

EFFECT OF PERCUSSION MASSAGE DEVICE ON HAMSTRING AND QUADRICEPS SORENESS, H:Q RATIO AND AGILITY AMONGST BASKETBALL PLAYERS

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Abstract :

Background:

Delayed onset muscle soreness (DOMS) following strenuous or unaccustomed exercise can negatively affect neuromuscular performance in basketball players. Increased soreness of the hamstring and quadriceps muscles may alter the hamstring-to-quadriceps (H:Q) ratio and impair agility. Percussion massage devices are increasingly used as a recovery method to reduce exercise-induced muscle soreness and restore functional performance.

Aim: To investigate the effect of a percussion massage device on hamstring and quadriceps muscle soreness, hamstring-to-quadriceps ratio, and agility among basketball players.

Material and Method: An experimental, single-group repeated-measures study was conducted on 30 male basketball players aged 18–25 years, with a mean age of 20.2 ± 2.2 years. Participants were assessed at four stages: normal baseline, after exercise-induced muscle soreness, immediately after percussion massage treatment (0 hour), and after a second treatment session at 24 hours. Muscle soreness score, H:Q ratio (%), and agility time (seconds) were recorded at each stage. Data were analysed using the Friedman test, Wilcoxon signed-rank test with Bonferroni correction, Kendall's W, and Spearman's rank correlation.

Intervention: Participants received a muscle-soreness induction protocol followed by percussion massage to the thigh muscles. Treatment was delivered for 30 minutes per day for two days according to the study protocol, with the documented massage application using a Hypervolt device at medium intensity (40 Hz) to the vastus lateralis, rectus femoris and vastus medialis for 2 minutes each.

Results: Significant changes were observed across all four stages for muscle soreness, H:Q ratio and agility time ($p < 0.001$). Muscle soreness increased from a baseline mean of 0.00 to 3.87 ± 0.68 after soreness induction, then decreased to 2.47 ± 0.57 immediately after treatment and 0.37 ± 0.49 at 24 hours. The H:Q ratio decreased from $115.33 \pm 7.93\%$ at baseline to $99.73 \pm 10.21\%$ after soreness induction, followed by improvement to $107.07 \pm 9.43\%$ at 0 hour and $113.33 \pm 7.99\%$ at 24 hours. Agility time increased from 16.24 ± 0.87 seconds at baseline to 17.77 ± 0.88 seconds after soreness induction and subsequently improved to 16.72 ± 0.93 seconds and 15.86 ± 0.77 seconds at 0 and 24 hours, respectively. Significant correlations were found between muscle soreness and H:Q ratio ($\rho = -0.626$, $p < 0.001$) and between muscle soreness and agility time ($\rho = 0.606$, $p < 0.001$). **Conclusion:** Exercise-induced muscle soreness significantly impaired the H:Q ratio and agility performance in basketball players. Percussion massage treatment produced significant and progressive reductions in muscle soreness and improvements in H:Q ratio and agility, with the greatest recovery observed after the second treatment session at 24 hours.

Keywords - Delayed onset muscle soreness, percussion massage, hamstring-to-quadriceps ratio, agility, basketball players, sports physiotherapy.

I. INTRODUCTION

Basketball is a high-intensity intermittent team sport requiring repeated sprinting, jumping, acceleration, deceleration, rapid changes of direction and other explosive movements. Successful basketball performance depends on muscular strength, power, speed, agility, neuromuscular control and the ability to recover between periods of intense activity. Competitive basketball places considerable demands on the lower limbs because players repeatedly perform high-force movements over relatively short periods. Systematic reviews have described basketball as a sport involving substantial physical and physiological demands, with frequent high-intensity movements, accelerations, decelerations and changes of direction.¹⁰

The quadriceps and hamstring muscle groups contribute substantially to acceleration, deceleration, jumping, landing and change-of-direction activities. The quadriceps primarily contribute to knee extension and force production, whereas the hamstrings contribute to knee flexion, hip extension and dynamic stabilization of the knee. The coordinated action of these muscle groups is important for maintaining knee stability and producing efficient movement during sports-specific activities. Alterations in muscle strength, fatigue or soreness may influence the mechanical and neuromuscular demands of basketball.

