to the **VAS** 10 cm line at the point that represents their pain intensity. Using a ruler, the score is determined by measuring the distance (mm) on the 10-cm line between the “no pain” anchor and the patient’s mark, providing a range of scores from 0 –100[20].

Measurement of Knee joint functional disability:

The participant was instructed to complete the Arabic-language printed WOMAC questionnaire in a quiet area. After being given the questionnaire subscales, the participant was requested to complete the 17-item physical function subscale, the Subscale measuring pain (5 items) and subscale measuring stiffness (2 items). Every item was rated from 0 (nothing), 1 (slight), 2 (moderate), 3 (extremely), and 4 (severe). All conversations took place in Arabic[21]**.** The elements for each of the three subscales are added up to produce the overall ArWOMAC score. The index is out of a total of 96 possible points, with 0 being the best and 96 being the worst. Higher ArWOMAC ratings correspond to worse pain, stiffness and functional disability[22].Each participant completed ArWOMAC questionnaire just before and after treatment.

Procedures for treatment

Conventional physical therapy program:

Each training session was preceded by 10 minutes of general warming up. The maximum load for all strengthening exercises (70 % of one repetition maximum) was evaluated during the first treatment session and reviewed weekly in order to make any necessary adjustments. Resistance was progressively increased as strength improves. The treatment protocol was 12 treatment sessions (3 sessions per week) for 4 weeks for the 2 groups for an average time of the session 30-45 Minutes. Patients in both groups underwent typical lower limb strengthening and stretching exercises, including resistance exercises for the quadriceps. Multiple angle isometric seated quadriceps knee extension exercises (30°, 60°, and 90°) were performed for three repetitions and three sets using TheraBand 10s for each angle. Three sets of ten repetitions of straight leg raising with progressive ankle weight, three sets of ten repeats of ankle planter flexion with resistance using TheraBand, three sets of thirty seconds of hamstring stretching, three sets of ten repetitions of hip abduction and adduction with weights (side lying) using ankle weights, bilateral Calf raises 2 sets of 10 repetitions and Step up/down 2 sets of 10 repetitions [11].

Application of Vibrating foam roller:

Patients received the conventional physical therapy program and the vibrating foam roller**.** It produces uniform oscillations with medium intensity 2400 rpm 40 Hz used. The vibrating foam roller intervention consisted of 3 sets of 30 seconds in duration with a 30 seconds rest between sets[12].Vibrating foam roller was applied while the patient in a long sitting position with the legs extended, foot relaxed and hands were placed behind their back for balance. Participant was instructed to use their arms to propel their body back and forward, from the ischial tuberosity down to the popliteal fossa (Figure 3.A) using small kneading motions on the way down in a smooth and continuous motion of 3 seconds forward and 1 second backward and then vice versa from popliteal fossa to ischial tuberosity repeating this pattern until reaching a total of 30 seconds set [9] (Figure 3.B).

A: Starting position ischial tuberosity **B:** Ending position popliteal fossa.

Figure 3: Vibrating foam roller training (A: starting position, B: ending position)

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The first set was performed on the lateral aspect of the hamstring targeting (biceps femoris), the second set on the center targeting (semitendinosus) and the third set on the medial aspect targeting (semimembranosus). They also instructed to exert as much pressure as possible on the vibrating foam roller.

Statistical Analysis:

Data were expressed as mean± SD. Unpaired t-test and chi square were used to compare between subjects' characteristics to evaluate the average age (years), weight (kg), height (cm), and BMI (Kg/m2) of the two groups. Shapiro-Wilk a normality test and Kolmogrov-smirnov a nonparametric test was used for testing normality of data distribution. MANOVA was performed to compare within and between groups' effects for all measured variables; hamstring flexibility degree, pain intensity level and knee functional disability score. Statistical package for the social sciences computer program (version 20 for Windows; SPSS Inc., Chicago, Illinois, USA) was used for data analysis. P ≤ to 0.05 was considered significant.

Results

Demographic data of participants

Out of 42 patients who were enrolled in the study, 21 were randomly assigned to the group (A) and treated with the conventional physical therapy regimen; 21 were assigned to the Vibrating foam roller, group (B) and subjected to a conventional physical therapy regimen plus vibrating foam roller. Demographic data of participants of both groups shown in Table 1.

