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The Biomechanical Effects of Percussive Therapy Treatment on Jump Performance

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ABSTRACT

International Journal of Exercise Science 15(1): 994-1006, 2022. Percussive therapy treatment is one form of myofascial release that has gained popularity amongst the sport community. It has been suggested that percussive therapy treatment may improve range of motion and improve athletic performance, but these claims are largely anecdotal. Currently, the effects of percussive therapy treatment on performance of athletic tasks is relatively unknown. Therefore, the purpose of this research was to assess the effects of percussive therapy treatment on jump performance and passive range of motion. Twenty-six recreationally active college individuals performed countermovement jump and drop jump activities on two different days (one day with and one day without the use of percussive therapy treatment). Three-dimensional kinematics and kinetics were assessed during the jump activities. Passive range of motion was additionally assessed before and after warm up. A significant decrease in peak ankle eversion (2.0° during landing and 2.4° during take-off) was evident during the drop jump following the use of percussive therapy. All other frontal/sagittal plane peak joint angle and moment changes were nonsignificant. The hip and knee flexors and ankle extensors all showed increases in passive range of motion following treatment. Athletes who use percussive therapy treatment prior to physical activity will not have any adverse effects on performance or increased risk of injury. Muscles with lower levels of flexibility might be more susceptible to strain or injury. Percussive therapy treatment increased range of motion, which might help decrease the risk of injury.

KEY WORDS: Range of motion, kinematics, kinetics, ground reaction force

INTRODUCTION

Fascia has been found to help with force transmission, movement, and postural control (15). It has been suggested that stresses on the muscle may lead to fascia tightness due to inflammation. As a result, muscle might lose its pliability and be prevent from reaching its full length (15). Furthermore, stresses on the fascia could lead to fibrous adhesions, which have been shown to inhibit normal mechanics of the muscle and lead to a decreased ability to reach full length

(6).This change in mechanics could also lead to a decrease in joint range of motion (ROM), muscle strength, and soft-tissue extensibility (27).

Adequate levels of joint ROM are necessary for sport performance, and therefore a lack of tissue extensibility can impair sport performance and potentially put athletes at increased injury risk. Padua et al. suggested that an increase in ankle dorsiflexion ROM can help decrease the risk of an ankle sprain as reduced levels of ankle dorsiflexion ROM might impair balance (33). Additionally, reductions in ankle dorsiflexion ROM affect basketball players and can lead to more erect landings (33), which can be problematic as the reduction in ankle ROM can also lead to a decrease in knee flexion ROM during drop landings (21). Furthermore, the overall increase in stiffness during landing might also increase vertical ground reaction force (GRF), which can lead to a greater risk of knee or ankle injury (21).

Reduction in injury risk and increased performance are two primary goals of athletes when setting up training and treatment plans. Myofascial release (MR) has been found to help decrease fibrous adhesions and tightness in muscles (6), which can aid in ROM improvements. There are different methods that can be used as part of MR, one of those techniques includes manual massage (15). Manual MR is typically performed by a clinician and can last up to 90 minutes (6). However, a modality which has gained attention recently is self-myofascial release (SMR), which is a cheaper and more readily available alternative that has been found to mimic manual MR and has been theorized to have similar therapeutic effects (6). SMR is often performed by the individual and is achieved through the use of roller massage bars, foam rollers, vibrating roller devices, and percussive therapy treatment (29). It should be noted that the term SMR has been a point of discussion as to whether this is the most accurate term to describe the technology employed in this study and it is debatable as to whether a different term, such as “rolling” is more appropriate (7).

