

# **ORIGINAL SCIENTIFIC PAPER**

# Determine the Occurrence of Latent Myofascial Trigger Points Through Binary Logistic Regression Model in Sportsmen

Rajdeep Das<sup>1</sup>, Birendra Jhajharia<sup>1</sup>, Durgesh Shukla<sup>3</sup>, Vangie Boto-Montillano<sup>4</sup>, Dinesh Kumar<sup>5</sup>

<sup>1</sup>Department of Exercise Physiology, Lakshmibai National Institute of Physical Education, Deemed University Gwalior, Madhya Pradesh, India, <sup>2</sup>Department of Community Medicine, Gajra Raja Medical College, Madhya Pradesh, India, <sup>3</sup>Faculty Physical Education Department, De La Salle University-Dasmarinas Cavite, Philippines, <sup>4</sup>Department of Physical Education and Sports Science, University of Delhi, India

# Abstract

This study aimed to ascertain the prevalence of latent myofascial trigger points (L-MTrPs) among male athletes. Ninety participants were randomly included in the study. The presence of L-MTrPs was identified based on Simon's criteria, leading to the categorization of participants into two groups: L-MTrPs (n=45) and non-myofascial trigger points (N-MTrPs) (n=45). Pain pressure thresholds (PPT) of muscles were quantified using a pressure algometer, while force production was measured with HUMAC NORM isokinetic. The range of motion (ROM) for knee flexors and extensors was determined using Kinovea software. These parameters were treated as independent variables, whereas L-MTrPs and N-TrPs were considered dependent variables. Binary Logistic Regression (Enter Method) was employed for data analysis. Model fitness was evaluated through standard error computation, Wald's  $\chi$ 2, and odds ratios with a 95% confidence interval. Model adequacy was assessed via the likelihood ratio, Cox & Snell (R2), Nagelkerke (R2), and Hosmer and Lemeshow tests. The results effectively predicted L-MTrPs and N-MTrPs. In conclusion, reduced force production, lower PPT, and ROM are recommended for athletes to prevent the development of L-MTrPs.

Keywords: binary logistic, myofascial pain syndrome, peak torque, range of motion, regression model, athletes

## Introduction

Myofascial Pain Syndrome (MPS) is a musculoskeletal ailment responsible for the sensation of pain (Duarte et al., 2021). This type of pain is characterised by the presence of hyperirritable regions known as trigger points (TrPs). These hyperirritable regions, specifically termed myofascial trigger points (MTrPs), are located within taut groupings of skeletal muscle fibers (Bethers et al., 2021; Das & Jhajharia, 2022b). These are tender, firm nodules measuring 3–6 mm in diameter (Donnelly & Simons, 2019). The research findings indicate that there is a notable difference in the occurrence of myofascial pain between males (37%) and females

(65%) (Xia et al., 2017; Sabeh et al., 2020). Moreover, clinically, MTrPs are categorized into two types, namely active and latent MTrPs (L-MTrPs) (Jiménez-Sánchez et al., 2021). MTrPs that do not elicit pain are commonly referred to as L-MTrPs (Ge & Arendt-Nielsen 2011; Cygańska et al., 2022), whereas constant discomfort is a result of active-MTrPs (A-MTrPs) (Ibrahim et al., 2021). Musculoskeletal injuries are very common, and research in the fields of sports and exercise has shown that these are the most frequent kinds of injuries (Haser et al., 2017; Lee et al., 2020). Moreover, scientific investigation indicates that myofascial pain constitutes a substantial percentage (approximate-



Correspondence:

Raideep Das

Lakshmibai National Institute of Physical Education, Department of Exercise Physiology, Gwalior, Madhya Pradesh, India E-mail: rjdpdas94@gmail.com ly 85%) of musculoskeletal pain from injuries (Wheeler, 2004), As a consequence, scholars have recommended that MPS be taken into consideration as a possible cause of musculoskeletal pain (San-Antolín et al., 2020). Research indicates that athletes are susceptible to developing MTrPs over time (Fousekis & Kounavi, 2016; Kisilewicz et al., 2018; Das et al., 2022). Long-term or inconsistent training, low-load repetitive muscular activity, chronic and acute mechanical and electrical damage, persistent stress, and prolonged ischemia can all damage myofibrils and promote the formation of L-MTrPs (Ge & Arendt-Nielsen, 2011), It requires a thorough evaluation and a customised treatment plan (Barbero et al., 2019). The presence of MTrPs in the myofascial system is linked with reduced flexibility and strength of the affected muscles, as well as an increased sensation of muscle tightness (Fousekis & Kounavi, 2016; Haser et al., 2017). Athletes who are injured experience a decline in physical performance (San-Antolín et al., 2020; San-Antolín-Gil et al., 2022). Therefore, it becomes very important to identify MTrPs and take proper action. A correct diagnosis is the first step to treatment, and diagnostic accuracy depends on test reliability. Reliability pertains to the level of agreement among examiners when conducting the same test on the same patients (Das & Jhajharia, 2022a). There are a number of technologies that have been utilised to detect MTrPs, including microdialysis, biopsies (Do et al., 2018), imaging techniques by ultrasonography (Elbarbary et al., 2023), electromyography (Chattrattrai et al., 2023), and a digital pressure algometer (Karpuz et al., 2023). Among them, the most cost-friendly tool is the pressure algometer. This device is used by various researchers and they confirm that it has high reliability (Escalona-Marfil et al., 2020). This instrument measures the pain pressure threshold (PPT) of muscles. From the review of literature, it was observed that L-MTrPs reduced range of motion (ROM), muscular strength (Walsh et al., 2019), and PPT (Rodríguez-Jiménez et al., 2022). Therefore, these factors are believed to be crucial to determining the existence of L-MTrPs. Despite the fact that a great number of studies on MPS and MTrP have been published, only a few have been published regarding the symptoms of L-MTrPs. In addition, L-MTrPs can have a negative impact on daily life and sports performance (Shah et al., 2015; Das & Jhajharia, 2022b; Das et al., 2023), therefore, L-MTrPs is perceived as a serious health problem by researchers (Ribeiro et al., 2018). A review of related literature suggests that MTrPs reduce muscular strength (Das & Jhajharia, 2022b) and flexibility (Das et al., 2023) which affect the daily activity of sports person as well as sedentary people. Therefore, the purpose of this study was to identify that losing muscular strength, flexibility, and low PPT can be the symptoms of L-MTrPs. From the past research evidence, it was found that most of the studies were conducted on A-MTrPs, and very few studies are available on L-MTrPs (Duarte et al., 2023). Li and his colleagues reported in their systematic review article that a number of studies failed to properly report the MTrP diagnostic criteria (Li et al., 2020). Therefore, the objective of the study was to find out the symptoms of L-MTrPs. To fulfil the purpose of this study, a binary logistical regression approach was used. The findings of the present study will help the athletes detect the early symptoms of L-MTrPs, and that will help them prevent and take proper care of myofascial layer.

