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The effectiveness of neuromuscular taping and combined therapeutic exercises in reducing pain and improving knee health in soccer players

Siti Muawanah[1,2*], Ismaningsih[1], Rezky Guna Putra[4], Siti Juariah[3], Eva Oktariani[4], Agustiyawan[5], Deinike Wanita[4], Azliyana Azizan[2,6]

[1] Department of Physiotherapy, Faculty of Pharmacy and Health Sciences, Abdurrab University, Pekanbaru, Indonesia.

[2] Centre of Physiotherapy, Faculty of Health Sciences, Universiti Teknologi MARA, Puncak Alam 42300 Selangor, Malaysia.

[3] Department Health Science, Faculty of Pharmacy and Health Sciences, Abdurrab University, Pekanbaru, Indonesia.

[4] Department of Medicine, Faculty of Medicine, Abdurrab University, Pekanbaru, Indonesia.

[5] Department of Physiotherapy, Faculty of Health Sciences, Veteran National Development University, Jakarta, Indonesia.

[6] Clinical and Rehabilitation Exercise Research Group, Faculty of Health Sciences, Universiti Teknologi MARA, Puncak Alam, Selangor, Malaysia, 42300.

* Correspondence: Siti Muawanah; siti.muawanah@univrab.ac.id

ABSTRACT

This study aimed to determine how neuromuscular taping (NMT), isometric training, and core stability exercises could help male soccer students with jumper's knees, aged 14 to 17, improve their well-being and agility. This quasi-experimental study employed a pre-test and post-test design with two groups, each consisting of fourteen participants (n=14 per group). The intervention group received isometric training and core stability exercises combined with additional Neuromuscular Taping (NMT), while the control group performed only isometric training and core stability exercises. Clinical data were collected before and after the intervention using the Visual Analog Scale (VAS) to assess pain and the Illinois Agility Test (IAT) to evaluate agility. Three times a week for five weeks, the 15-session treatment was conducted under constant safety supervision. Both groups showed lower VAS scores (control: 5.71±1.204 to 3.00±0.961, p=0.0001; intervention: 5.43±1.222 to 1.93±1.072, p<0.000) and higher IAT scores (control: 21.67±1.112 to 15.37±0.780, p<0.000; intervention: 21.67±1.112 to 14.72±0.766, p=0.0001). Significant post-treatment effects on VAS (p=0.033) were found by independent t-tests. The intervention group, which received NMT,

isometric training, and core stability exercises, showed better results in terms of pain reduction and agility improvement for the jumper's knee.

KEYWORDS

Neuromuscular Taping; Pain; Isometric Training; Core Stability Exercise; Jumper’s Knee

1. INTRODUCTION

Soccer requires a significant amount of lower limb strength and sporadic high-intensity exercises, which are essential for performing motions like jumping, kicking, and running. Appropriate training regimens are necessary to reduce the chance of injuries during play as well as to improve players' performance (Sever & Zorba, 2018). Jumper's knee is one particular injury that soccer players may sustain; it is characterized by a tear in the patellar tendon caused on by repeated jumping motions. This medical condition is caused by a number of reasons, such as leg deformities, malpositioning of the patella, ongoing stress on the patella, and muscle imbalances that repeatedly strain the patellar tendon, causing microtears in the tendon. Jumper's knee in soccer players can be considerably reduced in frequency and severity with regular monitoring of athletes' training loads and the application of suitable rehabilitation techniques (Vries et al., 2016).

The clinical diagnosis of discomfort and dysfunction in the patellar tendon is known as patellar tendinopathy or jumper's knee. Athletes who jump from adolescence into their fourth decade of life are most typically affected. For recreational athletes, this condition limits their involvement in sports and activities; for professional athletes, it may end their careers. As symptoms intensify, they affect everyday activities including standing to sit, squatting, climbing stairs, and prolonged sitting. In order to reduce symptoms and encourage healing, managing patellar tendinopathy frequently entails a multimodal strategy that includes treating biomechanical problems, altering training regimens, and implementing suitable rehabilitation exercises (Van Der Worp et al., 2014).

Patellar tendinopathy, an overuse injury, typically manifests as a progressive rise in pain. Localized pain right below the kneecap during running or jumping exercises is the usual symptom of patellar tendinopathy. Athletes frequently continue to train and compete despite mild to moderate symptoms. When injuries are only measured by time absent from training and competition, it is difficult to establish the prevalence of overuse injuries such patellar tendinopathy because these conditions are often unreported (Van Der Worp et al., 2016). It is difficult to pinpoint the exact

prevalence of patellar tendinopathy in athletes since the time-loss approach only records the most severe acute injuries and overuse injuries (Lian et al., 2005).

This emphasizes how crucial it is to use thorough injury surveillance techniques that take into account both time-loss and non-time-loss criteria in order to precisely determine the incidence and consequences of patellar tendinopathy in sports populations (Claudino et al., 2017).

