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Comparative Study Of Foam Rolling And Vibration Therapy On Blood Creatinine Level, Pain Sprint Speed, Lower Limb Power And Hip Range Of Motion In Delayed Onset Muscle Soreness

Jatin Prajapat[1], Sheetal Kalra[*2], Joginder Yadav[1], Sajjan Pal[1], Sonia Pawaria[1]

[1]Faculty of Physiotherapy, SGT University, Gurugram, Haryana, India
[2]School of Physiotherapy, Delhi Pharmaceutical and Research University, Delhi, India

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ABSTRACT

Muscle soreness appears after high-intensity unaccustomed exercise, especially eccentric exercise and it peaks between 24 and 72 hours post-exercise. It can result in reduced muscle power, range of motion hence impacting athletic performance. Different treatment strategies are available to alleviate symptoms of Delayed Onset Muscle Soreness (DOMS). The present study was done to draw a comparison between the effects of foam rolling and vibration therapy on pain, hip range of motion, sprint speed and lower limb power in subjects with exercise-induced muscle damage. It was a comparative Experimental Study design. The sample consisted of 30 Male students who were randomly allocated to 2 groups, i.e. Group A (Foam Rolling) and Group B (Vibration Therapy) with 15 participants in each group. Participants performed ten sets of 10 repetitions of back squats at 60% of their 1-repetition maximum, followed by either foam rolling or vibration therapy 24 and 48 hours post-DOMS protocol. Blood Creatinine level was measured before inducing DOMS(day 1) and after 24 hrs(day2) and 48 hrs(day 3) of recovery. Increase in serum levels of CK is used as an indirect marker of the microtrauma associated with DOMS. Pain, lower limb power, sprint speed and Hip range of motion were measured using Numeric Pain Rating Scale, Vertical Jump test, Sprint speed 30-meter test and goniometer respectively after 24 and 48 hours of recovery. Results showed both groups showed improvement on Day 2 and 3. However, Vibration therapy showed statistically better improvement compared to Foam Rolling group.

*Corresponding Author

Name: Sheetal Kalra
Phone: 9990003410
Email: sheetalkalra1237@gmail.com

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INTRODUCTION

Muscle soreness is a common occurrence following unaccustomed physical activity. Muscle soreness has been differentiated into "acute" and "delayed onset" corresponding to the time in which soreness occurs. Delayed onset muscle soreness (DOMS) presents as tenderness to palpation and/or movement and decrease in flexibility and maximal voluntary force production.DOMS is believed to result from abnormal muscle activity and intense isometric exercise. By impairing function 24 to 48 hours post eccentric muscle activity, DOMS may limit the ability to perform activities of daily living, therapeutic exercise, or sports participation (Mancinelli

et al., 2006). Various treatment option for DOMS is available in literature such as cryotherapy, stretching, anti-inflammatory drugs, Ultrasound, massage, compression, foam rolling, vibration therapy, electrical stimulation etc (Lau and Nosaka, 2011). Foam rolling is commonly used as a recovery tool after a bout of physical activity, which advocates claiming that foam rolling corrects muscular imbalances, alleviates muscle soreness, relieves joint stress, improves neuromuscular efficiency and enhance ROM (Macdonald, 2014). During foam rolling individual use their body mass on a foam roller to exert pressure on the soft tissue. The motions place both direct and sweeping pressure on the soft tissue, stretching it and generating friction between it and the foam rolling. Foam roller comes in several sizes and foam densities. Commercial foam rolls are typically available in two sizes; Standard (6×36 inch) and half-size (6×18 inches) (Cheatham *et al.*, 2015). Studies have found foam rolling to be effective in increasing joint excursion, increased pressure pain threshold and reduced pain. However, there are contradictory results concerning muscle strength after foam rolling therapy. Vibration may be defined as an oscillatory change of force, acceleration and displacement concerning time. Vibration could represent an effective exercise intervention for enhancing neuromuscular performance in athletes (Veqar, 2014). Recent research suggests that vibration therapy may reduce the symptoms in DOMS. Previous work suggests that vibration enhance reflex activity by stimulating muscle spindle leading to a tonic vibratory reflex (Custer *et al.*, 2017). In a healthy individual, local vibration stimulates an immediate increase in muscle activity, and also there is an increase of ROM in individuals with acute soft tissue injury (Mancinelli *et al.*, 2006). Studies have found DOMS affect athletic performance by reducing muscle torque and joint excursion. To the best of researcher's knowledge till date, no study has been done comparing the effects of vibration therapy and foam rolling on pain, range of motion, and performance variables like vertical jump height and sprint speed that affect performance in individual sports. Therefore the purpose of the current study was to compare the effects of foam rolling and vibration therapy in delayed onset muscle soreness in college-going students.