Literature has found improvements in passive ROM of the ankle, knee, and hip joints after SMR through foam rolling (13). Lack of hip and knee ROM may lead to an increased risk of injury, especially in sports that require a lot of jumping and sprinting (37). Reduced ROM has also been found to decrease movement efficiency, thus further emphasizing the importance of maintaining and recovering ROM for injury prevention and performance gains (28). SMR with the use of a foam roller has been suggested to enhance performance because it increases mobility and neuromuscular efficiency (18) and provides an acute improvement on joint ROM and delayed onset muscle soreness (27). Additionally, improvements in knee joint ROM and pressure pain threshold have been shown after a foam roller intervention, both with and without active motion during the rolling session (10), thus illustrating the breadth of impact in terms of techniques. However, research has found that foam rolling has a very small effect on jump performance and quadriceps and hamstrings strength (22). Similarly, Kalichman and David found that foam rolling did not induce any significant changes in jump height or explosive strength (23). Improved ROM without any detrimental effects on jump height could potentially aid in the longevity of an athlete as the increased ROM has been suggested to decrease injury risk (37). A systematic review conducted in 2015 found that the use of both foam rollers and roller massage has short-term benefits on the increase of joint ROM while not having any negative impact on muscular performance. Furthermore, the authors suggested the use of these modalities may help with DOMS and decreased muscular performance after intense bouts of activity (9). As percussive therapy treatment gains popularity, it becomes important to assess its effect on these same criteria to ensure that this version of SMR does not hinder athletic performance or contribute to an increase in injury risk. Percussive therapy is a newer version of SMR that is gaining traction in the sport community. It is usually performed through a motorized handheld device which creates a percussive reverberation through the muscle as the attachment head at the end of the device cyclically hits the muscle tissue.

The countermovement jump (CMJ) is a common technique used to assess lower extremity muscular power (3). Jump height and power output are two variables of the CMJ that help determine sports performance (25). While stretching is often conducted prior to jumping activities, acute stretching has been found to decrease maximal force production and jump height performance (32). However, Baumgart et al. found that SMR with the use of foam rollers did not have adverse effects on jump height performance (5). Often used alongside the CMJ, the drop jump (DJ) has been used in the past to enhance performance and to help assess injury-risk of the lower extremities (34). Howe et al. suggests that higher ROM might lead to lower GRF during the DJ (21). Limitations in dorsiflexion ROM might also lead to a decrease in knee and hip flexion during jump landings (21). It has been suggested that landing mechanics should be optimized to help decrease the risk of injury when performing jumping activities (17). According to Avedesian et al., higher knee adduction angles have been associated with an increase in anterior cruciate ligament (ACL) injury risk (2), which can occur during jump landings. Additionally, it has been suggested that a reduction in plantar flexion and knee extension moments during landing might lead to a reduction in force absorption (24). This decrease in the sagittal plane might lead to an increase in the frontal plane, thus increasing the risk for soft tissue injuries. Jumping is a predominantly sagittal plane motion as the ankles, knees, and hips move through a flexion/extension pattern to create a vertical movement (i.e. enhance jump height). Frontal plane movements (abduction/adduction) are not believed to contribute to the movement performance and can place the body in a more compromised position which could lead to joint injuries (2).

Currently it is unknown how percussive therapy treatment impacts both the jumping performance and landing performance from a biomechanical perspective. The purpose of this study was to assess the benefits of percussive therapy treatment as a warm up tool on passive joint ROM at the hip, knee, and ankle as well as performance and landing kinematics and kinetics during a CMJ and DJ, respectively. It was hypothesized that there would be 1) an increase in passive joint ROM of the hip, knee, and ankle immediately after treatment, 2) an increase in peak sagittal plane angles and a decrease in peak moments at the hip, knee, and ankle, 3) a decrease in peak frontal plane knee abduction angles and moments, and 4) an increase in jump height immediately after percussion treatment.

METHODS

Participants

Approval was granted from the CSULB Institutional Review Board and each participant signed an informed consent form prior to participation. This research was carried out fully in accordance to the ethical standards of the International Journal of Exercise Science (31). An a-priori power analysis was performed using G*Power (Version 3.1, Christian Albrechts University, Kiel, Germany). Right ankle dorsiflexion range of motion from Padua et al. (33) using a pre- and post-test experimental group showed a need for 21 subjects, which provided 80% power at an alpha level of 0.05. A total of 26 (11 females, 15 males, age 25.5 ± 2.5 years, mass 71.13 ± 14.89kg and height 1.69 ± 0.10m) healthy, recreationally active college students with at least 6 months of volleyball or basketball playing experience volunteered for the study. Any history of lower extremity surgery or injuries in six months prior to the study were excluded from participation.