Research that specifically looked at the prevalence of patellar tendinopathy revealed that the prevalence of tendinopathy varied depending on the sport played. Elite athletes had a much higher prevalence than recreational athletes, with volleyball players having the highest frequency (14.4%) and soccer players having the lowest prevalence (2.5%) (Rudavsky & Cook, 2014). Among the sports analyzed, basketball, netball, cricket, and Australian football had the highest frequency of pathology (36%) among players; among asymptomatic elite athletes, the prevalence of tendon pathology was 22% for male athletes, twice as high as for female athletes.4. Young basketball players were shown to have a 7% prevalence of patellar tendinopathy, but 26% of them had tendon pathology on MRI without any symptoms, demonstrating that it affects more than just adults (Jonsson & Alfredson, 2005).

Ruptures of the patellar tendon, however, are rare. According to the most thorough examination of tendon rupture, the patellar tendon accounted for only 6% of all tendon ruptures in the body. When patellar tendon ruptures do occur, they usually happen to older people (mean age 65 years) (Visnes & Bahr, 2007). Tendon pathology was present in every patient who had a ruptured patellar tendon. Even though they are uncommon, patellar tendon ruptures can impair mobility and necessitate immediate medical care for the best possible outcome (Dar & Mei-Dan, 2019). In order to restore function and strength to the knee joint, surgical intervention and rigorous rehabilitation are usually necessary for patellar tendon ruptures. In order to lower the incidence of patellar tendon injuries, particularly in older persons, prevention techniques such suitable strengthening exercises and abstaining from high-risk activities are essential. This injury will not be covered in this review because it is extremely rare. This injury will not be covered in this review because it is extremely rare (Rudavsky & Cook, 2014).

Chemical or mechanical stimulation of the skin tissue causes the sensory experience of jumper's knee discomfort, which is sometimes exacerbated by tissue damage. Acute pain goes away fast, while chronic pain lasts for a long period. Patellar tendinosis is characterized by pain that is localized at the insertion of the patellar tendon and worsens with jumping, landing, or kicking.

Furthermore, the chronic pain associated with patellar tendinosis can significantly affect an athlete's training regimen and overall performance, necessitating specialist interventions to effectively manage symptoms (Silva et al., 2015). Athletes and medical professionals must work together to develop focused treatment programs that address the underlying pathology as well as pain management techniques (de Vries et al., 2017).

The severity of the problem is indicated by the advancement of pain from post-exercise to interfering with daily activities. In addition to impairing athletic performance, this pain affects how related muscles operate, which reduces agility (Sighamoney et al., 2018). Superior agility in soccer players reduces their chance of injury, highlighting the importance of successful intervention techniques. Targeted workouts to increase muscle strength and flexibility can be an effective intervention strategy. This will increase agility and lower the risk of injury for soccer players. Restoring optimal athletic function and slowing the course of pain can be achieved by putting thorough rehabilitation protocols into place early in the management of patellar tendinopathy (McCall et al., 2020).

Agility, or the ability to quickly and precisely change direction of movement without losing balance, is one of the most crucial components of physical health. It is particularly crucial in sports where fast reflexes are required because it encompasses coordination, speed, and flexibility (Yoon et al., 2014). Because agility is so important in soccer, any condition that impairs it, like jumper's knee, can have a big effect on a player's performance and risk of injury. Jumper's knee can cause pain and decreased lower limb function, which can impair an athlete's agility and make it difficult for them to move around the field. It is essential to address agility deficiencies in soccer players through focused rehabilitation and training regimens in order to maximize performance and reduce injury risk (Sighamoney et al., 2018).

While prior studies have explored interventions like kinesiotaping techniques, isometric training, and core stability exercises to alleviate pain and enhance agility in patients with jumper's knee, the combined application of neuromuscular taping (NMT), isometric training, and core stability exercises remains relatively unexplored. Further research is necessary to establish the efficacy, optimal combinations, and long-term benefits of integrating neuromuscular taping, isometric training, and core stability exercises for treating jumper's knee. Existing studies have shown promising results individually, but comprehensive evidence on their combined effects is limited. Robust research could validate these approaches and guide clinicians in implementing evidence-based treatment strategies that maximize outcomes for patients with jumper's knee (Yoon et al., 2014).

This study aims to fill this gap by investigating the effectiveness of combining NMT with isometric training and core stability exercises in reducing pain and enhancing agility in soccer players with jumper's knee, specifically focusing on students at the PTPN V Riau Indonesia Soccer School. This research intends to contribute new knowledge by specifically evaluating how the combination of neuromuscular taping (NMT), isometric training, and core stability exercises impacts pain reduction and enhances agility in soccer players with jumper's knee, a focus that hasn't been extensively studied in this context before. It seeks to generate evidence on the synergistic effects of these interventions, potentially offering a comprehensive treatment approach tailored to the needs of athletes at the PTPN V Riau Indonesia Soccer School.

The research seeks to contribute valuable insights that can inform rehabilitation practices and optimize the performance of athletes facing this challenging condition. By elucidating the combined effects of neuromuscular taping, isometric training, and core stability exercises on pain management and agility enhancement in soccer players with jumper's knee, this study aims to refine rehabilitation protocols and enhance overall athletic performance. Such insights could potentially lead to more effective and targeted interventions that benefit athletes not only at the PTPN V Riau Indonesia Soccer School but also globally.