MATERIALS AND METHODS

Participants

This experimental study was carried out at SGT Hospital Physiotherapy Department, Gurugram.The study was approved by the Departmental Research Committee (DRC) and Departmental ethical committee of Faculty of Physiotherapy, SGT University, Ref No SGTU/FOP/2019/25. A sample of 30 students based on inclusion and exclusion criteria were recruited. The students of SGT University were invited to participate in the study. The inclusion criteria for the study were: male participants(non-athletes) in the age group of 18-25, creatinine kinase level in a range of 55 to 170 units per litre, Minimum pain on a scale in a range of 3-4 after inducing DOMS, Participants having a score of 31-40 cm(i.e. Average score) on vertical jump test for lower limb power. And the exclusion criteria were: recent orthopaedic surgery in last one year, Any musculoskeletal or neurological problem that affected the compliance of subjects to participate in the study. A written informed consent form was obtained from the subjects. Demographic data of subjects were collected, and the examination was done. The subjects were randomly allocated into two groups by simple random sampling. Group a –foam rolling, group b- vibration therapy. All subjects were asked to fill a Physical A activity readiness Questionnaire to screen them before allowing them to participate in the study.

Procedure for inducing DOMS

Both groups received a one-time exercise protocol that consisted of participants performing, ten sets of 10 repetitions of barbell back squats at 60% of their 1RMs to a predetermined depth. The squat technique was adopted from the National Strength and Conditioning Association. The tempo for each repetition was of 4-second eccentric contraction, no pause, and a 1- second concentric contraction. Participants were rested for 2 minutes between sets. Total squat time was 8 minutes, 20 seconds, and rest time was 18 minutes. After inducing DOMS, participants having pain less than 3-4 according to NPRS scale were excluded from the study, but they were given treatment for DOMS in Physiotherapy OPD of SGT Hospital.

Procedure of group A (Foam Rolling)

Participants used custom-made foam roller which was constructed of a hollow polyvinyl chloride pipe that had a10.16-cm outer diameter and 0.5-cm thickness and was surrounded by neoprene foam with a 1-cm thickness. They were instructed to begin with the foam roller at the most distal portion of the muscle. The researcher instructed them to place as much body mass as tolerable on the foam roller at all times and to roll their body mass back and forth along with the roller as smoothly as possible at a cadence of 50 beats per minute (i.e., one rolling motion per 1.2 seconds). Foam rolling was

performed for 45 seconds and followed by a 15-second rest. This was accomplished for each muscle group, i.e. quadriceps, gluteal, hamstring, adductors and iliotibial bend and repeated once. Total foam-rolling time, including rest, was 20 minutes. Foam rolling was performed on sessions 1(24 hours post-DOMS protocol), 2 (48hours post-DOMS protocol). Furthermore, participants performed foam rolling after testing sessions 2 and 3 because the intensity of DOMS increased within the first 24 hours and peaked around 48 hours post-exercise. We have chosen these because no empirical evidence recommending the most optimal duration and timing of post-exercise foam rolling is available. The foam-rolling technique for each muscle, and the order in which each muscle was foam rolled is as follows (Pearcey *et al.*, 2015) .(Figure 1).

Quadriceps

Subjects were in a prone position with the roller approximately 7.62 cm inferior to the anterior superior iliac spine; participant crossed one leg over the other. They rolled down to a superior position to the patellar tendon and came back using their elbows to guide movement.

Adductors

Subjects were in a prone position with the hip flexed and externally rotated. Participants positioned themselves on the roller with the proximal portion of the adductor group just inferior to the inguinal area. They rolled down to a position superior to the medial condyle and came back by shifting their body mass from side to side.

Hamstrings

Subjects were in a position just inferior to the gluteal fold with the hips unsupported, and participant crossed one foot over the other. Their body mass was supported and manoeuvred by the hands, which was posterior to the body. They rolled from the starting position down to the superior portion of the popliteal fossa and back.

Iliotibial Band

Subjects were in a side-lying position just inferior to the greater trochanter; participants placed the free lower extremity anterior to the supported extremity. They rolled down to just superior to the lateral condyle and came back with the free foot guiding the movement.

Gluteals

Subjects were in a position just inferior to the posterior portion of the iliac crest on the lateral portion of the gluteal region, participants were cross 1 foot over the opposite knee in figure-4 formation while supporting the body on the one hand. Using the support hand, they rolled down to a position superior to the gluteal fold and back.

Procedure of group B (Vibration therapy)

A vibration treatment was applied to those Muscles in which DOMS was induced. The treatment was given using a handheld Vibrator (Dynamic Tissue Stimulation). A total of 25-minute approx treatment was given while the subjects were lying on a massage table, and the head of the vibration machine (10 cm in diameter) was applied to the Quadriceps, Adductors, Hamstring, Iliotibial band, Gluteals muscles. A semi-permanent ink pen was used to mark the skin to stimulate the same sites over days. In the present study, the vibration treatment was applied not only for the muscles that were mainly used in the exercise but also for other muscles and other sites of the body in the belief that the treatment might enhance lymphatic flow around the upper body to reduce swelling, which was assumed to be the main effect of the vibration treatment on eccentric exercise-induced muscle damage (Lau and Nosaka, 2011).