# Methods

#### Participants

For this study, 90 national-level players were randomly selected on the basis of their sports participation and sports experience from Madhya Pradesh, India, and the research was carried out at the Exercise Physiology Laboratory of Lakshmibai National Institute of Physical Education in Gwalior, India. In this study, a cross-sectional comparative research design was used. The diagnostic criteria proposed by Simons (Donnelly & Simons, 2019) were utilized to identify L-MTrPs. (1) a band of muscle that is physically taut; (2) a spot that is tender and overly sensitive; (3) the compression of MTrP elicits the reproduction of referred pain; (4) and the jump sign when compressed (Zuil-Escobar et al., 2015). The inclusion criteria for the L-MTrPs group were based on three requirements. Firstly, the presence of L-MTrPs in the hamstring and quadriceps muscle groups located in the lower limbs. Secondly, the subjects had to be male athletes who played a sport that involved jumping, sprinting, twisting, turning, acceleration, and deceleration as essential components. Additionally, these athletes had to play their sport competitively, which was defined as participating a minimum of twice per week in an organized training or match situation for a team that competed in an official league or cup. Lastly, all subjects were collegiate athletes who were currently in the competition phase of their sport. On the other hand, the inclusion criteria for the non-L-MTrPs group were the absence of a palpable taut band in the muscles. The exclusion criteria for this study were multifaceted. Firstly, subjects were excluded if they were currently experiencing any injury or illness, including any systemic muscular or neural disease, or any lower limb or lower back injury in the previous three months. Secondly, the study excluded subjects who had recently been diagnosed with or treated for fibromyalgia, suffered from vascular or neural conditions, or received treatment for MTrPs (active or latent). Subjects who met the inclusion criteria were explained the study and were included in the sample only if they agreed to participate. Purposive sampling was used to select the first group, which consisted of 45 subjects diagnosed as positive for L-MTrPs. The second group consisted of subjects who were negative for MTrPs. To ensure an equal sample size and better statistical inference, 45 non-MTrPs subjects were included in this study. A skilled

Table 1. Participants' basic characteristics

•		
Parameter	L-MTrPs (N-45)	Non-TrPs (N-45)
Subject characteristics	Mean ± SD	$Mean \pm SD$
Age (Years)	20.67±2.17	20.55±2.28
Height (Centimetre)	161.11±5.81	161.20±5.56
Weight (Kilogram)	58.41±5.26	59.84±5.71

L-MTrPs: Latent Myofascial Trigger Points; Non-TrPs: Non-Trigger Points; N: Sample Size;SD: Standard Deviation

physiotherapist supervised the test. Written consent was obtained from the participants' parents or legal guardians. The ethics committee of the Lakshmibai National Institute of Physical Education approved this study. It was conducted according to the latest version of the Declaration of Helsinki (approval number: 392/1346/27, 22 February 2023).

Table 1 demonstrates the basic characteristics of L-MTrPs Group's age  $20.67\pm2.17$  years, height  $161.11\pm5.81$ cm, and the weight  $58.41\pm5.26$ kg, whereas non-TrPs age  $20.55\pm2.28$  years, height  $161\pm5.56$ cm, weight  $59.84\pm5.71$ kg (Table 1). The mean age, height, and weight were found to be statistically same for both the group (p>0.05). All the participants were actively engaged in competitive sports.

## Instruments

The evaluation of PPT was performed using a digital pressure algometer (FPX 25 Wagner Instruments, Greenwich, CT, USA) in accordance with the methodology reported by Cygańska et al. (2022). It has been reported that this device has high reliability (Castien et al., 2021; Cygańska et al., 2022). The measurement of force production by peak torque (Newton/meter2) in knee tests was performed using the HUMAC NORM isokinetic machine (Computer Sports Medicine, Inc., Stoughton, MA, USA). It has been reported that the reliability of this machine ranges between 0.74-0.89, indicating its consistent and dependable performance in measuring the peak torque (Habets et al., 2018). Kinovea® version 0.9.5 software was used by the researchers to measure the ROM. The software was found to be a valid and reliable tool for measuring accurately at distances up to 5 meters from the object. It is available for free download at (https:// www.kinovea.org/) (Puig-Diví et al., 2019; Fernández-González et al., 2020).