Repeated high-intensity exercise can produce transient neuromuscular fatigue and exercise-induced muscle damage. Eccentric contractions are particularly associated with delayed onset muscle soreness (DOMS), reductions in muscle force and changes in neuromuscular function. DOMS generally develops several hours after strenuous or unfamiliar exercise and may persist for several days. Exercise-induced muscle damage can consequently affect an athlete's ability to produce force and perform movements requiring speed, power and coordination.

Muscle soreness may be particularly relevant to basketball because many basketball-specific activities require eccentric muscle actions. Deceleration, landing after a jump and rapid changes in direction require the lower-limb musculature to absorb external forces while controlling joint movement. Repeated exposure to these activities may contribute to temporary muscular fatigue and soreness. Previous research examining exercise-induced muscle damage has demonstrated that soreness can be accompanied by reductions in athletic performance, including sprinting and agility-related activities. Therefore, appropriate recovery strategies are important for maintaining functional performance during subsequent training and competition.

The hamstring-to-quadriceps (H:Q) ratio characterizes the relative strength relationship between knee flexor and extensor muscle groups. It provides information regarding muscular balance around the knee and is commonly considered in athletic screening, rehabilitation and return-to-sport decision-making. The ratio may be influenced by the testing method, contraction velocity, testing position, athlete characteristics and the type of ratio calculated. A temporary reduction in the H:Q ratio following strenuous activity may reflect a greater reduction in hamstring function relative to quadriceps function and may indicate altered muscular balance.

Maintenance of an appropriate relationship between hamstring and quadriceps muscle function is important during activities involving acceleration, deceleration and changes of direction. During basketball, the quadriceps contribute to force production and control of knee flexion during landing, while the hamstrings contribute to posterior-chain force production and dynamic control of the knee. Consequently, fatigue or soreness affecting either muscle group may modify the relative contribution of the two muscle groups and potentially influence the H:Q ratio.

Agility is another important component of basketball performance. It involves the ability to rapidly accelerate, decelerate and change direction while maintaining adequate body control. Basketball players repeatedly perform movements that require rapid changes in velocity and direction, making agility an important functional performance characteristic. A systematic review of basketball demands has identified acceleration, deceleration, changes of direction and jumping as important components of basketball activity.¹⁰ Therefore, any intervention that may assist recovery of lower-limb muscle function could potentially have relevance to agility performance.

Basketball involves repeated eccentric loading during deceleration, landing and changes of direction. If recovery is inadequate, soreness and temporary reductions in muscular function may affect high-speed movement. Although previous studies have investigated muscle soreness, strength changes and athletic performance separately, comparatively less attention has been given to the relationship between exercise-induced soreness, H:Q ratio and agility in basketball players.

Percussion massage devices are increasingly used as recovery tools. They deliver rapid mechanical impulses to the soft tissues and are commonly used by athletes following training or competition. Proposed effects include changes in perceived muscle soreness, muscle stiffness, flexibility and short-term neuromuscular performance. A systematic review of massage-gun interventions reported potential benefits for performance and recovery outcomes, although the evidence varied according to the outcome measured and the treatment protocol used.¹¹

The physiological mechanisms underlying percussion massage are not completely established. Possible explanations include temporary alterations in muscle stiffness, increased local mechanical stimulation, changes in pain perception and modulation of neuromuscular responses. However, these mechanisms should be interpreted cautiously because different studies have used different devices, frequencies, treatment durations and muscle groups. Therefore, findings from one percussion-massage protocol cannot necessarily be generalized to every device or application.

Recent experimental evidence has provided further support for investigating percussion massage as a recovery strategy. A randomized controlled study examining exercise-induced muscle fatigue reported that percussion massage produced immediate effects on muscle tone and stiffness and was associated with recovery of muscle strength over the subsequent 48-hour period.¹² Another randomized clinical trial investigating physically active men following a fatigue protocol reported reductions in quadriceps pain over time following percussion massage, although statistically significant superiority between groups was not demonstrated for all strength outcomes.¹³ These findings indicate that percussion massage may influence some recovery-related outcomes, while its effects on specific sports-performance variables require further investigation.