Protocol

To assess the effects of percussive therapy treatment (PTT), the study involved participants performing CMJ and DJ trials immediately after warm up with and without percussive therapy involved on two separate days. On day 1, participants were instructed to warm up for 5 minutes on the cycle ergometer at a self-selected speed. Participants were then instructed to perform three submaximal CMJs and DJs after the warm up. In order to perform the CMJ, instructions were given to stand with one foot on each force plate with hands on their hips. Participants were instructed to perform a fast-downward movement to squat as fast as possible, followed by a quick vertical movement to jump as high as possible. For the DJ trials, participants were instructed to stand on the box and drop into a jump with both legs landing simultaneously. Similar to the CMJ, participants were instructed to place their hands on their hips and jump as high as possible immediately following landing.

Passive ROM of the joints were measured after the warm up and practice jump trials were completed. A goniometer was utilized to measure iliopsoas and rectus femoris tightness (Thomas test), hamstring tightness (90-90 test), and ankle dorsiflexion tightness (ankle lunge test). During the Thomas test, the participants were lying supine at the edge of the table with both legs hanging freely off the table (38). The participant then pulled the contralateral leg to their chest using both arms to flex the hip and the knee. To measure iliopsoas tightness, the fulcrum of the goniometer was placed on the hip joint, with the stationary arm at the trunk and movement arm measuring the femur. To measure rectus femoris tightness, the fulcrum of the goniometer was placed on the knee joint, with the stationary arm at the femur and the movement arm measuring the tibia.

During the 90-90 test, the participants were lying supine on the table with both their hip and knee placed at 90 degrees of flexion (38). The hip was stabilized at 90 degrees while the knee was then passively extended until the first sign of resistance was felt. The fulcrum of the

goniometer was placed at the knee joint, with the stationary arm at the femur and movement arm measuring the tibia.
During the ankle lunge test, the participants stood with one foot in front of the wall and the other foot resting where they felt was comfortable. The participants held on to the wall for balance and were instructed to lunge forward trying to touch their testing knee to the wall without lifting their heel off of the floor. The protocol was slightly adapted from Bennell et al. (8) and incorporated a goniometer instead of an inclinometer to measure the angle of tibia. The fulcrum of the goniometer was placed at the ankle joint, with stationary arm parallel to the floor while the moving arm measured the tibia angle. During the lunge, the PI put their hand by the heel to make sure the heel was not coming off of the floor, but no attempt was made to limit pronation or supination of the foot. All ROM measurements were performed three times by the same PI (measurements used for analysis were averaged across the three trials).

Following the range of motion trials, retroreflective markers were placed on the participant. Retroreflective markers were placed bilaterally on the following bony landmarks: iliac crest, greater trochanter, medial and lateral femoral epicondyles, medial and lateral malleoli, and first and fifth metatarsals. Four 4-marker clusters were placed bilaterally on the thighs and shanks. Additionally, two 2-marker clusters were placed on the sacral region to track the pelvis and a 4-marker heel cluster on each foot. Raw marker data were collected using a 15-Camera Qualisys Oqus 300 motion capture system (Qualisys North America, Inc. Illinois, USA) sampling at 240Hz. Two floor embedded force plates were used to collect raw force data (1200Hz, Bertec Corp., Columbus, Ohio, USA). A 30cm (12in) box was used to perform the DJ.. A static trial for model building purposes was collected after which the static markers were removed, leaving only the marker clusters for dynamic tracking. CMJ and DJ trials were then performed in a randomized order for a total of five successful trials in each condition. Trials were excluded if the participant did not land symmetrically after dropping off of the box during the DJ. One-minute rest was provided in between jumps.

Day 2 followed the same procedure while also including the use of PTT. After the range of motion assessment, PTT was performed bilaterally with the Theragun™ G3PRO (Therabody, Los Angeles, CA, speed: 40 percussions per second) on the gluteus group, hamstrings, quadriceps, calves, peroneals, and plantar surface of the foot. Total treatment time was 30 seconds per muscle group and 10 seconds on the plantar surface for a total of 2 minutes and 50 seconds. Treatment was performed using continuous tolerable pressure with the 3 by 10 seconds method of treatment, which consisted of 10 seconds each on the origin, insertion, and muscle belly moving in a medial-lateral direction. ROM was again assessed immediately after percussion treatment, followed by CMJ and DJ trials as described above for day 1.