#### Pain Pressure Threshold Examination

The pain test utilised algometric measurement, with the pain threshold defined in lbs/cm2 and the pressure applied at a constant speed. The PPT was determined as the threshold point at which pressure sensations transitioned to pain (Ortega-Santiago et al., 2020). The measurement of the pain threshold for particular muscles was conducted, and the identification of the locations of the L-MTrPs was established as mentioned by Cygańska et al. (2022). A device at a 90° angle to the skin surface measured the quadriceps and hamstrings in a supine and prone position, respectively (Fig 1), consistently beginning at the locations on the right side. When the test point initially hurt, the individual was instructed to say "STOP." Before measuring the actual sites, a trial measurement was taken on the subject's forearm muscles to ascertain their pain threshold. Each measurement was analysed by the same researcher and separated by five minutes. The following sequence was used to test each subject's muscle groups: initially, the right and left quadriceps muscle groups (Vastus lateralis, Rectus femoris, and Vastus Medialis), then the right and left hamstring muscles (Bicep femoris, semitendinosus, and semimembranosus). A physical therapist with over a decade of experience oversaw the measurement process. A 30-second break was provided between each measurement, and the mean of three trials was computed for analysis. This approach to assessing PPT has been proven to demonstrate strong intra- and inter-examiner consistency (Chesterton et al., 2007).



FIGURE 1. Evaluation of Latent Myofascial Trigger Points

#### Muscular Strength Measurement

After algometric measurements, the CSMi HUMAC NORM isokinetic dynamometer was used to measure the participants' lower limb force production. Knee flexion and extension muscle strength were measured while participants were positioned on the testing table with stabilisation straps and a horizontal pad over their thighs. The trunk was supported by the backrest of the table. Peak isokinetic concentric knee extension and flexion torque of both legs were evaluated at an angular velocity of 180°/s velocity. The knee extension and flexion contractions were performed through a range of 0-90° (full extension is defined as 0 degree). All participants were instructed to complete three submaximal trials at a given angular velocity for familiarisation and warmup. Peak isokinetic concentric knee extension and flexion torque were measured with the right and left legs at 180°/s extension. All the participants performed five maximal repetitions of knee extension and flexion at a selected angular velocity. A break of at least 3 minutes was given when the machine setting was changed for the opposite leg. The order of testing was randomised for the



FIGURE 2. Evaluation of Muscular Strength

right and left legs. Verbal encouragement and visual feedback were given by the investigator to all participants to help them concentrate on the quality of their movements. The greatest peak torque (Nm) for knee extension and flexion was calculated automatically by the HUMAC NORM System and served as the outcome measure (Tasmektepligil, 2016).

#### **ROM Examination**

A GoPro 9 action camera recorded each participant's knee joint from the sagittal and frontal axis profiles. Markers, both passive and reflective, were placed on the greater trochanter, the external femoral condyle, and the lateral malleolus to measure the angular displacement of the knee joint as seen from the side (Silva et al., 2018; Fernández-González et al., 2020). A tripod-mounted camera was 80 cm high and 1.5 m from participants. To maintain camera-to-participant dis-

tance, the tripod was placed on floor tape. Before the tests, everyone did a five-minute warm-up. The knee of each subject was positioned near the edge of the table while they lay prone on it (Fig 3). The individual was instructed to bend their knee as much as possible before extending it to determine the angle of knee flexion. The unfolded leg was measured as knee extension, and a closer to 0° angle was considered a good extension ROM. All videos were imported onto a laptop and analysed using Kinovea software. The greater trochanter, external femoral condyle, and lateral malleolus were marked in the Kinovea. An angle was placed in the external femoral condyle. One line went through the humerus bone and ended at the greater trochanter (stationary arm), while the other went through the tibia bone and ended at the lateral malleolus (movable arm). Angles were used to describe the two lines' intersection (Das et al., 2023).



FIGURE 3. Knee Range of Motion (A) Flexion, (B) Extension

#### Statistical Analyses

The statistical analysis was performed using IBM SPSS (version 26.0.0) and involved binary logistic regression (Entre Method) to analyze the relationship between L-MTrPs and N-MTrPs (dependent variables) and PPT, force production, and ROM (independent variables). The analysis included calculation of,  $\beta$ , standard error  $\beta$ , Wald's  $\chi$ 2, odds ratio with a 95% confidence interval. Model evaluation was conducted using the like-lihood ratio test, Cox & Snell (R2), and Nagelkerke (R2) tests,

and the goodness of fit test was evaluated using the Hosmer & Lemeshow test. Additionally, the observed and predicted frequencies by the regression model were calculated with a cut-off of 0.50. The level of statistical significance was set at  $p \le 0.05$ .

# Result

Table 2 demonstrates the descriptive statistics of average force production, average PPT, and average ROM of keen flexion and extension in the L-MTrPs and non-TrPs groups. And there was

	Group	Ν	Mean ± S. D	S.E	p-value
Aug Dight log Forge Due dustion	L-MTrPs	45	152.36 ± 21.73	3.23	0.013*
Avg. Right leg Force Production	non-TrPs	45	163.07 ± 18.04	2.69	
Avg. Loft log Force Production	L-MTrPs	45	165.23 ± 19.63	2.92	0.033*
Avg. Left leg force Production	non-TrPs	45	175.64 ± 25.60	3.81	
DDT Dight log	L-MTrPs	45	21.07 ± 2.85	0.42	0.000*
PPT Right leg	non-TrPs	45	25.04 ± 1.49	0.22	
DDT Dight log	L-MTrPs	45	20.95 ± 2.31	0.34	0.000*
PPT Right leg	non-TrPs	45	24.91 ± 1.62	0.24	
Avg. Flovion POM	L-MTrPs	45	136.11 ± 2.08	0.31	0.021*
Avg. Flexion KOW	non-TrPs	45	137.03 ± 1.62	0.24	
Avg Extension ROM	L-MTrPs	45	$2.38 \pm .80$	0.11	0.028*
Avg. Extension ROM	non-TrPs	45	2.02 ±.76	0.11	

Avg: Average; ROM: Range of Motion; S. D: Standard Deviation; S. E: Standard Error;

a statistically significant difference found as the p-value is <0.05. Model summary (Table 3) shows that the 82.5% change in the criterion variable can be accounted to the predictor variables in this model.