2. METHODS

2.1. Study Design

This quasi-experimental study employed a pre-test and post-test design, consisting of two groups. The research was carried out at the PTPN Riau Soccer School in Riau, Indonesia, spanning from September 18 to October 30, 2022. The study protocol adhered to ethical standards outlined in the Declaration of Helsinki and received approval from the Clinical Research Ethics Committee of the Faculty of Medicine, Abdurrab University (Approval Number: NO. 001/KEP-UNIVRAB/VIII/2022). Informed consent was obtained from all participants before their inclusion in the study.

2.2. Participants

A total of twenty-eight soccer students diagnosed with jumper’s knee (patellar tendinopathy) met the inclusion criteria for this study. Given the absence of similar research, the sample size was determined based on the agility scores related to jumper's knee. A previous study indicated that patients with jumper’s knee exhibited an agility score of 14.48 ± 0.66 points without intervention and 13.95 ± 0.32 points after intervention. To detect a significant difference in agility scores of 2.6

between groups, with an effect size of 0.95, aiming for an 80% test power at a significance level of 5% (0.05), a minimum of 28 participants were required for the two groups in this study (Sighamoney et al., 2018).

Patients diagnosed with jumper's knee received assistance from a sports doctor and a physiotherapist based on their history, risk factors, and examinations. Inclusion criteria comprised soccer students actively participating in sports, males aged 12–18 years, experiencing palpable pain in the patellar tendon, displaying pain in stage one appearing after exercise, or pain in stage two manifesting before and after, but not during exercise, and having a symptom duration of at least 3 months. Exclusion criteria included acute jumper's knee, chronic joint disease, signs or symptoms of other knee pathology, prior knee surgery, patellar tendon abnormality in previous cases, history of knee injury (e.g., meniscus and ligaments), and complaints of knee instability, impingement syndrome, or patellofemoral pain (Everhart et al., 2017).

2.3. Procedures and Instruments

All participants' demographic and clinical characteristics were recorded, including age, gender, weight, height, BMI, VAS pain intensity, and Illinois Agility Test (IAT) results. The outcome measures for this study were the intensity of perceived pain, evaluated using the Visual Analog Scale (VAS). The VAS instrument was utilized to assess pain intensity through a 10 cm line table with a scale reading from 0 to 10 cm. The scale interpretation ranged from >0–1 cm (no pain) to 9–10 cm (very severe pain). The VAS pain intensity was measured before intervention, 1 week, and 5 weeks after intervention. During the measurement, patients were asked to mark their pain intensity on the scale with a pencil, corresponding to the explanation provided by the researcher regarding the meaning of each scale. The VAS score was determined by measuring the distance between the ends of the line indicating no pain to the point indicated by the patient (Bimson et al., 2017).

The Illinois Agility Test (IAT) was employed to assess the agility performance of PTPN V RIAU soccer students. The test required specific equipment, including a non-slip flat surface, a 10-meter-long running track, a 5-meter width (distance between start and finish points), 8 marking cones, a stopwatch, whistle, tape measure as a barrier, forms, and stationery. The researcher set up the test, prepared the forms, and recorded the time using a stopwatch. The test area was measured and marked using cones. Participants started in a standing position, in contrast to the initial test where participants lay forward with their heads toward the start line. After the signal "ready," participants ran forward 5 meters to cone 2, then zig-zagged back around cones 3, 4, and 5 as fast as possible,

arriving at the end of the track. They then returned in the original direction, ran 5 meters to cone 7, and ran another 5 meters straight to cone 8, passing the finish cone. The time stopped as noted by the study; the results of the time achieved in seconds were recorded after the participants ran past the starting line. The measurement of the Illinois Agility (McCall et al., 2020). Test (IAT) scores is presented in Table 1.

Table 1. Measurement of the Illinois Agility Test (IAT)

Interpretation	Category	Males	Females
Excellent	1	<15.2	<17.0
Very good	2	16,1-15.2	17,9-18.0
Good	3	18,1-16,2	21,7-18,0

The physiotherapist, trained by David Blow, employed Neuromuscular Taping (NMT) in knee treatment. Utilizing I and Y-shaped strips, 25 cm long and 2.5 cm wide, applied anteriorly, medially, and laterally to the patella. The protocol featured two 25 cm, 2.5 cm wide I tapes along the collateral ligament with 50% tape tension, a 25 cm, 2.5 cm wide horizontal tape below the patella with 25% tension, and a 30 cm, 5 cm wide Y tape with an initial 5 cm base laterally to the patella without tension. This NMT, based on David Blow's technique, applied passive stretching and eccentric methods for jumper's knee. Kinesiological tape, with 120-140% stretchability, lasting 3-5 days on the skin, was chosen for its dynamic and effective prevention of jumper's knee (Ortega-Castillo et al., 2020) as depicted in Figure 1 (Marcolin et al., 2017).