Table 1: Demographic data of participants of both groups

	Group (A)	Group (B)	t-value	P-value	significances
Age (years)	52±7.2	53.6±6.8	-0.775	0.443	N.S
Weight (Kg)	63.3±7.8	62.2±9	0.413	0.682	N.S
Height (cm)	163.9±7.3	164.3±9.1	-0.149	0.882	N.S
BMI (Kg/m^2)	23.5±1.7	23±1.8	0.955	0.345	N.S
Sex Males Females	N (%) 4 (19%) 17 (81%)	N (%) 5 (24%) 16 (76%)	χ^2= 0.141	0.707	N.S

χ2: chi square, p- value: significance

Normality Test

The normality assumption, variance homogeneity, and presence of extreme scores were checked in the data. With p>0.05, the Shapiro-Wilk and Kolmogorov-Smirnov tests proved that all of the measured variables were normally distributed.

Effect of treatment on all analyzed variables:

The 2x2 mixed MANOVA design statistical analysis was used to examine how the vibrating foam roller affected the measured variables,

There were statistically significant effects of the first independent variable (the examined group) on the measured variables (F=6.29, P=0.001) and there were significant effects of the second independent variable (the measuring periods) on the examined dependent variables (F=296.6, P=0.001). Also, there was significant interaction (F=45.1, P=0.001) tested by 2x 2 mixed MANOVA design statistical analysis (Table 2).

Table 2: Between groups 2 x2 mixed MANOVA design at variable measuring periods and conditions for all dependent variables.

Variation source	F	P	η2
Groups	6.29	0.001	0.405
Measuring periods	296.6	0.001	0.970
Interaction	45.1	0.001	0.830

F-value: Mixed MANOVA F value. P-value: Probability value. η2: partial eta square

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The impact of vibrating foam roller on Hamstring flexibility

Within group comparison

Group (A): The mean value ± SD of hamstring flexibility by knee extension ROM pre and post treatment of group (A) was 50.6 ± 7.4 and 56.2 ± 6.6 degrees respectively. There was a statistically significant increase in hamstring flexibility in group (A) post treatment by 11% compared with that of pre-treatment (p = 0.001).

Group (B): The mean value ± SD of hamstring flexibility by knee extension ROM pre and post treatment of group (B) was 52 ± 8.7 and 66 ± 6.5 degrees respectively. There was a statistically significant increase in hamstring flexibility in group (B) post treatment by 27% compared with that of pre-treatment (p = 0.001). **(Table 3).**

Between groups comparison

There was no statistically significant difference in the mean values of hamstring flexibility pretreatment between groups (p= 0.559) while there was statistically significant difference post treatment between groups (p= 0.001) in favor of group (B) **(Table 3, Figure 4)**.

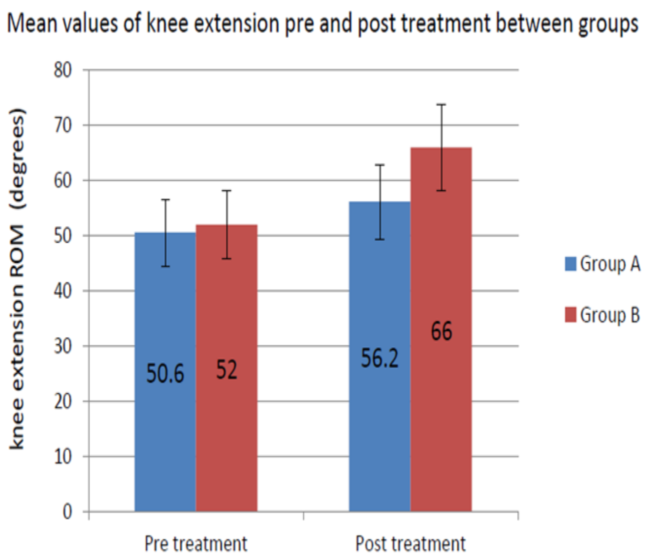

Figure 4: Mean values of knee extension pre and post treatment between groups

The impact of vibrating foam roller on pain intensity level

Within group comparison

Group (A) The mean value ± SD of pain by VAS scale pre and post treatment of group (A) was 7.8 ± 0.8 and 6.5 ± 0.9 cm respectively. There was a statistical significant decrease in pain intensity level in group (A) post treatment by 16.7% compared with that of pre-treatment (p = 0.001).

Group (B) The mean value ± SD of pain by VAS scale pre and post treatment of group (B) was 7.7 ± 1 and 4.3 ± 1 cm respectively. There was a statistically significant decrease in pain intensity level in group (B) post treatment by 44.2% compared with that of pre-treatment (p = 0.001). (Table 3).

Between groups comparison

There was no statistically significant difference in the mean values of pain intensity level pretreatment between groups (p= 0.879). While there was statistically significant difference post treatment between groups in favor of group (B) mean difference (p= 0.001). **(Table 3, Figure 5)**.