# Table 3. Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square				
1	37.937a	.619	.825				
a. Estimation terminated at iteration number 8 because parameter estimates changed by less than .001.							

Table 4. Hosmer and Lemeshow Test

Table 4. Hosmer and Lemeshow rest								
Step	<b>Chi-square</b>	df	Sig.					
1	3.193	8	.922					

The hosmer and lemeshow test is also a test of model fit. The hosmer-lemeshow statistic indicates a poor fit if the significance value is less than 0.05. Here the model adequately fit the data, as the p-value is .922 (>0.05; Table 4).

Table 5 shows the overall predictive accuracy is 91.1% now that we have our predictors in the model. The model predicted

# Table 5. Classification Tablea

			Predicted					
	Observed		TrF	S	Percentage Correct			
			Non-TrPs	LTrPs				
Step 1	TrPs	Non-TrPs	41	4	91.1			
		L-MTrPs	4	41	91.1			
	Overall Percentage				91.1			

a. The cut value is .500

### Table 6. Variables in the Equation

		B S.E.	C E	S.E. Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
			3.E.					Lower	Upper
Step 1a	Avg. Right leg Force Production	-0.06	0.03	4.92	1	0.026*	0.93	0.88	0.99
	Avg. left leg Force Production	-0.02	0.02	1.48	1	0.223	0.97	0.93	1.01
	PPT Right leg	-0.51	0.15	10.66	1	0.001*	0.59	0.44	0.81
	PPT Left leg	-0.83	0.24	11.35	1	0.001*	0.43	0.26	0.70
	Avg. Flexion ROM	-0.72	0.34	4.46	1	0.035*	0.48	0.24	0.94
	Avg. Extension ROM	1.49	0.74	4.08	1	0.043*	4.45	1.04	18.99
	Constant	142.56	54.35	6.87	1	0.009*	8.224E+61		

Avg.: Average; ROM: Range of Motion

for L-MTrP (91.1%) and for non-TrPs (91.1%). from Block 0 that without considering any of our predictors, the likelihood or probability of a correct prediction was 50%; thus, our predictors certainly contributed to successful prediction.

The significant predictors were observed, such as average right leg force production (OR 0.93; 95% CI: 0.88–0.99), PPT right leg (OR 0.59; 95% CI:0.44–0.81), PPT left leg (OR 0.43; 95% CI: 0.26–0.70), average flexion ROM (OR 0.48; 95% CI: 0.24–0.94) and average extension ROM (RO 4.45; 95% CI: 1.04-18.99), as their p-values were less than 0.05. However, average left leg force production (p-value 0.22) was not significant predictors in the logistic regression model (Table 6).

From the table summary, we found that this model was 82.5% fit, Hosmer and Lemeshow test also confirmed that this model was good as the p-value is >0.05. That means average force production, PPT, and ROM were predicting L-MTrPs. Therefore, if the reduction in force production, lower PPT, and restriction of ROM occur, those are symptoms of L-MTrPs. In this study, it was hypothesised that force production, PPT, and ROM were the significant predictor variables of the L-MTrPs. According to the model this hypothesis was accepted.

## Discussion

The objective of this research endeavour was to identify pertinent variables directly associated with the prediction of L-MTrPs. To achieve this objective, the study employed binary logistic regression analysis. Force production, PPT, and ROM were considered independent variables, and L-MTrPs and non-TrPs were considered dependent variables. Drawing from an extensive review of related literature, it became evident that L-MTrPs exert a negative influence on muscle force production (Kim et al., 2017; Das & Jhajharia, 2022b). A critical finding from this investigation was the prominence of PPT as a diagnostic marker for L-MTrPs. Research evidence suggests PPT is a reliable source to identify A-MTrPs (Valera-Calero et al., 2023). Notably, several researchers have called for further elucidation on this aspect (Doraisamy & Anshul, 2011). Additionally, L-MTrPs were observed to adversely impact joint ROM, this phenomenon has been consistently underscored by a variety of authors (Charles et al., 2019; Walsh et al., 2019; Öztürk et al., 2022). For instance, a study by Girasol et al. investigated the correlation between L-MTrPs and ROM in the upper trapezius, revealing a reduction in ROM (Girasol et al., 2018). Similarly, other studies highlighted L-MTrPs induced limitations in ankle planter-flexion and dorsi-flexion ROM due to gastrocnemius muscle TrPs (Benito-de-Pedro et al., 2020). Consequently, the evident connection between these variables and L-MTrPs emerges as significant. Consistent with prior research, a lower pain threshold has been linked to muscular abnormalities. Notably, a discrepancy in PPT greater than 2 kg/cm2, in comparison to the identical muscles on the opposing side, is indicative of the presence of L-MTrPs (Park et al., 2011; Cordeiro et al., 2021; Das et al., 2022). This firmly establishes PPT as a robust diagnostic parameter for L-MTrPs, a conclusion bolstered by our own statistical analysis. The precise pathophysiology underpinning myofascial pain remains somewhat enigmatic. Studies indicate that oxidative stress, inflammation, and glial cell activity, particularly astrocytes within the central nervous system, contribute to the persistence of pain signals,