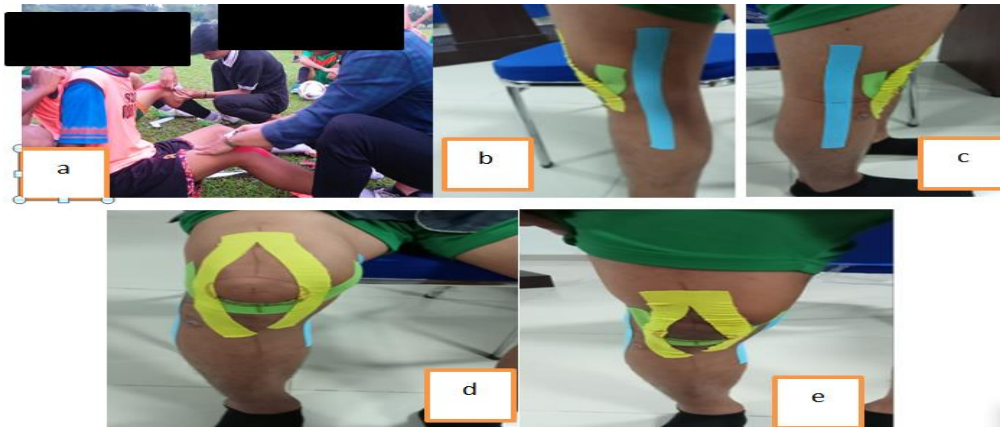

Figure 1. Neuromuscular Tapping (NMT) Application
Source: Muawanah et al. (2022)

Several isometric training types were used in this study: Straight leg raise: Sit on the floor with the injured leg extended forward and the ankle tilted towards it. Then, move the injured leg up 6-8 inches and hold for 6 seconds. Slowly lower it to the floor, repeating this movement 20 times (20 reps). Leg extension: Quadriceps exercise involving the contraction of the quadriceps muscles. Extend the knee joint by lifting the lower leg until it is fully straight. Use weights heavy enough to cause fatigue but not pain. Hold this position for 6 seconds. Perform this exercise for 3 sets, with each set consisting of 10 movements (10 repetitions) (Nyoman et al., 2021).

Wall squat exercise: Keep your shoulders relaxed and open your feet shoulder-width apart. Then, lower your body slowly with your back straight until your knee joint forms a 45-degree angle. Hold the position for 10 seconds, then slowly rise back to standing upright. Repeat this movement for 10 reps for 3 sets. Step-up/Single leg passing: Stand with the injured leg 3 to 5 inches high, while the healthy foot remains on the floor. Straighten the injured knee so the healthy leg lifts off the floor. Slowly lower your healthy foot back to the floor. Perform this movement for 4 sets and hold for 1 minute with the aim of training proprioception (balance) and anti-gravity muscle coordination (McCall et al., 2020) (Figure 2).

Figure 2. Isometric Training
Source: Muawanah et al. (2022)

Several types of core stability exercises are used in this study to train deeper muscles in the abdomen, connected to the spine, pelvis, and shoulders: Plank as the initial core exercise (Saki et al., 2023). This exercise can be used as a good warm-up by holding the position for 15-60 seconds and maintaining control of the position. Do this movement for 1 rep for 3 sets and hold for 1 minute with the aim of training proprioception and balance. Oblique Planks: This exercise is very effective for helping the lateral side of the pelvic muscle strength, stability, and maintaining the strength of the oblique and transverse abdominis (Tekin et al., 2018). The exercise is performed in a sideways position, keeping the body straight from head to toe. Hold the position for 15-60 seconds while

maintaining control of the position. Do this movement for 1 rep for 3 sets and hold for 1 minute. Hip Bridge or Supine Bridge, namely maintaining the position for 15-60 seconds while maintaining position control. Do this movement for 1 rep for 3 sets and hold for (Muawanah et al., 2022) 1 minute. Superman, hold this position for the allotted time. Then repeat the movement with the other leg and arm. Continue this exercise with sets of x reps: 2 x 12 per side (2 times a week) (Prieske et al., 2016) (Figure 3).

Figure 3. Core Stability Exercises
Source: Muawanah et al. (2022)

2.4. Statistical Analyses

Data analysis was conducted using the Statistical Package for the Social Sciences, version 17.0 (SPSS, Inc., Chicago, IL, USA). The study compared mean scores between two groups: jumpers knee patients with isometric exercise intervention and core exercises as the control group, and jumpers knee patients with neuromuscular taping (NMT) treatment and a combination of isometric and core exercises as the intervention group. To assess differences in VAS pain scale and IAT scores before and after treatment within each group (control and intervention), a paired t-test was performed for normally distributed data, and the Wilcoxon signed-rank test was utilized for non-normally distributed data. For comparing post-treatment scores between the two groups, an independent t-test was applied for normally distributed data, and the Mann-Whitney test was used for non-normally distributed data. A significance level of $p < 0.05$ was considered for statistical significance.

3. RESULTS

The 28 participants were divided into two groups based on age, weight, height, BMI, jumper's knee cases, and male gender. In the control group (n = 14) with isometric training and core stability exercise, the average age was 15.65 ± 0.85 years (range 14–17 years). Table 2 presents the general characteristics of the participants.