Outcome measure

NPRS (Numerical Pain Rating Scale)

The NPRS was designed to measure a subject's perceived pain level on an 11-point scale (0 indicating "no pain" and ten the "worst pain imaginable" (Singla *et al.*, 2015).

Blood serum CK test

This was done by a trained lab technician in haematology lab of SGT Hospital, Gurugram. Approximately 5ml of blood was drawn from the antecubital vein by a standard venipuncture technique, allow to clot at room temperature, and centrifuged for 10 min. At 4 degree Celcius to obtain serum. Serum CK activity was determined spectrophotometrically by an automatic blood analyzer. Using a Standard test kit (Smith *et al.*, 1994a).

Sprint Speed 30-meter test

Participants performed a 30-m sprint on an indoor synthetic track. They completed two submaximal sprint trials of increasing intensity with a 4-minute break between trials. Next, two maximal sprint trials were completed with a 4-minute break between trials. During the break, participants were asked to perform semi-active recovery as they walked slowly back to the starting line. A stopwatch was used to record the time of the sprint. Participants were instructed to start and were encouraged to give maximal effort when they were ready. The faster of the two trials was used for analysis (Pearcey *et al.*,

2015).

Vertical Jump Test

The subjects were standing straight beside a high wall and raised their hand. To measure their standing reach, they touched the wall as high as they can with their fingers. They put chalk on the fingertips and were asked to make a temporary mark on the wall. The athlete then jumped as high as they can from a flat-footed position and tried to touch the highest point on the wall they can. The distance between the first mark on the wall (standing reach) and the highest point on the wall (point of highest jump) was the subjects standing vertical jump height. A tape measure was used to measure from the first point to the second (Petschnig *et al.*, 1998).

Range of motion of Hip joint measured by a goniometer

For measuring hip Flexion fulcrum of the goniometer was centred over the lateral aspect of the hip joint, using the greater trochanter of the femur for reference. Align proximal arm with the lateral midline of the pelvis. Align distal arm with the lateral midline of the femur, using the lateral epicondyle as a reference.

Goniometer alignment For measuring extension-Center fulcrum of the goniometer over the lateral aspect of the hip joint, using the greater trochanter of the femur for reference Align proximal arm with the lateral midline of the pelvis Align distal arm with the lateral midline of the femur, using the lateral epicondyle as a reference.

Goniometer alignment for measuring Abduction; Center fulcrum of the goniometer over the anterior superior iliac spine (ASIS) of the extremity being measured Align proximal arm with an imaginary horizontal line extending from one ASIS to the other Align distal arm with the anterior midline of the femur, using the midline of the patella for reference. Palpate the midpoint between the femoral epicondyles to confirm that the midline of the patella is not displaced medially or laterally (Nussbaumer *et al.*, 2010).

Data collection

Readings were taken for pain, blood creatinine level, hip range of motion(flexion, extension, abduction), vertical jump height and sprint speed tests respectively on day 1^{st}(before inducing DOMS), day 3^{rd}(after 24 hrs) and day 4^{th}(after 48 hrs).

Statistical Analysis

Data analysis was performed with the software package IBM SPSS 21. Mean and standard deviation of all dependent variables of both the groups was calculated. Comparison between the groups for all the variables (NPRS score, Blood Creatinine level, Vertical Jump, Sprint Speed and Hip range of motion) was made on 1^{st} day, 3^{rd} and 4^{th}-day using independent t-test. Comparison of the effect of training within the groups on 1^{st} day, 3^{rd} and 4^{th} day for all the variables was done using one way ANOVA followed by post hoc analysis. The significance level was set at 95% ($p \leq 0.05$).

RESULTS AND DISCUSSION

Baseline characteristics of 30 subjects who have completed the intervention are shown in Table 1. There was no significant difference in baseline measurements and demographics of the subjects in both the groups.

The statistical analysis results showed that the blood creatinine level, sprint speed, vertical jump height and pain improved in both the groups but group B showed much better results statistically than group A results in terms of all the variables.

1. In the present study, Foam Rolling (GROUP-A), there was an improvement in all the parameters. On comparing the values of baseline to 4th day, the following percentage change was noticed
2. 2.66%(flexion), 21.24%(extension) and 8.06%(abduction) improvement in hip range of motion
3. 9.30% improvement in vertical jump height,
4. 13.90% improvement in sprint speed
5. 77.72% improvement in blood CK level and
6. 75.05% reduction in pain when compared with the baseline values.
7. And Vibration therapy (GROUP-B) also improved in all the parameters. On comparing the values of baseline to 4th day, the following percentage change was noticed.
8. 2.77%(flexion), 25.87%(extension) and 8.87%(abduction) improvement in hip range of motion
9. 11.68% improvement in vertical jump height,
10. 19.04% improvement in sprint speed,
11. 77.80% improvement in blood creatinine level and
12. 76.90% reduction in pain when compared with the baseline values.