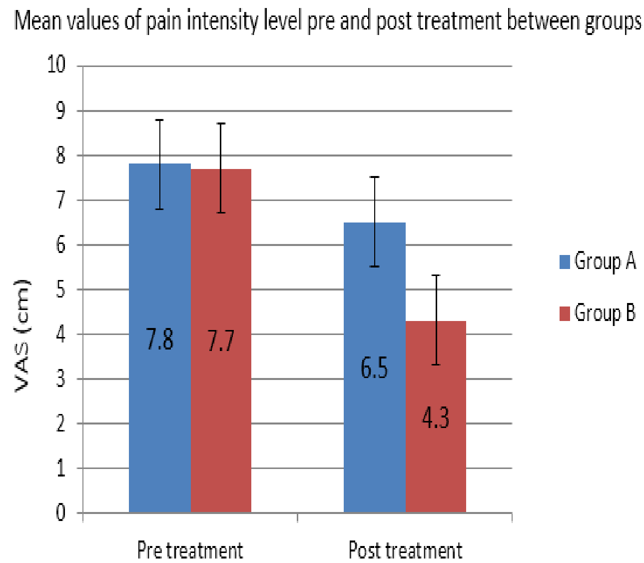

Figure 5: Mean values of pain intensity level pre and post treatment between groups

The impact of vibrating foam roller on knee functional disability

Within group comparison

Group (A) The mean value ± SD of knee function by ArWOMAC score pre and post treatment of group (A) was 48.5 ± 3.1 and 42.8 ± 4 respectively. There was a statistically significant decrease in ArWOMAC in group (A) post treatment by 12% compared with that of pre-treatment (p = 0.001).

Group (B) The mean value ± SD of knee function by ArWOMAC score pre and post treatment of group (B) was 48.8 ± 4.6 and 38 ± 4.4 respectively. There was a statistically significant decrease in ArWOMAC in group (B) post treatment by 22% compared with that of pre-treatment (p = 0.001). (Table 3).

Between groups comparison

There was no statistically significant difference in the mean values of ArWOMAC score pretreatment between groups (p= 0.816). While there was statistically significant difference post treatment between groups in favor of group (B) (p= 0.001). (Table 3, Figure 6).

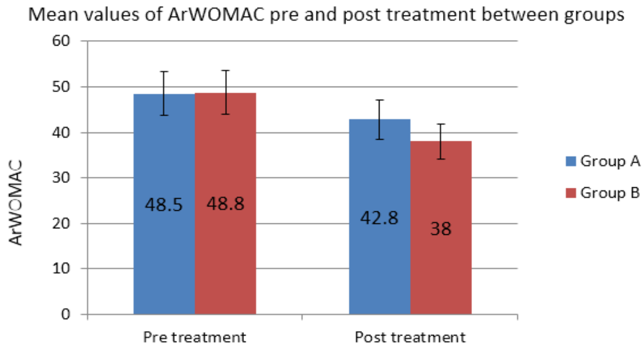

Figure 6: Mean values of ArWOMAC score pre and post treatment between groups

Table (3): Mean ±SD of measured variables pre and post treatment of (A) & (B) groups.

Measured variables	Group (A) Mean ±SD	Group (B) Mean ±SD	Mean difference (95% CI)	f-value	P-value	η2
Pain intensity (cm)						
Pre-treatment	7.8 ± 0.8	7.7 ± 1	0.043 (-0.5, 0.6)	0.023	0.879	0.001
Post treatment	6.5 ± 0.9	4.3 ± 1	2.2 (1.6, 2.8)	51.6	0.001*	0.564
Mean difference (95% CI)	1.3 (1, 1.5)	3.4 (3.1, 3.6)				
% of change	16.7%	44.2%				
P-value (within group)	0.001*	0.001*				
Hamstring flexibility (degrees)						
Pre-treatment	50.6 ± 7.4	52 ± 8.7	-1.4 (-6.5, 3.6)	0.347	0.559	0.009
Post treatment	56.2 ± 6.6	66 ± 6.5	-9.8 (-13.9, -5.7)	23.5	0.001*	0.371
Mean difference (95% CI)	-5.6 (-7.4, -3.9)	-14 (-15.8, -12.2)				
% of change	11%	27%				
P-value (within group)	0.001*	0.001*				
Knee function						
Pre-treatment	48.5 ± 3.1	48.8 ± 4.6	-0.3 (-2.7, 2.1)	0.055	0.816	0.001
Post treatment	42.8 ± 4	38 ± 4.4	4.7 (2.1, 7.3)	13.3	0.001*	0.250
Mean difference (95% CI)	5.8 (4.9, 6.6)	10.7 (9.9, 11.6)				
% of change	12%	22%				
P-value (within group)	0.001*	0.001*				

Discussion

This study looked at how utilizing a vibrating foam roller affected people with chronic knee osteoarthritis' hamstring flexibility, pain intensity level and knee functional disability.