culminating in MTrPs (Widyadharma, 2020). Nociceptive chemicals released in response to tissue injury or inflammation are pivotal in perpetuating pain in MTrPs. These chemicals sensitise nerve fibers, inducing pain perception. Biochemical accumulation within MTrPs, localised regions of muscle stiffness and discomfort, includes neurotransmitters, neuropeptides, cytokines, and inflammatory mediators. According to Simons' hypothesis, abnormal endplate activity prompts the release of elevated acetylcholine levels, triggering a cascade. Calcium channels open, and calcium binding to troponin prompts muscle fiber contraction. Inadequate ATP supply sustains contraction near abnormal endplates, leading to an energy crisis, heightened metabolic demands, reduced blood flow, hypoxic conditions, and polarization. This energy crisis may trigger the release of neuroreactive substances and metabolic byproducts (e.g., bradykinin, substance P, and serotonin), sensitising peripheral nociceptors (Shah et al., 2015). Beyond PPT, athletes should not overlook the significance of force production and ROM, as research underscores their pronounced influence by L-MTrPs (Walsh et al., 2019; Cao et al., 2021; Yeste-Fabregat et al., 2021). The exact mechanisms behind these effects remain a subject of exploration. Emerging hypotheses, on the other hand, suggest that L-MTrPs could be a source of muscle dysfunction, causing fatigue, muscle tightness, shortened sarcomeres, and different patterns of activation. These dynamics result in suboptimal muscle contraction, diminished force production, and compromised ROM (Bagcier et al., 2022; Schneider et al., 2022). Consequently, athletes displaying reduced force production and ROM may be predisposed to L-MTrPs. The implications of this study indicate that athletes may unwittingly develop L-MTrPs, potentially impairing performance. It's worth noting that untreated L-MTrPs can even carry greater consequences (Celik & Mutlu, 2013). Therefore, athletes are advised to prioritise proper maintenance of their fascial structures to mitigate such risks.

#### Strength of the study

This investigation demonstrates novely and innovation, as the majority of prior research has primarily focused on A-MTrPs and their associated symptoms, with limited inquiry into L-MTrPs within the sports domain. Our study has yielded substantial findings that can serve to aid athletes in averting the transformation of L-MTrPs into A-MTrPs, thus preserving and optimizing their physical performance.

#### Limitations

The limitations of this study are that it has an exclusive focus on the hamstring and quadriceps muscle groups, as well as its restriction to athletes performing at the national level.

## Conclusion

The findings of the study suggest that if an athlete has lower force production, lower PPT in muscles, and restrictions in ROM, that indicates the occurrence of L-MTrPs. Therefore, athletes should take proper care of the muscle fascial structure. Coaches and physical trainers should include routine assessments of the force production, PPT, and ROM of the athletes. Sports scientists and physiotherapists should conduct more studies in this aspect and explore this area. Future studies are recommended for other muscle groups and focus on specific athletic disciplines.

#### **Conflicts of Interest:**

The authors did not report any potential conflicts of interest.

#### Acknowledgments:

- The researcher extends their gratitude to the dedicated athletes who took part in this study. We also appreciate the invaluable support provided by the research facility at our institute during the data collection phase. Additionally, special thanks go out to the Department of Exercise Physiology for their generous equipment assistance.
- Received: 15 September 2023 | Accepted: 27 September 2023 | Published: 01 October 2023

#### References

- Bagcier, F., Yurdakul, O. V., Üşen, A., & Bozdag, M. (2022). The relationship between gluteus medius latent trigger point and muscle strength in healthy subjects. *Journal of Bodywork and Movement Therapies*, *29*, 140– 145. https://doi.org/10.1016/j.jbmt.2021.10.001
- Barbero, M., Schneebeli, A., Koetsier, E., & Maino, P. (2019). Myofascial pain syndrome and trigger points: Evaluation and treatment in patients with musculoskeletal pain. *Current Opinion in Supportive & Palliative Care*, 13(3), 270–276. https://doi.org/10.1097/SPC.000000000000445
- Benito-de-Pedro, M., Becerro-de-Bengoa-Vallejo, R., Elena Losa-Iglesias, M., Rodríguez-Sanz, D., López-López, D., Palomo-López, P., ... & Calvo-Lobo, and C. (2020). Effectiveness of Deep Dry Needling vs Ischemic Compression in the Latent Myofascial Trigger Points of the Shortened Triceps Surae from Triathletes on Ankle Dorsiflexion, Dynamic, and Static Plantar Pressure Distribution: A Clinical Trial. *Pain Medicine*, 21(2), e172–e181. https://doi.org/10.1093/pm/pn2222
- Bethers, A. H., Swanson, D. C., Sponbeck, J. K., Mitchell, U. H., Draper, D. O., Feland, J. B., & Johnson, A. W. (2021). Positional release therapy and therapeutic massage reduce muscle trigger and tender points. *Journal of Bodywork and Movement Therapies, 28*, 264–270. https://doi.org/10.1016/j.jbmt.2021.07.005
- Cao, Q.-W., Peng, B.-G., Wang, L., Huang, Y.-Q., Jia, D.-L., Jiang, H., Lv, Y., ... & Huang, D. (2021). Expert consensus on the diagnosis and treatment of myofascial pain syndrome. *World Journal of Clinical Cases*, 9(9), 2077– 2089. https://doi.org/10.12998/wjcc.v9.i9.2077
- Castien, R. F., Coppieters, M. W., Durge, T. S. C., & Scholten-Peeters, G. G. M. (2021). High concurrent validity between digital and analogue algometers to measure pressure pain thresholds in healthy participants and people with migraine: A cross-sectional study. *The Journal of Headache and Pain*, 22(1), 69. https://doi.org/10.1186/s10194-021-01278-8
- Celik, D., & Mutlu, E. K. (2013). Clinical Implication of Latent Myofascial Trigger Point. Current Pain and Headache Reports, 17(8), 353. https://doi. org/10.1007/s11916-013-0353-8
- Charles, D., Hudgins, T., MacNaughton, J., Newman, E., Tan, J., & Wigger, M. (2019). A systematic review of manual therapy techniques, dry cupping and dry needling in the reduction of myofascial pain and myofascial trigger points. *Journal of Bodywork and Movement Therapies*, 23(3), 539– 546. https://doi.org/10.1016/j.jbmt.2019.04.001
- Chattrattrai, T., Janal, M. N., Lobbezoo, F., & Raphael, K. G. (2023). The association between sleep bruxism and awake bruxism: Polysomnographic and electromyographic recordings in women with and without myofascial pain. *Journal of Oral Rehabilitation*, 50(9), 822– 829. https://doi.org/10.1111/joor.13468
- Chesterton, L. S., Sim, J., Wright, C. C., & Foster, N. E. (2007). Interrater Reliability of Algometry in Measuring Pressure Pain Thresholds in Healthy Humans, Using Multiple Raters. *The Clinical Journal of Pain*, 23(9), 760–766. https://doi.org/10.1097/AJP.0b013e318154b6ae
- Cordeiro, M. A., dos Santos, M. B. R., Zotz, T. G. G., & de Macedo, A. C. B. (2021). The influence of sex and level of physical activity on maximum tolerance to mechanical pain. *Brazilian Journal of Anesthesiology (English Edition)*, S010400142100378X. https://doi.org/10.1016/j.bjane.2021.09.019
- Cygańska, A. K., Tomaszewski, P., & Cabak, A. (2022). Pain threshold in selected trigger points of superficial muscles of the back in young adults. *PeerJ*, *10*, e12780. https://doi.org/10.7717/peerj.12780
- Das, R., & Jhajharia, B. (2022a). Fascia and Myofascial Pain Syndrome An Overview. Asian Pacific Journal of Health Sciences, 9(4s), 228–232. https://doi.org/10.21276/apjhs.2022.9.45.44
- Das, R., & Jhajharia, B. (2022b). Original Article Correlation between latent myofascial trigger point and peak torque production of lower limb muscles on sports person. *Journal of Physical Education and Sport, 22*, 2224–2230. https://doi.org/10.7752/jpes.2022.09283
- Das, R., Jhajharia, B., Ciocan, V. C., Majumdar, I., & Sharma, A. (2023). The Relationship Between Latent Myofascial Trigger Point and Range of Motion of Knee Flexor and Extensor Muscles. *Physical Education*