Raw marker and force data were imported into Visual 3D Biomechanical Suite (C-Motion Research Biomechanics, Maryland, USA). A Butterworth low-pass filter with a cutoff frequency of 6Hz was utilized to filter raw marker data and a cutoff frequency of 25Hz was used to filter GRF data (1). The dominant leg was used for statistical analysis. Kinematic and kinetic variables were calculated and analyzed during the stance phase (defined as the foot being in contact with the ground) prior to the jump. The CMJ was split into two phases; the loading phase began with the onset of knee flexion from a standing posture and ended at maximum knee flexion while the take-off phase began at maximum knee flexion and ended with toe off, as evidenced by a vertical ground reaction force of < 10N. The DJ was also split into two phases: the landing phase of the DJ was defined when the participants came in contact with the force plate (force > 10N) until maximal knee flexion. The take-off phase of the DJ was defined from peak knee flexion to toe off (force < 10N). A Cardan rotational sequence X-Y-Z was used to calculate joint angles, which were polarized according to the right hand rule. Moments were calculated using inverse dynamics (reported as internal moments), normalized to body mass, and polarized according to the right hand rule. Vertical ground reaction forces were normalized to body weight (BW).

Statistical Analysis

Means and standard deviations were calculated using SPSS for Mac (Version 25.0, SPSS Inc., Evanston, IL). A paired *t*-test was used to analyze with and without treatment dependent variables. Baseline (day 1) testing and treatment (day 2) measurements were analyzed for kinetic and kinematic dependent variables (peak joint angles and internal moments in the sagittal and frontal plane of the hip, knee, and ankle, vertical ground reaction force, and jump height). ROM measurements (Iliopsoas, Rectus Femoris, 90-90 Hamstring, and Ankle Lunge) were analyzed using two measurements from day 2 of testing; pre-treatment and post-treatment. Significance levels were set at $i < 0.05$ for all tests.

RESULTS

There were no significant differences at the ankle, knee, and hip joints between baseline and treatment. Specifically, peak joint angles, internal moments, and GRF_{peak} during the loading and take-off phases of the CMJ were similar between both days (Table 1). Jump height did not diminish after PTT was performed.

Peak ankle eversion angles were significantly decreased in both the loading and take off phases following PTT (Table 2). There were no other significant differences evident in peak angles, moments, GRF_{peak}, or jump height during the DJ.

The Iliopsoas, 90-90 test, and ankle lunge test all demonstrated increased ROM following treatment ($p < 0.001$ for all tests, Table 3). The Iliopsoas increased by 4.5˚. The 90-90 Test increased by 3.4˚, and the Ankle Lunge increased by 3.9˚. However, PTT did not improve Rectus Femoris passive ROM.

Table 1. Peak joint angles, internal moments, and vertical ground reaction force (GRF) during the loading and take off phases of the countermovement jump (Mean ± STD)