Table 2. General characteristics of the participants

Variables N=28	Control Group Isometric and Core Exercise (n=14)		Intervention Group Isometric and Core Exercise and NMT (n=14)		p value
Male gender	Mean ± SD	Min; Max	Min; Max	Mean ± SD	
Age (year)	15.64±0.84	14:17	14:16	15.50±0.65	0.379
Weight (kg)	57.35±9.03	40:70	42:64	55.93±6.24	0.261
Height (cm)	168.57±4.67	157:175	161:174	169.84±3.25	0.401
BMI (kg/m2)	21.12±4.38	16:33	15:22.16	19.29±1.88	0.198

Note: *body mass index (BMI); cm: centimeter; kg: Kilogram; Min: Minimum; Max: maximum.*

In the intervention group with neuromuscular taping (NMT) and a combination of isometric and core exercises (n = 14), the average age was 15.50 ± 0.65 years (range 14–16 years). No significant age difference was observed between the two groups (p > 0.379). The average body weight in the control group was 57.35 ± 9.03 kg (range 40–70 kg), and in the intervention group, it was 55.93 ± 6.24 kg (range 42–64 kg), with no significant difference (p > 0.261). The mean height in the control group was 168.57 ± 4.67 cm (range 157–175 cm), and in the intervention group, it was 169.84 ± 3.25 cm (range 161–174 cm), with no significant difference (p > 0.401). The mean BMI in the control group was 21.12 ± 4.38 kg/m2 (range 16.30–33.90 kg/m2), and in the intervention group, it was 19.29 ± 1.88 kg/m2 (range 15–22.16 kg/m2), with no significant difference (p > 0.198) as presented in Table 2.

Table 3 below shows that the research included 14 participants (n = 14) in the control group, which received isometric exercise and core stability exercise interventions, and 14 participants (n = 14) in the intervention group, which received the same interventions with the addition of NMT application.

Table 3. Visual Analog Scale and Agility Illinois Test scores before and after intervention between the two treatment groups

Variable Group	Pre-treatment		Post-treatment			
N= 28	**Mean ± SD**	**Min; Max**	**Mean ± SD**	**Min; Max**	**Δ Score**	**p^1**
Control Group (VAS)	5.71±1.204	4.00;8.00	3.00±0.961	2.00; 5.00	2.714±0.726	<0.000
Intervention Group (VAS)	5.43±1.222	3.00;7.00	1.93±1.072	1.00; 5.00	3.50±1.286	<0.000
Control Group (IAT)	21.67±1.112	20.32;23,64	15.37± 0.780	14.44; 17.32	6.300±1.363	<0.000
Intervention Group (IAT)	21.32±1.306	19.09;24.11	14.72 ± 0.766	12.63; 15.37	6,606±1.016	<0.000
p-value p^2	VAS p>0.539	IAT p>0.451	VAS p<0.010	IAT p<0.033	VAS p<0.010 IAT p<0.033	

Note: *Min: Minimum; Max: maximum; SD: Standard deviation; VAS: Visual analogue scale; IAT: Illinois agility test; SD: Standard deviation; IAT: Illinois agility test; the p-value is based on p-Value p^1; Paired t-test and p-value p^2 independent T-test significant at p value < 0,05.*

There was significant different in pain (VAS) reduction and an increase in agility (IAT) between before and after treatment. The control group, which received isometric exercise and core stability exercise interventions, had a mean pre-treatment VAS pain score of 5.71 ± 1.204 (range 4.00–8.00) and a mean post-treatment score of 3.00 ± 0.961 (range 2.00–5.00). The results of the parametric statistical test (paired t-test) showed that the total VAS score in the control group improved significantly ($p < 0.000$), as presented in Table 3 above and Figure 4(a) below.