Theory and Methodology, 23(2), 192–198. https://doi.org/10.17309/ tmfv.2023.2.06

- Das, R., Jhajharia, B., Ciocan, V., Sharma, A., & Majumdar, I. (2022). Myofascial Trigger Points and its Influence on Athletic performance-A Review. *NeuroQuantology*, 20, 467–483. https://doi.org/10.48047/ ng.2022.20.19.NQ99043
- Do, T. P., Heldarskard, G. F., Kolding, L. T., Hvedstrup, J., & Schytz, H. W. (2018). Myofascial trigger points in migraine and tension-type headache. *The Journal of Headache and Pain*, 19(1), 84. https://doi.org/10.1186/ s10194-018-0913-8
- Donnelly, J. M., & Simons, D. G. (Eds.). (2019). *Travell, Simons & Simons' myofascial pain and dysfunction: The trigger point manual* (Third edition). Wolters Kluwer Health.
- Doraisamy, M. A. & Anshul. (2011). Effect of Latent Myofascial Trigger Points on Strength Measurements of the Upper Trapezius: A Case-Controlled Trial. *Physiotherapy Canada*, *63*(4), 405–409. https://doi.org/10.3138/ ptc.2010-27
- Duarte, F. C. K., Chien, R., Ghazinour, G., Murnaghan, K., West, D. W. D., & Kumbhare, D. A. (2023). Myofascial Pain as an Unseen Comorbidity in Osteoarthritis: A Scoping Review. *The Clinical Journal of Pain, 39*(4), 188– 201. https://doi.org/10.1097/AJP.000000000001102
- Duarte, F. C. K., West, D. W. D., Linde, L. D., Hassan, S., & Kumbhare, D. A. (2021). Re-Examining Myofascial Pain Syndrome: Toward Biomarker Development and Mechanism-Based Diagnostic Criteria. *Current Rheumatology Reports*, 23(8), 69. https://doi.org/10.1007/s11926-021-01024-8
- E Silva, D. C. C. M., de Andrade Alexandre, D. J., & Silva, J. G. (2018). Immediate effect of myofascial release on range of motion, pain and biceps and rectus femoris muscle activity after total knee replacement. *Journal* of Bodywork and Movement Therapies, 22(4), 930–936. https://doi. org/10.1016/j.jbmt.2017.12.003
- Elbarbary, M., Goldberg, M., Tenenbaum, H. C., Lam, D. K., Freeman, B. V., Pustaka, D. J., ... & Azarpazhooh, A. (2023). Assessment of Concordance between Chairside Ultrasonography and Digital Palpation in Detecting Myofascial Trigger Points in Masticatory Myofascial Pain Syndrome. *Journal of Endodontics*, 49(2), 129–136. https://doi.org/10.1016/j. joen.2022.11.013
- Escalona-Marfil, C., Coda, A., Ruiz-Moreno, J., Riu-Gispert, L. M., & Gironès, X. (2020). Validation of an Electronic Visual Analog Scale mHealth Tool for Acute Pain Assessment: Prospective Cross-Sectional Study. *Journal of Medical Internet Research*, 22(2), e13468. https://doi.org/10.2196/13468
- Fernández-González, P., Koutsou, A., Cuesta-Gómez, A., Carratalá-Tejada, M., Miangolarra-Page, J. C., & Molina-Rueda, F. (2020). Reliability of Kinovea® Software and Agreement with a Three-Dimensional Motion System for Gait Analysis in Healthy Subjects. *Sensors*, 20(11), 3154. https://doi.org/10.3390/s20113154
- Fousekis, K., & Kounavi, E. (2016). The Effectiveness of Instrument-assisted Soft Tissue Mobilization Technique (Ergon© Technique), Cupping and Ischaemic Pressure Techniques in the Treatment of Amateur Athletesi, Myofascial Trigger Points. *Journal of Novel Physiotherapies*, s3. https:// doi.org/10.4172/2165-7025.S3-009
- Ge, H.-Y., & Arendt-Nielsen, L. (2011). Latent Myofascial Trigger Points. Current Pain and Headache Reports, 15(5), 386–392. https://doi.org/10.1007/ s11916-011-0210-6
- Girasol, C. E., Dibai-Filho, A. V., de Oliveira, A. K., & de Jesus Guirro, R. R. (2018). Correlation Between Skin Temperature Over Myofascial Trigger Points in the Upper Trapezius Muscle and Range of Motion, Electromyographic Activity, and Pain in Chronic Neck Pain Patients. *Journal of Manipulative and Physiological Therapeutics*, 41(4), 350–357. https://doi.org/10.1016/j.jmpt.2017.10.009
- Habets, B., Staal, J. B., Tijssen, M., & van Cingel, R. (2018). Intrarater reliability of the Humac NORM isokinetic dynamometer for strength measurements of the knee and shoulder muscles. *BMC Research Notes*, *11*(1), 15. https://doi.org/10.1186/s13104-018-3128-9
- Haser, C., Stöggl, T., Kriner, M., Mikoleit, J., Wolfahrt, B., Scherr, J., ... & Pfab,
  F. (2017). Effect of Dry Needling on Thigh Muscle Strength and Hip Flexion in Elite Soccer Players. *Medicine & Science in Sports & Exercise*, 49(2), 378–383. https://doi.org/10.1249/MSS.00000000001111
- Ibrahim, N. A., Abdel Raoof, N. A., Mosaad, D. M., & Abu el kasem, S. T. (2021). Effect of magnesium sulfate iontophoresis on myofascial trigger points in the upper fibres of the trapezius. *Journal of Taibah University Medical Sciences*, 16(3), 369–378. https://doi.org/10.1016/j.jtumed.2020.12.015
- Jiménez-Sánchez, C., Gómez-Soriano, J., Bravo-Esteban, E., Mayoral-del Moral, O., Herrero-Gállego, P., Serrano-Muñoz, D., & Ortiz-Lucas, M. (2021). Effects of Dry Needling on Biomechanical Properties of the Myofascial Trigger Points Measured by Myotonometry: A Randomized Controlled Trial. *Journal of Manipulative and Physiological Therapeutics*, 44(6), 467–474. https://doi.org/10.1016/j.jmpt.2021.06.002