In this study, 42 individuals of both genders who were diagnosed by orthopedic surgeons as having mild to moderate chronic knee OA and were recommended for physical therapy treatment were included.

Each participant measured prior and after treatment. The included patients were measured to determine hamstring flexibility, pain intensity level and knee functional disability. Then they received Four weeks of conventional physical therapy program (A) and four weeks of conventional physical therapy program with VFR (B).

The Effect of VFR Training on Hamstring flexibility

The present study showed a significant improvement (P<0.05) of hamstring flexibility using digital absolute axis goniometer to measure active knee extension ROM by 16% compared with that of the conventional group (A). These results confirmed the effect of VFR training on hamstring flexibility in chronic knee OA patients.

The results of this study came into agreement with a systematic review and meta-analysis on Effect of vibration foam roller on the range of motion which the total result of the study demonstrated that VFRs achieved better gains than foam rollers (FRs) in terms of improving the ROM (SMD, 0.53; 95% CI, 0.29–0.77; *I*2=55%). The subgroup analysis was based on VFRs for the ROM in the hip, knee, and ankle joints. The results for the knee indicated that VFRs improved the ROM (SMD, 0.59; 95% CI, 0.24–0.95; *I*2=66%) [23].

For further support of the current study results a randomized controlled trial which compared a vibrating foam roller with a non-vibrating foam roller intervention on knee range of motion and pressure pain threshold on Forty-five subjects. For knee ROM, within group analysis revealed a posttest increase of approximate 7 degrees (p<.001, ES: 0.50) for the vibrating roller, 5 degree (p<0.001, ES: 0.50) increase for the non-vibrating roller, and a 2 degree (p<0.001, ES: 0.20) increase for the control group [24].

The Effect of VFR Training on Pain Intensity Level

The present study showed a significant improvement (P<0.05) of pain intensity level using VAS scale by 27.5% compared with that of the conventional group (A). This supports the effect of VFR for reducing pain intensity levels in chronic knee OA patients.

The results of this study came into agreement with an RCT conducted by Kanabur et al. (2022) they investigated the clinical effects of dynamic cupping therapy vs. vibrating foam roller on pain intensity level, range of motion, function, and quality of life on 45 elderly patients with sub-acute and chronic osteoarthritis of knee. This study concluded vibration foam rollers are shown to improve pain intensity level significantly with P = 0.0001, due to the reduction of the soreness in the muscles by enhancing local blood circulation [25].

A study by Romero et al. (2019) compared Vibration with Non-Vibration Foam Rolling as a recovery tool after exercise for hip and knee joint regarding pain intensity level using VAS on 38 subjects both genders. The results suggested that the VFR group achieved greater benefits in pain intensity level perception than FR group. This study used to explore the influence of adding vibration to an FR during recovery. The first important finding is that the VFR group achieved greater benefits in pain intensity level perception and provided the first data verifying that VFR could improve individual tolerance to pain more than FR when measuring only post treatment [26].

The Effect of VFR Training on knee functional disability

The current study demonstrated a notable enhancement in physical function, as evidenced by significant results (P<0.05) when utilizing the ArWOMAC index by 10% compared with that of the conventional group (A). This underscores the positive impact of VFR training on the physical functioning of patients with chronic knee OA.

The results of this study came into agreement with a randomized controlled trial which compared the effect of dynamic cupping therapy with vibrating foam roller on knee function and quality of life in elderly with sub-acute and chronic osteoarthritis of knee. To function assessed by WOMAC the study had effective pre-post outcomes by 3 weeks, with a significant P-value for VFR had an effective result on function it is justified that with improvement in pain intensity level and muscle length there is an improvement of function too[25]. Additionally, a review by Weiwelhove et al. (2019) analyzing research on VFR concluded that it was more beneficial than NVFR [8].

To sum up the results of current study suggest that the addition of VFR to Conventional physical therapy program for chronic knee OA can decrease patient’s pain intensity level, increasing hamstring flexibility through knee extension ROM and decrease knee joint functional disability in patients with unilateral chronic knee OA. Our suggestion was supported by the results of this study regarding the effect of VFR training in patients with chronic knee OA showed improvements which was comparable to Conventional physical therapy program.

Conclusion

Our study results showed that the effect of VFR combined with conventional physical therapy program on improving knee pain intensity level, hamstring flexibility and knee joint functional disability in patients with chronic knee OA.

Authors’ contributions

The authors have determined that all individuals indicated as authors are eligible for authorship. The content and plagiarism of the paper are the responsibility of all authors who have critically evaluated and approved the final version.

Availability of data and materials

The collected and analyzed data during the study are available upon reasonable request and following approval from all authors.

Conflict of interest

This article has no potential for a conflict of interest.

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