Table 1: Subjects baseline characteristics represented as Mean ± SD

Variables	Group A	Group B (Mean ± SD)	t-value	p-value
Age	(19.27 ±1.10)	(19.20 ±1.08)	0.28	0.24NS
Height	(171.93±5.13)	(170.13 ±2.74)	0.71	1.00NS
Weight	(69.40±5.24)	(70.07 ±6.19)	1.59	0.31NS
BMI	(23.53 ±2.12)	(24.24 ±2.46)	0.63	0.17NS
NPRS	(3.00 ±0.00)	(3.00 ±0.00)	0.05	0.25 NS
Blood Creatinine Level	(312.87 ±89.70)	(320.73 ±110.05)	5.25	0.27 NS
Sprint Speed Test	(7.13 ±1.55)	(6.83 ±1.31)	-0.07	0.41NS
Vertical Jump Height	(92.53±4.43)	(91.53 ±4.76)	0.08	0.27NS
Hip ROM (Flexion)	(127.80 ±2.67)	(127.07±3.43)	0.02	0.59NS
Hip ROM (Extension)	(11.60 ± 1.50)	(11.60 ±1.24)	-0.13	0.71NS
Hip ROM (Abduction)	(28.87± 1.55)	(27.87 ± 1.88)	0.25	1.21NS

Figure 1: Foam rolling for Hams(A), Quads(B), Gluteals(C), Adductors(D), IT band(E)