- Karpuz, S., Yılmaz, R., & Yılmaz, H. (2023). Evaluation of temporomandibular joint dysfunction in traumatic brain injury patients. *Journal of Oral Rehabilitation*, 50(6), 476–481. https://doi.org/10.1111/joor.13445
- Kim, H. A., Hwang, U. J., Jung, S. H., Ahn, S. H., Kim, J. H., & Kwon, O. Y. (2017). Comparison of shoulder strength in males with and without myofascial trigger points in the upper trapezius. *Clinical Biomechanics*, 49, 134– 138. https://doi.org/10.1016/j.clinbiomech.2017.09.001
- Kisilewicz, A., Janusiak, M., Szafraniec, R., Smoter, M., Ciszek, B., Madeleine, P., ... & Kawczyński, A. (2018). Changes in Muscle Stiffness of the Trapezius Muscle after Application of Ischemic Compression into Myofascial Trigger Points in Professional Basketball Players. *Journal of Human Kinetics*, 64(1), 35–45. https://doi.org/10.2478/hukin-2018-0043
- Lee, J.-W., Lee, J.-H., & Kim, S.-Y. (2020). Use of Acupuncture for the Treatment of Sports-Related Injuries in Athletes: A Systematic Review of Case Reports. International Journal of Environmental Research and Public Health, 17(21), 8226. https://doi.org/10.3390/ijerph17218226
- Li, L., Stoop, R., Clijsen, R., Hohenauer, E., Fernández-de-las-Peñas, C., Huang, Q., & Barbero, M. (2020). Criteria Used for the Diagnosis of Myofascial Trigger Points in Clinical Trials on Physical Therapy: Updated Systematic Review. *The Clinical Journal of Pain*, 36(12), 955–967. https://doi. org/10.1097/AJP.00000000000875
- Ortega-Santiago, R., González-Aguado, Á. J., Fernández-de-las-Peñas, C., Cleland, J. A., de-la-Llave-Rincón, A. I., ... & Plaza-Manzano, G. (2020). Pressure pain hypersensitivity and referred pain from muscle trigger points in elite male wheelchair basketball players. *Brazilian Journal of Physical Therapy*, 24(4), 333–341. https://doi.org/10.1016/j. bjpt.2019.05.008
- Öztürk, Ö., FeyziOğlu, Ö., Güven, F., & ÇeviK Saldiran, T. (2022). Myotonometric Evaluation of Latent Myofascial Trigger Points and Taut Band in Elite Athletes. *Journal of Basic and Clinical Health Sciences*. https://doi. org/10.30621/jbachs.959275
- Park, G., Kim, C. W., Park, S. B., Kim, M. J., & Jang, S. H. (2011). Reliability and Usefulness of the Pressure Pain Threshold Measurement in Patients with Myofascial Pain. *Annals of Rehabilitation Medicine*, 35(3), 412. https://doi.org/10.5535/arm.2011.35.3.412
- Puig-Diví, A., Escalona-Marfil, C., Padullés-Riu, J. M., Busquets, A., Padullés-Chando, X., & Marcos-Ruiz, D. (2019). Validity and reliability of the Kinovea program in obtaining angles and distances using coordinates in 4 perspectives. *PLoS One*, *14*(6), e0216448. https://doi.org/10.1371/ journal.pone.0216448
- Ribeiro, D. C., Belgrave, A., Naden, A., Fang, H., Matthews, P., & Parshottam, S. (2018). The prevalence of myofascial trigger points in neck and shoulder-related disorders: A systematic review of the literature. *BMC Musculoskeletal Disorders*, 19(1), 252. https://doi.org/10.1186/s12891-018-2157-9
- Rodríguez-Jiménez, J., Ortega-Santiago, R., Bonilla-Barba, L., Falla, D., Fernández-de-Las-Peñas, C., & Florencio, L. L. (2022). Immediate Effects of Dry Needing or Manual Pressure Release of Upper Trapezius Trigger Points on Muscle Activity during the Craniocervical Flexion Test in People with Chronic Neck Pain: A Randomized Clinical Trial. *Pain Medicine (Malden, Mass.), 23*(10), 1717–1725. https://doi.org/10.1093/ pm/pnac034
- Sabeh, A., Bedaiwi, S., Felemban, O., & Mawardi, H. (2020). Myofascial pain syndrome and its relation to trigger points, facial form, muscular hypertrophy, deflection, joint loading, body mass index, age and educational status. *Journal of International Society of Preventive and*