	Loading Phase			Take Off Phase		
Peak Angles (°)						
	Pre	Post	*p-value*	Pre	Post	*p-value*
Ankle Dorsiflexion	25.1 ± 5.0	25.3 ± 4.6	0.745	57.0 ± 6.9	56.9 ± 6.7	0.920
Ankle Eversion	-6.3 ± 4.3	-6.6 ± 3.8	0.572	-7.0 ± 5.8	-5.7 ± 4.7	0.132
Knee Flexion	-81.3 ± 11.0	-82.1 ± 11.7	0.625	-81.7 ± 10.3	-81.5 ± 10.9	0.904
Knee Adduction	17.5 ± 7.5	18.5 ± 6.8	0.347	16.4 ± 7.3	16.8 ± 6.0	0.682
Hip Flexion	70.9 ± 10.6	71.2 ± 12.9	0.892	68.7 ± 10.8	70.5 ± 9.9	0.305
Hip Abduction	-4.9 ± 6.8	-5.9 ± 9.0	0.453	-5.7 ± 6.7	-2.9 ± 8.3	0.537
Peak Internal Moments (Nm/kg)						
Ankle Plantarflexion	-1.09 ± 0.39	-1.08 ± 0.43	0.911	-1.39 ± 0.05	-1.39 ± 0.29	0.895
Ankle Eversion	-0.26 ± 0.14	-0.27 ± 0.14	0.339	-0.29 ± 0.14	-0.29 ± 0.18	0.974
Knee Extension	1.81 ± 0.41	1.82 ± 0.41	0.793	1.83 ± 0.38	1.84 ± 0.40	0.746
Knee Adduction	0.22 ± 0.19	0.25 ± 0.19	0.201	0.22 ± 0.17	0.25 ± 0.19	0.075
Hip Extension	-2.36 ± 0.71	-2.41 ± 0.56	0.553	-2.27 ± 0.58	-2.32 ± 0.50	0.431
Hip Abduction	-0.38 ± 0.24	-0.38 ± 0.26	0.867	-0.90 ± 0.62	-0.84 ± 0.37	0.617
GRF_{peak} (BW)	1.15 ± 0.19	1.16 ± 1.80	0.671	1.21 ± .02	1.21 ± 0.22	0.946

Table 2. Peak joint angles, internal moments, and vertical ground reaction force (GRF) during the loading and take off phases of the drop jump (Mean ± STD)

	Landing Phase			Take Off Phase		
Peak Angles (°)						
	Pre	Post	*p-value*	Pre	Post	*p-value*
Ankle Dorsiflexion	38.2 ± 11.2	38.5 ± 10.8	0.802	56.0 ± 6.0	56.2 ± 6.1	0.820
Ankle Eversion	-6.3 ± 5.3	-4.3 ± 4.8	0.018*	-7.8 ± 5.3	-5.5 ± 4.4	0.008*
Knee Flexion	-65.4 ± 10.3	-64.6 ± 10.6	0.636	-83.0 ± 10.3	-81.0 ± 12.2	0.318
Knee Adduction	11.6 ± 7.7	12.7 ± 7.5	0.205	14.1 ± 7.0	14.8 ± 6.9	0.526
Hip Flexion	44.0 ± 9.5	45.2 ± 10.7	0.449	65.0 ± 9.4	65.8 ± 9.1	0.607
Hip Abduction	-0.3 ± 5.7	-2.11 ± 7.0	0.142	-1.2 ± 6.0	-2.9 ± 8.1	0.194
Peak Internal Moments (Nm/kg)						
Ankle Plantarflexion	-1.31 ± 0.38	-1.36 ± 0.39	0.202	-1.49 ± 0.35	-1.51 ± 0.36	0.672
Ankle Eversion	-0.30 ± 0.16	-0.33 ± 0.15	0.090	-0.23 ± 0.31	-0.26 ± 0.36	0.097
Knee Extension	1.81 ± 0.41	1.82 ± 0.41	0.793	1.83 ± 0.38	1.85 ± 0.40	0.746
Knee Adduction	0.49 ± 0.19	0.50 ± 0.19	0.551	0.25 ± 0.38	0.27 ± 0.40	0.256
Hip Extension	-3.44 ± 1.37	-3.36 ± 1.02	0.553	-2.40 ± 0.59	-2.45 ± 0.54	0.431
Hip Abduction	-3.44 ± 1.34	-3.36 ± 1.02	0.639	-0.90 ± 0.62	-0.84 ± 0.37	0.419
GRF_{peak} (BW)	1.85 ± 0.37	1.80 ± 0.41	0.379	1.27 ± 0.23	1.28 ± 0.25	0.667

*Significant difference between pre- and post-treatment (p-value < 0.05).