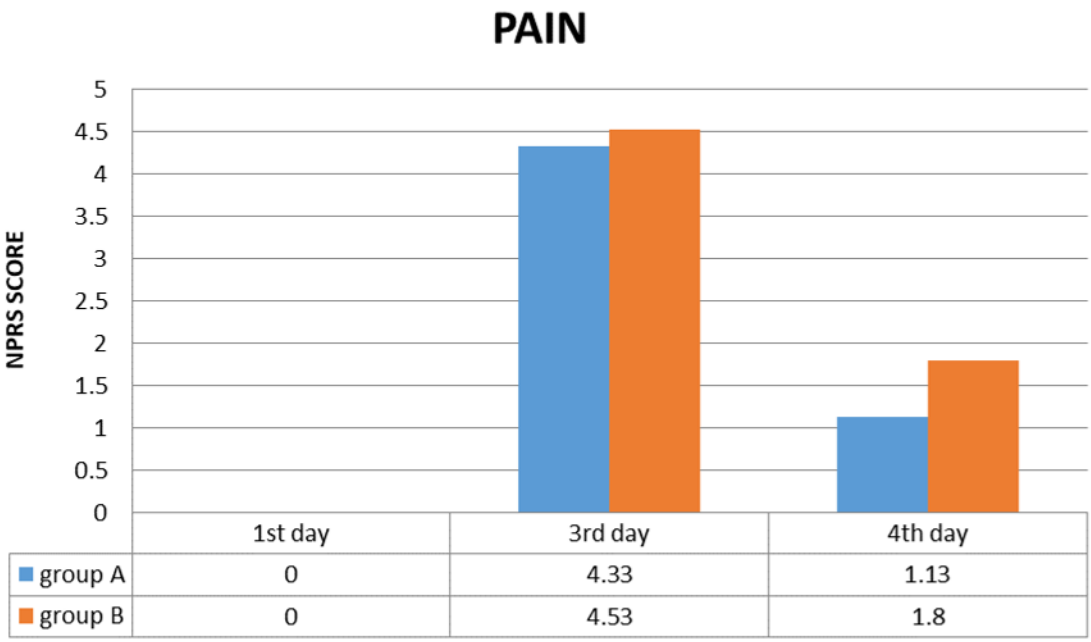

Figure 2: Comparison of NPRS score between group A and Group B

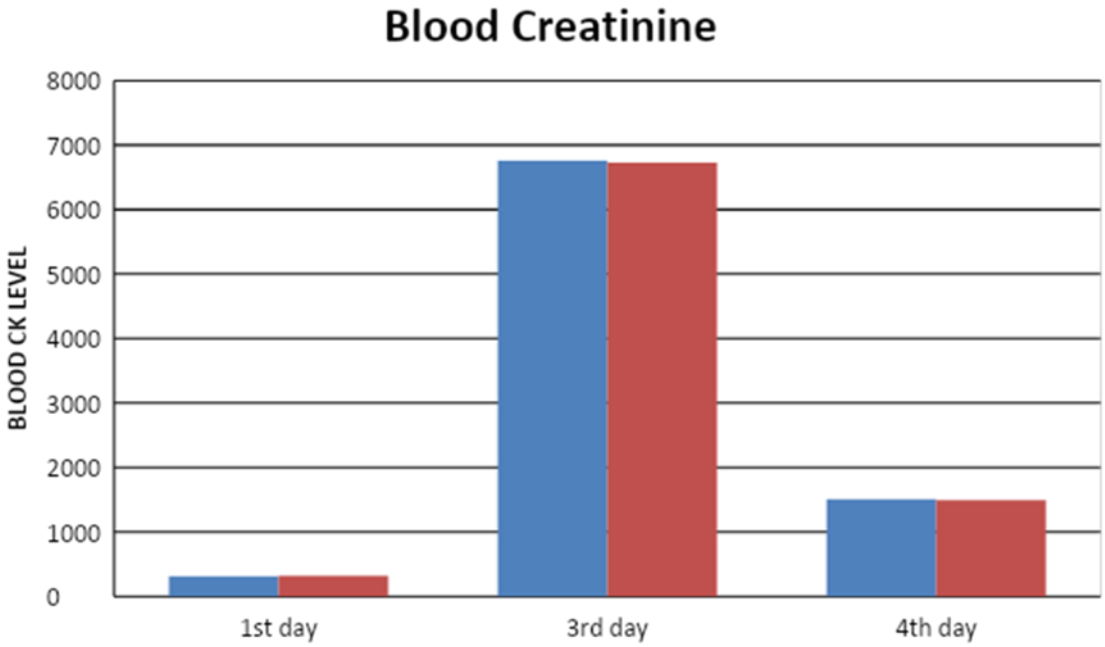

Figure 3: Comparison of Blood Creatinine score between group A and Group B

Changes in NPRS Score

Figure 2 presents the difference of NPRS score measure in both the groups. Mean and SD of NPRS score on day 1, post-intervention on 3^{rd} day and 4^{th} day in Group A was 0.00±0.00, 4.53±1.35 and 1.13±0.64 respectively. In Group B, the mean and SD value of NPRS score was at day 1, post-intervention on, 3^{rd} day and 4^{th} day was 0.00±0.00, 4.33±1.34 and 1.00±0.75 respectively. The between-group analysis of the NPRS score using independent t-test showed that there was no significant difference between both groups at baseline ($p > 0.05$) and significant difference on 4^{th} day ($p<0.05$). Also, a significant difference was seen on the 4^{th} day ($p<0.05$).

Changes in Blood Creatinine level

Figure 3 presents the difference of Blood creatinine level measure in both the groups. Mean and SD of blood creatinine level on day 1, post-intervention on 3^{rd} day and 4^{th} day in Group A was 320.73±110.00, 6727.87±800.05 and 1493.13±272.45 respectively. In Group B, the mean and SD value of blood creatinine at day 1, post-intervention on 3rd day and 4^{th} day was 312.87±89.70, 6756.87±751.34 and 1505.27±232.24 respectively.