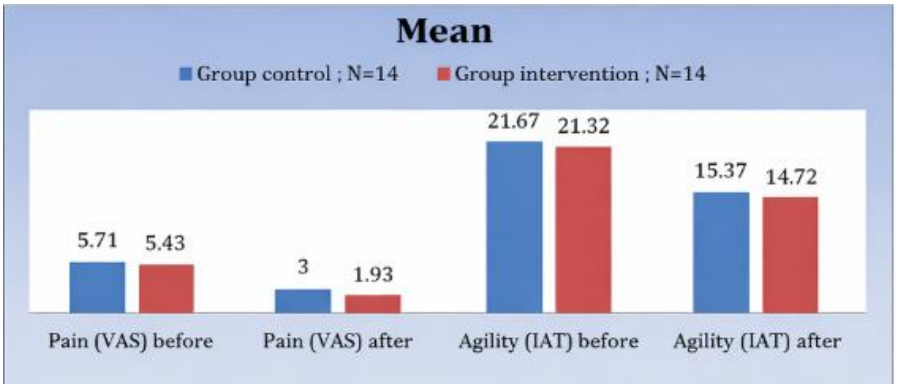

Figure 4(a). Mean VAS and IAT comparison for each group

The intervention group received neuromuscular taping (NMT) combined with isometric and core stability exercises. In this group, the mean VAS pain score decreased from 5.43 ± 1.222 (range 3.00–7.00) before treatment to 1.93 ± 1.072 (range 1.00–5.00) after treatment (Table 3; Figure 4a, 4b). The parametric statistical test (paired t-test) showed that the reduction in VAS scores was statistically significant ($p < 0.001$). In the control group, the mean agility (IAT) value decreased from 21.67 ± 1.112 (range 20.32–23.64) before treatment to 15.37 ± 0.780 (range 14.44–17.32) after treatment. The paired t-test indicated a statistically significant improvement in IAT scores ($p < 0.001$). In the intervention group, the mean agility (IAT) value decreased from 21.32 ± 1.306 (range 19.09–24.11) before treatment to 14.72 ± 0.766 (range 12.63–15.37) after treatment. The paired t-test showed that this improvement was also statistically significant ($p < 0.001$) (Table 3; Figure 4a).

Based on the minimum and maximum values, the intervention group showed better and more significant results in reducing pain and improving agility compared to the control group, indicating a meaningful clinical effect. A significant decrease in both VAS and IAT scores was observed at week 5. Participants in the intervention group received treatment over a period of 5 weeks, with a total of 15 sessions.

The independent t-test showed no significant differences in pain (VAS) between the two

groups before the intervention ($p > 0.539$). Similarly, no significant differences were found in agility (IAT) between the groups at baseline ($p > 0.451$), indicating that both groups were homogeneous prior to treatment. After the intervention, the independent t-test revealed significant differences between the two groups in both VAS ($p < 0.010$) and IAT ($p < 0.033$). Regarding pre–post differences, the mean reduction in VAS was 2.714 ± 0.726 in the control group and 3.50 ± 1.286 in the intervention group. For agility (IAT), the mean improvement was 6.300 ± 1.363 in the control group and 6.606 ± 1.016 in the intervention group. Overall, the mean data indicate a greater effect on pain reduction (VAS) and agility improvement (IAT) in the intervention group compared to the control group (Table 3; Figure 4b).

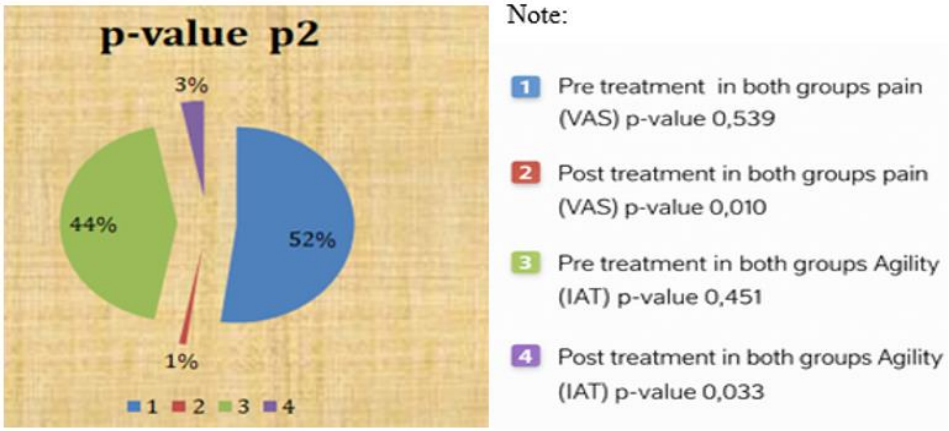

Figure 4 (b). VAS and IAT Difference Test after 5 weeks of intervention in the two treatment groups with independent t-test

The most common site of pain was identified as the proximal part of the patellar tendon just below the patella (65%-70%), followed by the quadriceps tendon (20%) and the side of the patellar tendon just at the tibial tuberosity (10%). A consistent physical finding for jumper's knee was the local tenderness of the patellar tendon (Everhart et al., 2017).

The bar chart compares the mean Visual Analog Scale (VAS) pain scores and Index of Agility Test (IAT) scores between a control group (N = 14) and an intervention group (N = 14) before and after five weeks of treatment. For VAS pain, both groups had similar pre-treatment scores (control: 5.71, intervention: 5.43), but post-treatment scores were lower in the intervention group (1.93) compared to the control group (3.00). For IAT agility, both groups started with comparable pre-treatment scores (control: 21.67, intervention: 21.32), but the post-treatment scores were slightly better in the control group (15.37) than in the intervention group (14.72).

The pie chart illustrates the p-values obtained from an independent t-test comparing Visual Analog Scale (VAS) pain scores and Index of Agility Test (IAT) scores between two treatment groups before and after five weeks of intervention, showing significant differences in post-treatment VAS pain ($p = 0.010$) and post-treatment agility ($p = 0.033$), while pre-treatment differences were not significant for either VAS ($p = 0.539$) or IAT ($p = 0.451$).

4. DISCUSSION

This study focused on assessing pain and decreased agility in soccer student patients with jumper's knee. The participants exhibited pain symptoms during both activities and after activities, progressing through stages one and two of jumper's knee. The pain experienced varied in intensity and was often associated with changes in exercise patterns, frequency, or excessive workload.