The duration and dosage of percussion massage may also influence its effects. A randomized controlled study investigating delayed onset muscle soreness compared different durations of percussion massage and found differences in recovery-related outcomes between treatment protocols.¹⁴ This suggests that treatment dosage may be an important consideration when designing recovery interventions. In sports physiotherapy, determining an appropriate treatment duration and intensity is therefore important for ensuring that an intervention is practical and appropriately targeted.

Despite the increasing use of percussion massage devices among athletes, evidence remains variable regarding their effect on sport-specific functional performance. Some studies have demonstrated improvements in soreness, fatigue or perceived recovery, whereas improvements in performance measures such as jumping have not been consistently observed.¹⁵ This variation indicates that percussion massage may not affect every aspect of athletic performance to the same extent.

Therefore, the present study was designed to examine the effect of a percussion massage device on hamstring and quadriceps muscle soreness, H:Q ratio and agility among basketball players. By assessing the participants at baseline, following induction of muscle soreness, immediately following percussion massage and at 24-hour follow-up, the study aimed to observe the short-term pattern of changes associated with the intervention.

II. AIM

To evaluate the effect of a percussion massage device on hamstring and quadriceps soreness, H:Q ratio, and agility among basketball players.

III. OBJECTIVES

- To determine the impact of percussion massage on muscle soreness post-exercise.
- To determine the effect of percussion massage on agility post-exercise.
- To determine the effect of percussion massage on H:Q ratio.

IV. MATERIALS AND METHODS

Parameter	Description
Study type	Experimental study
Study design	Single-group repeated-measures design
Study duration	6 months
Study population	Basketball players
Sampling	Convenient sampling
Sample size	30
Study setting	Sangli district
Age	18–25 years

Ethical clearance was obtained before recruitment. The study procedure was explained to participants and written informed consent was obtained. Participants were screened according to the stated inclusion and exclusion criteria. Outcome measures were recorded at baseline, after induction of muscle soreness, immediately after percussion massage, and at 24-hour follow-up.

V. INCLUSION CRITERIA

- Basketball players aged 18–25 years.
- Regularly training male basketball players.
- Participants willing to participate and available for 48-hour follow-up.
- Players who provided written informed consent.
- Players available for all required assessments and follow-up.

VI. EXCLUSION CRITERIA

- History of recent lower-limb injuries during the last 6 months.
- Neuromuscular or orthopaedic conditions affecting performance.
- Current use of other recovery therapy.
- Musculoskeletal injuries such as muscle tears, sprain or tendonitis.
- Neuromuscular disorders such as muscular dystrophy or myasthenia gravis.
- Autoimmune myopathies such as polymyositis or dermatomyositis.

VII. OUTCOME MEASURES

1. Likert Scale of Muscle Soreness

Muscle soreness was assessed using the Likert scale of muscle soreness documented in the study.

2. Illinois Agility Test

The Illinois Agility Test is a field-based test measuring agility and directional speed. It is performed on a 10 m × 5 m course using cones arranged in a prescribed pattern. The participant sprints and changes direction through the course, and completion time is recorded in seconds.

3. Hamstring-to-Quadriceps Ratio

The H:Q ratio is the ratio of hamstring muscle strength to quadriceps muscle strength and is expressed as a percentage. In the study protocol, hamstring and quadriceps strength values were used to calculate the ratio as: $H:Q \text{ Ratio (\%)} = \frac{\text{Hamstring strength}}{\text{Quadriceps strength}} \times 100$.