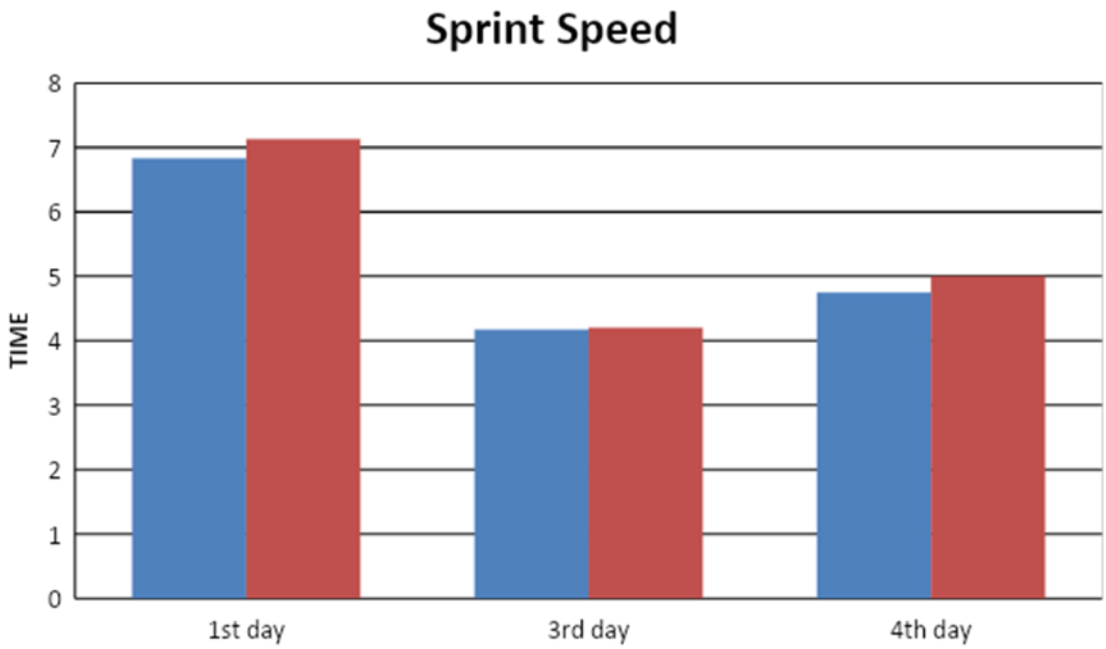

Figure 4: Comparison of Sprint Speed between group A and Group B

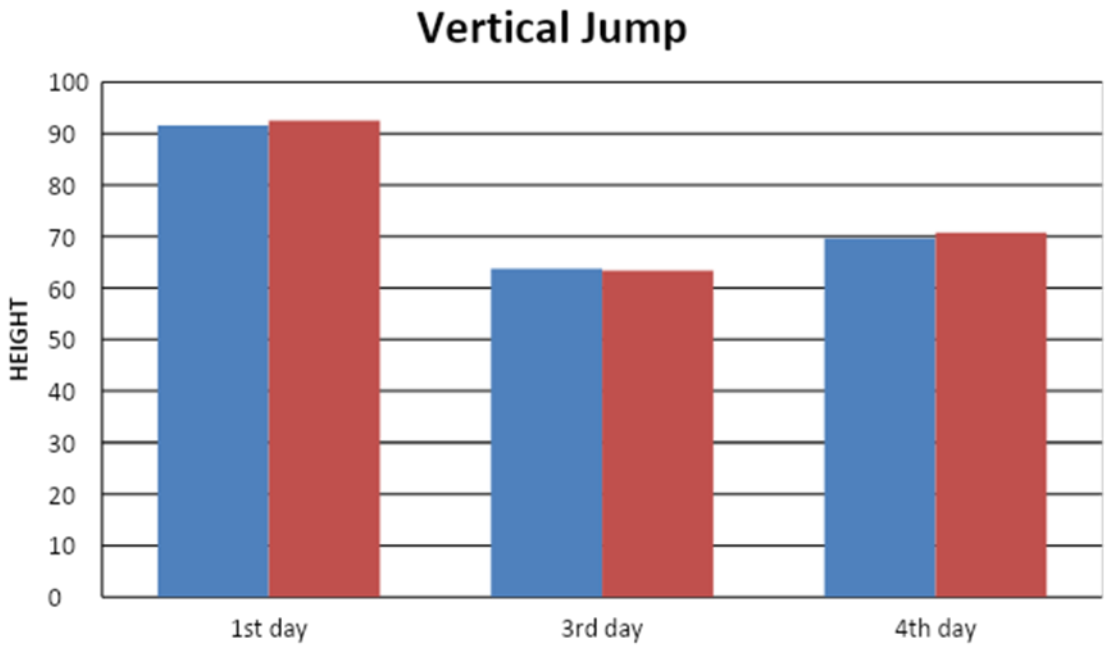

Figure 5: Changes in Vertical jump height score

The between-group analysis of the Blood Creatinine using independent t-test showed that there was no significant difference between both groups at baseline ($p > 0.05$) and significant difference on 3rd ($p<0.05$). Also, a significant difference was seen on the 4^{th} day ($p<0.05$).

Changes in Sprint speed

Figure 4 Presents the difference of Sprint speed measure in both the groups. Mean and SD of Sprint speed on day 1, post-intervention on 3^{rd} day and 4^{th} day in Group A was 6.83 ± 1.31, 4.17 ± 1.14 and 4.75 ± 1.32 respectively. In Group B, the mean and SD value of Sprint speed was at day 1, post-intervention on, 3^{rd} day and 4^{th} day was 7.13 ± 1.55 and 4.20 ± 1.37 and 5.00 ± 1.19 respectively. The between-group analysis of the Sprint speed using independent t-test showed that there was no significant difference between both groups at baseline ($p > 0.05$) and significant difference on 3^{rd} day ($p<0.05$). Also, a significant difference was seen on the 4^{th} day ($p<0.05$).

Changes in Lower limb power

Figure 5 Presents the difference of Vertical jump measure in both the groups. Mean and SD of Sprint