Notably, the study highlighted that pain below the knee due to jumper's knee led to a decrease in ball-playing agility, emphasizing the functional impact of this condition on the athletic performance of soccer players (Bimson et al., 2017). These findings underscore the importance of addressing both pain management and agility improvement in the treatment protocols for individuals with jumper's knee, aiming not only for symptom relief but also for the restoration of optimal athletic functionality (Ding et al., 2022). Future interventions, such as the application of neuromuscular taping along with isometric exercise and core stability exercises, demonstrated promising results in reducing pain and enhancing agility, as discussed in the study results (Marcolin et al., 2017).

The program started by using the Visual Analog Scale (VAS) to measure pain levels and the Illinois Agility Test to gauge improved agility before physiotherapy intervention was put into place. The individuals then participated in a 5-week intervention that was administered 15 times, followed by a re-measurement at the end of the program. This procedure sought to ascertain the effectiveness of each treatment given during the intervention in terms of pain reduction and agility development (Silva et al., 2015).

The application of neuromuscular taping in the pre-test and post-test results of the study showed a statistically significant improvement in both VAS (Visual Analog Scale) and IAT (Illinois Agility Test) scores within the intervention group. The results demonstrated superior and more effective outcomes with the additional use of neuromuscular taping (NMT) in conjunction with isometric exercise intervention and core stability exercise ($p<0.000$), as outlined in Table 3. Specifically, the mean VAS was higher in the intervention group (1.93 ± 1.072), and the mean agility IAT value after the intervention was 14.72 ± 0.766. In comparison, the control group exhibited a lower

mean VAS (3.00±0.961), and the mean agility IAT value after the intervention was 15.37 ± 0.780 (refer to Table 3 and Figure 4 (a) (b)).

The findings of this study provide valuable insights into the potential benefits of this intervention for individuals with jumper's knee, supporting the enhancement of muscle contractions and overall performance (Boz, 2020). These results suggest that neuromuscular taping can be beneficial when combined with isometric and core stability exercises to improve pain and agility. The study's comprehensive approach involved a 5-week regimen of isometric and core stability training, with a focus on activating the lower leg muscles, specifically the quadriceps femoris muscle, which is essential for kick strength and core muscle activation. In order to improve soccer players' overall performance, adjustments were also made to their posture and joint locations (Ortega-Castillo et al., 2020). Neuromuscular taping was found to be beneficial for those with jumper's knee when used in conjunction with passive stretching, eccentric treatments, isometric exercises, and core stability activities that involve muscle activation. This comprehensive strategy improved total body posture by strengthening the trunk and abdominal muscles (Ding et al., 2022).

Additionally, the intervention improved lymphatic and blood circulation, which decreased the amount of stress on mechanoreceptors under the skin. Additionally, the compression method used in conjunction with neuromuscular taping improved knee proprioception and stability, which in turn improved placement during movement errors and, ultimately, improved agility, balance, and coordination (Rahlf et al., 2019).

According to the study by Sever & Zorba (2018), soccer players who were actively participating in isometric training and core stability exercises showed an increase in agility when compared to the control group. According to this study, severe training loads during soccer play, inadequate recovery, and a lack of muscle-strengthening and balance workouts are the main causes of pain and impaired agility. These elements made many athletes more likely to get injuries, which in turn affected their performance and frequently prevented them from reaching their ultimate championship goals. Achieving targeted goals requires acknowledging the necessity of instruction and training that can have a lasting effect on athletes' performance (Söke et al., 2023).

Strengthening workouts physiologically cause myofibrils and muscle fibers, particularly type II, to enlarge. The overall amount of contractile protein, capillary density, and the quantity of connective tissues, tendons, and ligaments have all increased. Increased contractions of keratin, phosphokinase, ATP, and glycogen are among the biochemical alterations, as are a minor but notable

rise in the aerobic Krebs cycle enzymes' capability and a decrease in mitochondrial volume. In order to improve muscle strength and joint stability, isometric workouts promote maximal contractions under load (Yildirim et al., 2023).

Static and isometric exercises are integral to weight training, where there is no change in muscle length. Examples include pulling or pushing immovable objects while maintaining body position against pressure. Isometric training and core stability exercises conducted for five weeks significantly benefited athletes, reducing pain in jumper's knee and enhancing agility (Ding et al., 2022). This positive outcome arises from core stability exercises augmenting postural muscles, particularly in the trunk and posture, leading to increased overall body stability. Balanced and stable body movements alleviate the load and pressure on the patellar tendon, preventing recurrent instances of jumper's knee (Boz, 2020).

In addition, the study by Bimson Leah et al. (2017), which emphasizes the efficacy of pain reduction and agility development with a gradually introduced isometric exercise program, supports this study. In addition to improving muscle strength, patellar tendon function, proprioception, agility, and functional strengthening, continuous isometric exercise provides analgesic qualities that prevent undue strain on tendons and help players successfully return to sports (Huang et al., 2021).

The study's control group, which received three weekly sessions of isometric training and core stability exercises without Neuromuscular Taping (NMT) therapy, showed notable gains in agility and VAS pain scores ($p<0.000$). These findings highlight how important core stability exercises are to isometric training. A key role was played by isometric contraction, which is the contraction of muscle groups to lift or push an immovable object without limb movement or change in muscle length (Watanabe, 2019).