Table 3. Passive ROM and Jump Height Testing Measurements (Mean ± *STD*)

	Pre-Test	Post-Test	*p*-value
Iliopsoas (°)	-9.1 ± 7.8	-13.6 ± 8.9	**< 0.001**
Rectus Femoris (°)	49.6 ± 5.6	50.2 ± 5.6	0.367
90-90 (°)	58.2 ± 9.6	61.7 ± 10.2	**< 0.001**
Ankle Lunge (°)	33.2 ± 8.1	37.1 ± 7.1	**< 0.001**
CM Jump Height (m)	0.4 ± 0.1	0.4 ± 0.1	0.897
DJ Jump Height (m)	0.4 ± 0.1	0.4 ± 0.1	0.388

*Significant difference from pre- to post-treatment (*p*-value < 0.05). Passive ROM measurements were taken before treatment and immediately after treatment. For Thomas ROM measurements (-) was considered hip extension and (+) was considered knee flexion.

DISCUSSION

The purpose of this study was to assess the effects of percussive therapy treatment on passive joint ROM, hip, knee, and ankle kinematic and kinetic data. This is the first study to assess the effects of PTT on vertical jump performance in the CMJ and DJ, and passive joint ROM. The main objectives of this study were to investigate the effects of PTT on sagittal and frontal plane kinetic and kinematic data in the CMJ and DJ. It was hypothesized that active joint ROM of the hip, knee, and ankle would improve immediately after 30 seconds of PTT per muscle group. The results of the study partially agreed with the hypothesis. While there were no significant differences found in the CMJ variables, there was a significant decrease post-treatment in ankle eversion of the DJ during the take-off phase of the jump. Howe et al. suggests that limited ankle ROM can lead to compensatory movements patterns, such as an increase in ankle eversion angles (21). Percussive therapy treatment increased the passive ankle ROM, which in turn seemed to eliminate the compensatory pattern by decreasing eversion angle by 2.0º (loading phase) and 2.3º (take-off phase) during the DJ. The decrease in ankle eversion might have been as a result of an increase in passive ankle dorsiflexion by 4.9º, which provides more available ROM to utilize in the sagittal plane, thereby decreasing the dependence on the frontal plane at the ankle joint. Furthermore, there were small changes in the frontal plane of the hip and knee as peak knee adduction and hip abduction increased by small, non-significant amounts during the DJ landing-phase. The non-significant changes at the hip and knee were small in magnitude but the ankle magnitude changes were also small in terms of absolute value. It is presumable that this may have resulted in a shift from the ankle to the knee and hip joints. This could potentially be a more beneficial mechanism of movement though as the hip musculature which controls frontal plane motion is substantially larger than the musculature at the ankle. This could provide a better movement platform for the jumpers, which decreases the ankle risk and transfers responsibility of the movement to a joint better equipped to handle it. This may have been a compensatory change for the reduced ankle eversion and would warrant further testing on the hip musculature to potentially confirm this idea.

Research has demonstrated that MR does not enhance or inhibit performance measures such as, vertical jump or running (11). The results of the current study revealed that PTT will not diminish vertical jump performance. Hodgson et al. investigated the effects of MR with a roller massager and found similar findings with no improvements on any of the vertical jump height performance measurements (20). Jump height has been found to decrease with increased knee and hip flexion angles (35). The current study did not demonstrate any significant increases at the hip or knee joint, indicating that the jumpers did not squat down any further despite an increased passive ROM availability. This provides the jumpers with a larger ROM to work within, meaning they were not as likely to approach the end of their available ROM. This provides the jumpers with a bigger buffer zone from their end stage ROM. While performance improvements may be desired, the lack of existence is not something to be ignored. The improvements in passive joint ROM add to the flexibility of the athlete and given that they come without diminishment in performance, these improvements should not be taken lightly. It is possible that other improvements were present, such as psychological benefits, which were not assessed. Anecdotally, most of the participants indicated that they felt great after receiving the PTT, although no quantitative record of this was kept. This opens an additional line of potential follow up research on the effects of the psychological factor in terms of physical effects on more performance-related scenarios.

In the current study symmetrical landing was required and jump styles varied for all participants. Softer landings may lead to a decrease in GRF and an increase on ground contact time (12). Increasing ground contact time has been found to be caused by an increase in joint ROM, specifically with an increase in knee flexion and hip flexion ROM (12). Additionally, bilateral DJ landings have also been found to have greater hip joint ROM because the hip is a contributor to the dissipation of forces during landing tasks. Findings of the current study agree with Howe et al. limitations in ankle dorsiflexion did not affect hip ROM or GRF_{peak} (21). The current study did not see a significant change in GRF_{peak}, which suggests that PTT does not lead to a decrease in GRF_{peak} and it will not hinder jump height performance.