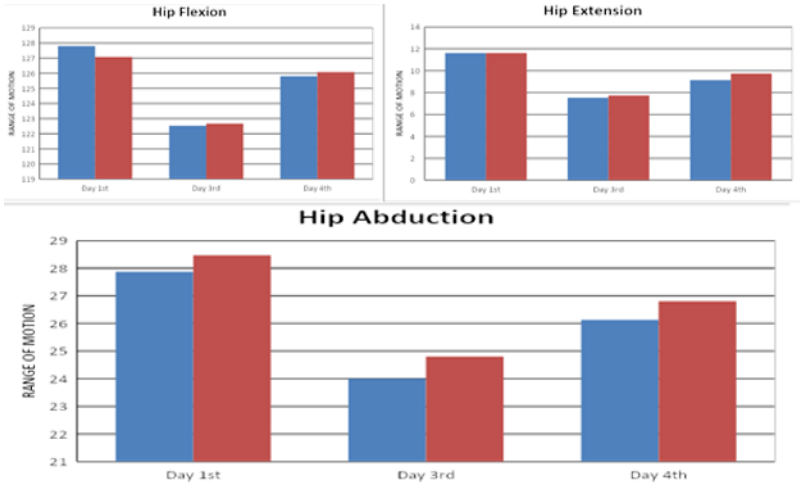

Figure 6: Showing Hip Range of motion changes between 2 groups

speed on day 1, post-intervention on 3^{rd} day and 4^{th} day in Group A was 91.53±4.76, 63.71±4.11 and 69.64±4.33 respectively. In Group B, the mean and SD value of Vertical jump was at day 1, post-intervention on, 3^{rd} day and 4^{th} day was 92.53±4.43, 63.33±4.25 and 70.73±1.90 respectively. The between-group analysis of the vertical jump using independent t-test showed that there was no significant difference between both groups at baseline ($p > 0.05$) and significant difference on 3^{rd} day ($p<0.05$). Also, a significant difference was seen on the 4^{th} day ($p<0.05$).

Changes in Hip Range of Motion

Figure 6 Presents the difference of hip range of motion(flexion, extension and abduction) measure in both the groups. The between-group analysis of the hip range of motion(flexion) using independent t-test showed that there was no significant difference between both groups at baseline ($p > 0.05$) and significant difference on 3rd day ($p<0.05$). Also, a significant difference was seen on the 4^{th} day ($p<0.05$). The between-group analysis of the hip range of motion(extension) using independent t-test showed that there was no significant difference between both groups at baseline ($p > 0.05$) and significant difference on 3^{rd} day ($p<0.05$). Also, a significant difference was seen on the 4^{th} day ($p<0.05$). The between-group analysis of the hip range of motion(abduction) using independent t-test showed that there was no significant difference between both groups at baseline ($p > 0.05$) and significant difference on 3rd day ($p<0.05$). Also, a significant difference was seen on the 4^{th} day ($p<0.05$).

The present study was conducted to investigate the effect of foam rolling and vibration therapy in DOMS on blood creatinine level, hip range of motion, sprint speed, vertical jump height and pain in collegiate students. The statistical analysis results showed that the blood creatinine level, sprint speed, vertical jump height and pain improved in both the groups but group B showed much better results statistically than group A results in terms of all the variables.

Effect of Intervention on Creatinine Kinase

It is a haematological test, Increases in serum levels of CK are used as an indirect marker of the microtrauma associated with DOMS. The result of this study shows that the blood CK level decreased 77.72% in group A that is foam rolling and 77.80% in group B that is vibration therapy after the 4^{th} day of treatment.

Our result is following the result published by Bakhtiary A. H. et al. in the year 2006, who also found that vibration therapy was effective to alleviate the effect of DOMS. In his study, he gave the physiological basis that vibration provides stimulation to muscle spindle and increases the afferent activities of muscle spindles, which may increase background tension and motor unit activity synchronization in the vibrated muscles and reduce the ck level (Aminian-Far *et al.*, 2011).

Krilov et al. reported that for better relaxation and faster restoration of the athlete's body, massage should be given after 2 to 3 hours of rest following exercise (Smith *et al.*, 1994b).

The initial accumulation of neutrophils occurs within a few hours after the onset of tissue injury and appears to be crucial to the subsequent manifestation of inflammatory events.

Effect of Intervention on Vertical Jump Height

It is a fitness test whose purpose is to measure the leg muscle power. The result of this study shows that the vertical jump height was increased by 9.30% in group A that is foam rolling and by 11.68%

in group B that is vibration therapy after the 4th day of treatment.

On the application of vibration, the motor neuron may become synchronized and result in more force production by the muscle group. Vibration may cause motor unit activation, synchronization between muscle spindles, reflexive recruitment of previously inactive motor units which leads to more force production for the exercise. Consequently, distribution of exercise load (contractile stress) over a larger number of active fibres, this prevents muscle damage or less reduction of ROM.

Bosco et al. (1999) concluded that the increase in power in generation capacity is due to the neural adaptation by the application of vibrations. (Cardinale and Bosco, 2003) Bakhtiary et al. (2007) concluded that decrease in strength after eccentric exercise could be prevented by the application of vibration which may increase the activity of muscle spindle and hence increase the background tension of skeletal tension (Aminian-Far *et al.*, 2011).

Effect of Intervention on Pain

Pain is an uncomfortable feeling which tells that something is wrong in the body, NPRS (Numerical Pain Rating Scale). The NPRS has been designed to measure a subject's perceived pain level on an 11-point scale (0 indicating "no pain" and 10 the "worst pain" imaginable

The result of this study shows that the pain decreased by 75.05% in group A that is foam rolling and by 76.90% in group B that is vibration therapy after the 4^{th} day of treatment.