VIII. INTERVENTION PROTOCOL

MUSCLE SORENESS INDUCTION PROTOCOL

Exercise	Duration
Squatting	30 seconds
Leg press	30 seconds
Heel digs	30 seconds
Marching on spot	30 seconds
Burpees	30 seconds

PERCUSSION MASSAGE PROTOCOL

Participants received percussion massage using a Hypervolt massage gun at medium intensity (40 Hz) over the thigh muscles. The documented application was:

Muscle	Duration
Vastus lateralis	2 minutes
Rectus femoris	2 minutes
Vastus medialis	2 minutes
Total documented massage time	6 minutes

IX. STATISTICAL ANALYSIS

For each outcome measure, values at the four study stages were first tested for normality using the Shapiro–Wilk test. Because the muscle soreness score and several stage-wise distributions departed from normality, a non-parametric approach was used. The Friedman test, the non-parametric equivalent of one-way repeated-measures analysis of variance, was used to determine whether each outcome changed significantly across the four stages. Where significant overall change was found, pairwise comparisons were performed using the Wilcoxon signed-rank test with Bonferroni correction. Kendall's W was used to summarize the strength of overall change across stages. Spearman's rank correlation was calculated between muscle soreness and H:Q ratio, and between muscle soreness and agility time. Statistical significance was considered at $p < 0.05$.

X. RESULTS

Outcome	Baseline Mean $\pm$ SD	Post-soreness Mean $\pm$ SD	0-hour Mean $\pm$ SD	24-hour Mean $\pm$ SD
Muscle soreness score	0.00 $\pm$ 0.00	3.87 $\pm$ 0.68	2.47 $\pm$ 0.57	0.37 $\pm$ 0.49
H:Q ratio (%)	115.33 $\pm$ 7.93	99.73 $\pm$ 10.21	107.07 $\pm$ 9.43	113.33 $\pm$ 7.99
Agility time (s)	16.24 $\pm$ 0.87	17.77 $\pm$ 0.88	16.72 $\pm$ 0.93	15.86 $\pm$ 0.77

All three outcome measures demonstrated statistically significant changes across the four study stages ($p < 0.001$).

Outcome	Chi-square	Df	p-value	Kendall's W
Muscle soreness score	87.77	3	<0.001	0.975
H:Q ratio (%)	90.00	3	<0.001	1.000
Agility time (seconds)	82.97	3	<0.001	0.922

Correlation	Spearman rho	p-value
Muscle soreness vs H:Q ratio	-0.626	<0.001
Muscle soreness vs agility time	0.606	<0.001

The negative correlation between muscle soreness and H:Q ratio indicates that greater soreness was associated with a lower H:Q ratio. The positive correlation between muscle soreness and agility time indicates that greater soreness was associated with slower agility performance.

XI. DISCUSSION

The present study demonstrated a consistent stage-wise pattern among 30 basketball players. Following induction of exercise-related muscle soreness, the H:Q ratio decreased and agility time increased compared with baseline, while muscle soreness increased. This indicates that experimentally induced soreness was accompanied by temporary changes in muscular balance and movement performance.

The increase in muscle soreness following the exercise protocol indicates that the protocol successfully produced the intended exercise-related muscular response. Muscle soreness increased from a baseline mean of 0.00 to 3.87 $\pm$ 0.68 after the soreness-induction protocol. At the same stage, the H:Q ratio decreased from 115.33 $\pm$ 7.93% to 99.73 $\pm$ 10.21%, while agility time increased from 16.24 $\pm$ 0.87 seconds to 17.77 $\pm$ 0.88 seconds. These changes indicate that increased soreness occurred concurrently with a reduction in the measured muscular balance and deterioration in agility performance.

The reduction in H:Q ratio following soreness induction may indicate a temporary alteration in the relative contribution or force-producing capacity of the hamstring and quadriceps muscle groups. Because the H:Q ratio represents the relationship between hamstring and quadriceps strength, changes in either component can influence the final ratio. Exercise-induced fatigue and soreness may therefore alter the measured relationship between these muscle groups. However, the present study did not independently measure the physiological contribution of each muscle group, and therefore the reduction in H:Q ratio should be interpreted as an observed functional change rather than evidence of a specific underlying physiological mechanism.