Increases in knee flexion angles have been found to help decrease frontal plane angles and moments (4). The current study demonstrated no significant changes in knee flexion angles in either jump. According to Giza et al. ankle sprains or foot fractures can occur with higher ankle eversion angles (16). Percussive therapy treatment decreased ankle eversion angles in the landing phase (2.0°) and take off phase (2.3°) of the DJ. Percussion therapy did not have adverse effects on hip, knee, and ankle joint moments. According to Koshino et al., avoiding increases in internal eversion moment might help decrease ankle sprain risk (26). Kim et al. suggests that decreasing plantar flexor and knee extensor moments might lead to an increase in hip reliance during jump landings (24). Additionally, Hiller et al. found that individuals with ankle instability take longer to stabilize after landing from a jump (19). This might lead to a higher risk of lateral ankle sprains (LAS), thus affecting athletic performance (19). Lateral ankle sprains are a common injury among athletes. Simpson et al. suggests that an increase in internal inversion moments might lead to a higher risk of LAS injury (36). LAS tend to occur during sports activity, especially in basketball, football, and soccer (26). The use of PTT for the athletes involved in jumping activities does not appear to elicit this response though, indicating that PTT does not add to the risk of LAS.

Passive joint ROM was hypothesized to increase at the hip, knee, and ankle after treatment. The results demonstrated an average increase in hip extension of 4.5˚, which demonstrates that treatment was beneficial. Mohr et al. had similar findings after foam rolling was performed for three 30 second bouts and found that there was an increase of 6.8˚ of hip flexion ROM (30), which is in agreement with the results of this study. The 90-90 hamstring test demonstrated an increase in hamstrings passive ROM with an average increase of 3.4˚. According to de la Motte et al., lower hamstring flexibility may lead to a higher risk of injury (30%) compared with those who have higher hamstring flexibility (14). SMR is becoming more frequently utilized in warm ups by athletes, and as evident by the increased ROM after use of PTT, this might help with reducing the risk of injury. Ankle passive ROM had an average increase of 3.88˚. Research suggests that muscles with lower levels of flexibility might be more susceptible to strains, especially while jumping (14). Therefore, jumping athletes might benefit from increased ankle flexibility as a way of reducing the risk of muscle strain. ROM increases were seen in three of the four tests conducted, indicating a good overall increase in the available ROM to the athlete. This aids in the reduction in injury risk while not impeding the performance as evident by the lack of decrease in jump height.

The current study is not without limitations. First, only one method of treatment was examined and it did not compare against others, such as foam rolling. It was also measured in an acute setting and did not test for long-term effects of PTT usage. Second, the PI performed all PTT treatments and was not blinded to the study. It would be impossible to blind the subjects to the study, however, future research could utilize a blind PI design in order to avoid any potential bias. A control group would also benefit this research as it may help to eliminate a potential learning bias. Third, the study utilized basketball and volleyball players. The idea was to look at individuals with more athletic experience to see the effects of PTT on a population with jumping experience. This may have contributed to the minimal differences evident in the participants. However, it should be noted that at higher levels, small differences can have big impacts as the margin for change is already minimal. Different sports and populations might elicit different response mechanisms and could be incorporated into future study designs. Experience level may be a big factor and future research could compare experienced jumpers to novice jumpers (in the same way experience level could be accounted for with other activities). Finally, gender was not controlled for in the statistical design of this study. Females, on average, are more flexible than males, which could alter their landing/jumping mechanics. Future research should incorporate the gender variable into the statistical design to look at the effects on mechanical variables, which could also span across different sports and activities.

Although there were no improvements on kinetic or kinematic variables (aside from the small decrease in peak eversion angles during the drop jump), PTT increased passive joint ROM. Performing 30 second bouts of PTT combined with a warm up does appear to enhance ROM without decreasing performance. Percussive therapy treatment might be a great addition for athletes seeking to increase their ROM without compromising their athletic performance.

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