Pain is decreased by vibration therapy effectively in our study which is accordance a study done by Lundeberg et al., concluded that vibration relieved the pain by activating the large diameter fibres while suppressing the transmission activity in small-diameter fibres. Vibration therapy prevents sarcoma disruption, which occurs due to the strain of eccentric exercises and thus helps in preventing DOMS. Vibration therapy leads to an increase in skin temperature and blood flow. Application of 50 Hz vibration can considerably reduce Interleukin-6 and Lymphocyte, which laterally converts into macrophages and cause further disruption of the WBC and RBC. They found no significant but substantial increase in neutrophils 24 hours post-exercise. Increase neutrophils recruitment is suggestive of the increased capacity of fight infection and reduced inflammation (Singla *et al.*, 2015).

Effect of Intervention on hip range of motion

The result of this study shows that hip ROM was increased by 2.66%(flexion), 21.24%(extension) and 8.06% (abduction in group A that is foam rolling and 2.77%(flexion), 25.87%(extension) and 8.87%(abduction) in group B that is vibration therapy after the 4th day of treatment.

The result is in accordance with the result by Bakhtiaryetal, 2007 showed that on the application of vibrator, the motor neuron might become synchronized and result in more force production of the muscle group. Vibration may cause motor unit activation, synchronization between muscle spindles, reflexive recruitment of previously inactive motor units which leads to more force production for the exercise. Consequently, distribution of exercise load (contractile stress) over a larger number of active fibres, this prevents muscle damage or increase of range of motion. The Cohen effect size showed that the effect of vibration treatment on ROM was large. It is important to note that the positive findings in DOMS and ROM did not extend to significant findings for muscle strength, swelling, or blood markers for muscle damage. This was not surprising because it has been documented in other studies that there is no association between the magnitude of DOMS and the magnitude of change in other markers of muscle damage.

Scott W. Cheatham et al. in the year (2015) conducted the research suggesting that both foams rolling and the roller massage may offer short-term benefits for increasing sit and reach scores and joint ROM at the hip, knee, and ankle without affecting muscle performance (Wiewelhove *et al.*, 2019).

Effect of Intervention on sprint speed

The result of this study shows that the sprint speed was increased by 13.90%in group A that is foam rolling and by 19.04% in group B that is vibration therapy after the 4th day of treatment. The result is supported by Paradisis and Zacharogiannis (2007). The results of their study indicate that the gain of the step length was more significant than the decrease of the step rate, so the net effect was an improvement of the running velocity. the vibration training period of 6 weeks, through the muscle contractions, produced significant positive changes in selected kinematical characteristics of sprint running (step length, step rate and running velocity) and selected explosive strength characteristics (jump height, the total number of jumps performed in a period of 30 s) in non experienced sprinters (Giorgos and Elias, 2007).

At motor unit level, it is suggested that the tonic vibration reflex affects primarily the ability of the participants to generate high firing rates in high-threshold motor units. During a vibration training stimulus, skeletal muscles undergo small changes in

muscle length, most likely since mechanical vibration is able to induce a tonic excitatory influence on the muscles exposed to it called "tonic vibration reflex". This reflex activates the muscle spindles, mediates the neural signals by afferents, and finally, activates the muscle fibres via large α-motoneurons.

The tonic vibration reflex is also able to cause an increase in recruitment of the motor units through activation of muscle spindles and polysynaptic pathways and increase facilitation of the reflex action on the motoneuron pool, probably resulting in a more rapid activation and training of high-threshold motor units (Bongiovanni *et al.*, 1990).

Scott W. et al. research suggests that foam rolling may offer short-term benefits for increasing sit and reach scores and joint ROM at the hip, knee, and ankle without affecting muscle performance. It has been postulated that DOMS is primarily caused by changes in connective tissue properties and foam rolling or roller massage may influence the damaged connective tissue rather than muscle tissue. This may explain the reduction in perceived pain with no apparent loss of muscle performance.

Another postulated cause of enhanced recovery is that it increases blood flow, thus enhances blood lactate removal, oedema reduction, and oxygen delivery to the muscle may be due to improvement in pain and ROM (Wiewelhove *et al.*, 2019).

Limitations

One limitation of the study is the fact that the effect of the intervention was studied only on the dominant leg; female participants were omitted; a healthy population was taken for study.

CONCLUSIONS

In conclusion, the results obtained from this study demonstrate that both vibration therapy and foam rolling was effective in causing early recovery post-exercise-induced muscle damage. Still, Vibration therapy group was found statistically superior in terms of alleviating of pain and increasing ROM. Performance variables which are also known as skill-based variables like lower limb power and sprint speed also improved in both the groups with statistically significant improvement seen in Vibration therapy group compared to the Foam rolling group. The findings are clinically relevant, so vibration therapy can be used to alleviate the effect of delayed onset muscle soreness.

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Conflict of Interest

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