Community Dentistry, 10(6), 786. https://doi.org/10.4103/jispcd. JISPCD 328 20

- San-Antolín, M., Rodríguez-Sanz, D., López-López, D., Romero-Morales, C., Carbajales-Lopez, J., Becerro-de-Bengoa-Vallejo, R., ... & Calvo-Lobo, C. (2020). Depression levels and symptoms in athletes with chronic gastrocnemius myofascial pain: A case-control study. *Physical Therapy in Sport*, 43, 166–172. https://doi.org/10.1016/j.ptsp.2020.03.002
- San-Antolín-Gil, M., López-López, D., Becerro-de-Bengoa-Vallejo, R., Elena Losa-Iglesias, M., Romero-Morales, C., Rodríguez-Sanz, D., ... & Calvo-Lobo, C. (2022). Influence of psychological factors on myofascial pain. In *The Neurobiology, Physiology, and Psychology of Pain* (pp. 405–415). Elsevier. https://doi.org/10.1016/B978-0-12-820589-1.00036-1
- Schneider, E., Moore, E. S., Stanborough, R., & Slaven, E. (2022). Effects of Trigger Point Dry Needling on Strength Measurements and Activation Levels of the Gluteus Medius: A Quasi-Experimental Randomized Control Study. *International Journal of Sports Physical Therapy*, 17(7). https://doi.org/10.26603/001c.55536
- Shah, J. P., Thaker, N., Heimur, J., Aredo, J. V., Sikdar, S., & Gerber, L. (2015). Myofascial Trigger Points Then and Now: A Historical and Scientific Perspective. *PM&R*, 7(7), 746–761. https://doi.org/10.1016/j. pmrj.2015.01.024
- Tasmektepligil, M. Y. (2016). The Relationship between Balance Performance and Knee Flexor-Extensor Muscular Strength of Football Players. *The Anthropologist*, 23(3), 398–405. https://doi.org/10.1080/09720073.201 4.11891960
- Valera-Calero, J. A., Sánchez-Jorge, S., Buffet-García, J., Varol, U., Fernándezde-las-Peñas, C., & Álvarez-González, J. (2023). Changes in stiffness at active myofascial trigger points of the upper trapezius after dry needling in patients with chronic neck pain: A randomized controlled trial. Acupuncture in Medicine, 41(3), 121–129. https://doi. org/10.1177/09645284221104831
- Walsh, R., Kinsella, S., & McEvoy, J. (2019). The effects of dry needling and radial extracorporeal shockwave therapy on latent trigger point sensitivity in the quadriceps: A randomised control pilot study. *Journal of Bodywork and Movement Therapies*, 23(1), 82–88. https://doi. org/10.1016/j.jbmt.2018.02.010
- Wheeler, A. H. (2004). Myofascial Pain Disorders: Theory to Therapy. *Drugs*, 64(1), 45–62. https://doi.org/10.2165/00003495-200464010-00004
- Widyadharma, I. P. E. (2020). The role of oxidative stress, inflammation and glial cell in pathophysiology of myofascial pain. *Postępy Psychiatrii i Neurologii*, 29(3), 180–186. https://doi.org/10.5114/ppn.2020.100036
- Xia, P., Wang, X., Lin, Q., Cheng, K., & Li, X. (2017). Effectiveness of ultrasound therapy for myofascial pain syndrome: A systematic review and metaanalysis. *Journal of Pain Research*, 10, 545–555. https://doi.org/10.2147/ JPR.S131482
- Yeste-Fabregat, M., Baraja-Vegas, L., Vicente-Mampel, J., Pérez-Bermejo, M., Bautista González, I. J., & Barrios, C. (2021). Acute Effects of Tecar Therapy on Skin Temperature, Ankle Mobility and Hyperalgesia in Myofascial Pain Syndrome in Professional Basketball Players: A Pilot Study. International Journal of Environmental Research and Public Health, 18(16), 8756. https://doi.org/10.3390/ijerph18168756
- Zuil-Escobar, J. C., Martínez-Cepa, C. B., Martín-Urrialde, J. A., & Gómez-Conesa, A. (2015). Prevalence of Myofascial Trigger Points and Diagnostic Criteria of Different Muscles in Function of the Medial Longitudinal Arch. Archives of Physical Medicine and Rehabilitation, 96(6), 1123–1130. https://doi.org/10.1016/j.apmr.2015.02.017