As emphasized by Yılmaz (2022), a study involving a four-week application of special isometric training and core stability exercises to children aged 9–17 years demonstrated significant improvements in agility parameters among 16 participants, favoring the experimental group (EG) in the agility test analysis ($p<0.05$). These findings underscore the positive impact of the isometric training program and core stability exercises on enhancing agility in young athletes (Silva et al., 2015).

In another study by Rahlf et al. (2019), focusing on osteoarthritis patients, the application of Kinesio tape for three consecutive days exhibited beneficial effects in terms of self-reported clinical outcomes related to pain, joint stiffness, and function ($p<0.03$). Additionally, this physiological

aspect provides insights into the holistic benefits of isometric exercises and core stability training, emphasizing their role in alleviating pain and enhancing functional outcomes in various populations (Prieske et al., 2016).

A study conducted by Kristianto et al. (2021) investigated the databases related to neuromuscular taping (NMT) and its application in diabetic foot cases for the period of 2010–2019. The concept analysis employed an 8-step approach using Walker and Avant's method. The results of the analysis on the NMT concept regarding diabetic foot revealed four main groups, highlighting benefits such as improved walking function, leg positioning, reduced pain response, enhanced body function index, increased leg muscle strength and motor function, expanded range of movement (ROM), maintenance of stability in leg joint function, and prevention of injury.

Building on previous research conducted by Ortega-Castillo et al. (2020), a systematic review aimed to produce a best evidence synthesis of the effect of taping in treating tendinopathies. An electronic search on five databases, including the Physiotherapy Evidence Database (PEDro) scale, identified 13 articles meeting eligibility criteria, involving 454 participants. Selected papers ranged from low to high quality, with an average score of 5. According to findings, there is limited evidence supporting taping alone for treating tendinopathies beyond the short term. Due to mixed methodological quality and an insufficient number of clinical trials, larger, long-term, high-quality studies are needed to support the theory that tendinopathies can benefit from taping application (Wirth et al., 2017).

The study demonstrated a significant increase in both groups (refer to Figure 4 (b)). Both groups exhibited positive effects in reducing Visual Analog Scale (VAS) pain ($p=0.010$) by 1% and increasing Immediate Agility Test (IAT) scores (p-value 0.033) by 3%. This finding aligns with a study by Boz (2020), involving 15 soccer players aged 14–16 years, where research incorporating core stability exercises indicated a significant difference ($p<0.01$) in certain performance parameters, particularly pro-agility test scores (Boz, 2020).

The results further indicated significant differences in pain scores (VAS) and IAT in the intervention group after 5 weeks of treatment (see Figure 4 (c)). The study concluded that the intervention group exhibited superior and more effective outcomes with additional taping treatment. The application of the neuromuscular taping method with isometric exercises and core stability exercises produces a local therapeutic effect, influencing reflex pathways directly. This approach

yields positive results, combined with the activation of movements appropriate to the limb area, stimulating receptors in the skin and lower tissues (Sighamoney et al., 2018).

Stimulation of these receptors sends exteroceptive and proprioceptive stimuli to the central nervous system, aiding in pain reduction and increased agility in jumping, knee running, and kicking activities—commonly employed by soccer players (Boz, 2020).

Notably, there were no studies combining neuromuscular taping treatment with isometric and core stability exercises in soccer school participants to reduce pain and increase agility in jumper's knee conditions. However, it is crucial to acknowledge several limitations in this research. Firstly, researchers faced challenges in controlling weather conditions as the study was conducted in the field. Improved agreements are needed for research to be conducted in closed locations. Additionally, researchers did not evaluate muscle mass, muscle strength, athlete balance, and growth factors. They were unable to control sample activities outside research hours. Coaches and athletes, particularly in soccer, are advised to use the NMT application, isometric exercises, and core stability exercises at the PTPN V Pekanbaru Soccer School to reduce the number of injuries, especially jumper's knee, which can effectively reduce pain and increase agility.

5. CONCLUSIONS

This study evaluated the effectiveness of adding neuromuscular taping (NMT) to a combination of isometric training and core stability exercises compared with isometric training and core stability exercises alone in reducing pain and improving agility in jumper’s knee cases at PTPN V Pekanbaru Soccer School. The intervention was conducted over a period of 5 weeks, with training sessions performed three times per week. A total of 28 participants were included in the study and randomly divided into two groups, with 14 participants in each group. The study was carried out in the open field of PT. Nusantara Plantations (PTPN) V.

The findings of this study indicate that isometric training combined with core stability exercises is effective in reducing pain and improving agility in individuals with jumper’s knee. Furthermore, the addition of neuromuscular taping (NMT) to this exercise program results in greater improvements in both pain reduction and agility compared to exercise alone.

In conclusion, the combined application of neuromuscular taping with isometric training and core stability exercises is more effective than isometric training and core stability exercises alone in reducing pain and enhancing agility in jumper’s knee cases at PTPN V Pekanbaru Soccer School.

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All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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