The deterioration in agility performance following soreness induction is also clinically relevant. Agility requires rapid acceleration, braking and redirection of the body while maintaining adequate lower-limb control. The increase in agility time from 16.24 seconds

at baseline to 17.77 seconds after soreness induction suggests that the participants required more time to complete the agility task during the sore condition. This observation is consistent with the concept that exercise-induced muscle soreness can temporarily interfere with high-speed movement and performance. Previous research has similarly investigated the effect of exercise-induced

muscle damage on sprint and agility performance.⁷

Following the first percussion massage treatment, muscle soreness decreased from 3.87 ± 0.68 to 2.47 ± 0.57 , while the H:Q ratio increased from $99.73 \pm 10.21\%$ to $107.07 \pm 9.43\%$. Agility time also decreased from 17.77 ± 0.88 seconds to 16.72 ± 0.93 seconds. These changes indicate that improvement occurred across all three outcome measures immediately following treatment. The findings suggest that percussion massage may have been associated with a short-term reduction in perceived soreness together with improvement in measured muscular balance and agility.

The reduction in soreness observed immediately after treatment is consistent with recent research investigating percussion massage following exercise-induced fatigue. A randomized crossover trial in physically active adults found lower perceived muscle fatigue and pain following percussive massage compared with passive recovery, together with modest improvements in knee-extensor torque and vertical jump height.¹⁶ These findings provide support for the possibility that percussion massage can influence both subjective recovery and selected physical-performance outcomes following strenuous exercise.

However, the effects of percussion massage on athletic performance are not uniform across studies. A randomized trial in runners reported improvements in quadriceps pain, fatigue and perceived recovery following percussion massage but did not demonstrate an effect on vertical jump performance.¹⁵ This indicates that an intervention may improve subjective recovery without necessarily producing improvements across every objective performance variable. The present study differs in that agility time and H:Q ratio were assessed in addition to muscle soreness, allowing changes in several related aspects of lower-limb function to be examined. At the 24-hour assessment, the participants demonstrated further improvement. Muscle soreness decreased to 0.37 ± 0.49 , the H:Q ratio increased to $113.33 \pm 7.99\%$, and agility time decreased to 15.86 ± 0.77 seconds. The greatest recovery was therefore observed at the 24-hour stage. The continued improvement may reflect a combination of the treatment response and the natural recovery process following exercise-induced soreness. The study design does not allow these two influences to be separated.

The progressive improvement observed over the 24-hour period is comparable with research examining percussion massage during post-exercise recovery. A recent randomized controlled study found that percussion massage was associated with recovery of muscle strength within 48 hours following exercise-induced fatigue, while also reducing immediate muscle tone and stiffness.¹² Another randomized controlled study examining DOMS reported differences in recovery-related outcomes following different durations of percussion massage.¹⁴ Together, these findings suggest that the response to percussion massage may extend beyond the immediate treatment period.

The significant correlation between muscle soreness and H:Q ratio provides an additional finding of the present study. A negative correlation was observed between soreness and H:Q ratio ($\rho = -0.626$, $p < 0.001$), indicating that greater soreness was associated with a lower H:Q ratio. This relationship suggests that the state of perceived muscular soreness was accompanied by an alteration in the relative strength relationship between the hamstrings and quadriceps. However, correlation does not establish a causal relationship, and other factors associated with fatigue and recovery may have contributed to both variables.

A positive correlation was also observed between muscle soreness and agility time ($\rho = 0.606$, $p < 0.001$). Thus, greater soreness was associated with longer agility completion time, representing slower performance. From a sports physiotherapy perspective, this relationship is relevant because basketball players depend on rapid changes of direction, acceleration and deceleration during training and competition. If soreness is accompanied by slower movement performance, monitoring recovery may be important before athletes return to high-intensity activity.

The relationship between soreness and agility may have several possible explanations. Muscle soreness may be associated with temporary changes in force production, movement tolerance and neuromuscular coordination. An athlete experiencing greater soreness may alter movement strategies to avoid discomfort, which could influence acceleration and changes of direction. However, these mechanisms were not directly measured in the present study. Therefore, they should be regarded as possible explanations rather than confirmed mechanisms.

The observed improvement in H:Q ratio may also have practical significance. An H:Q ratio closer to the participant's baseline measurement following recovery may indicate restoration of the pre-exercise relationship between knee flexor and extensor muscle strength. In the present study, the H:Q ratio improved from 99.73% after soreness induction to 107.07% immediately after treatment and 113.33% at 24 hours, approaching the baseline value of 115.33%. This progressive pattern occurred alongside a reduction in soreness and improvement in agility.

The findings may therefore be relevant to sports physiotherapy recovery programmes in which athletes are required to return to repeated high-intensity activity within a short period. Basketball training and competition involve considerable acceleration, deceleration and change-of-direction demands.¹⁰ Recovery strategies that reduce perceived soreness and support restoration of functional performance may consequently be useful as part of a broader recovery programme. Nevertheless, percussion massage should not be considered as a replacement for appropriate training-load management, rest, hydration, nutrition and other evidence-based recovery strategies.

The documented percussion massage protocol in the present study involved application to the vastus lateralis, rectus femoris and vastus medialis at medium intensity for two minutes per muscle. This standardized application is important because the effects of percussion massage may depend on treatment intensity, duration, muscle selected and timing of application. Recent research has similarly emphasized differences between protocols, making it difficult to establish a single optimal percussion-massage prescription. The present study also has important methodological considerations. The single-group repeated-measures design allowed each participant to serve as their own reference across the different stages, which reduced the influence of between-participant variability. However, there was no separate control group. Consequently, the improvement observed at 24 hours cannot be attributed

exclusively to percussion massage because spontaneous recovery from exercise-induced soreness would be expected to occur over time.

Repeated testing may also have influenced the results. Participants completed the same or related outcome assessments at multiple stages, and familiarity with the agility test could potentially influence subsequent performance. Similarly, changes in motivation, effort or perceived soreness may influence repeated measurements. These factors should be considered when interpreting the significant stage-wise differences.

The findings should also be interpreted in relation to the sample characteristics. The participants were male basketball players aged 18–25 years, meaning that the findings may not be directly applicable to female players, younger athletes, older athletes or athletes participating in other sports. The study also focused specifically on the hamstrings and quadriceps, while basketball performance involves multiple muscle groups and complex neuromuscular interactions.

Despite these limitations, the study provides a useful preliminary examination of the relationship between muscle soreness, H:Q ratio and agility following percussion massage. The simultaneous improvement in all three measured outcomes and the significant correlations between soreness and functional variables provide a basis for further research using controlled experimental designs. Future studies could compare percussion massage with passive recovery, static stretching or other recovery interventions and could investigate different frequencies, intensities and durations of percussion massage.

Overall, the findings indicate that exercise-induced soreness was associated with temporary reductions in H:Q ratio and agility performance, while percussion massage was followed by progressive improvement in these outcomes over the subsequent 24 hours. The greatest recovery was observed at the final assessment, suggesting that the combination of immediate treatment response and natural recovery may have contributed to the observed changes. Controlled studies with larger and more diverse samples are required to determine the independent contribution of percussion massage to these recovery effects.

XII. CONCLUSION

Exercise-induced muscle soreness of the hamstring and quadriceps significantly impaired the H:Q ratio and agility performance in basketball players. Percussion massage treatment was followed by significant and progressive reductions in muscle soreness and improvements in H:Q ratio and agility, with the greatest recovery observed after the second treatment session at 24 hours.

XIII. LIMITATIONS

- The study was conducted on a limited number of basketball players, which may affect generalizability.
- Only basketball players were included, so findings may not be applicable to athletes from other sports.
- The study focused on the hamstrings and quadriceps; other muscle groups were not assessed.
- The study primarily assessed short-term effects; long-term effects of percussion massage could not be determined.
- The absence of a separate control group limits attribution of changes specifically to percussion massage.

XIV. FUTURE RECOMMENDATIONS

- Future studies may be conducted with a larger sample size.
- Female basketball players may be included.
- Studies may include different age groups and athletes from other sports.
- Different percussion massage durations and intensities may be investigated.
- A control group may be included in future studies.
- Other outcomes such as muscle strength, flexibility and recovery time may be studied.
- Long-term effects on sports performance and injury prevention may be investigated.

XV. CLINICAL IMPLICATIONS

The findings indicate that percussion massage may be considered as a short-term recovery strategy following exercise-induced muscle soreness in basketball players. Monitoring soreness together with H:Q ratio and agility may help sports physiotherapists assess temporary changes in lower-limb function and recovery. Further controlled research is required before drawing conclusions about the independent effect of percussion massage.

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