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Effect of neuromuscular taping on proprioception and postural control. A systematic review

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Abstract

Introduction: Neuromuscular taping, or kinesio tape, is used in various clinical settings. Recent research suggests a favorable effect of neuromuscular taping on postural control, balance, and proprioception by stimulating mechanoreceptors and providing mechanical support. These properties can be beneficial for both healthy individuals and those with musculoskeletal disorders. Despite its popularity in recent years, the level of scientific evidence regarding the effect of neuromuscular taping on postural control, balance, and proprioception is currently unknown.

Objective: To analyze different types of neuromuscular taping applications in terms of their effectiveness on postural control, proprioception, and balance in both healthy individuals and those with musculoskeletal disorders. Additionally, to determine the level of published scientific evidence on neuromuscular taping in the last 5 years.

Materials and methods: A literature search was conducted in October and November 2021 using the following databases: PubMed, Web of Science (WOS), Physiotherapy Evidence Database (PEDro), and Scopus. The main eligibility criteria were clinical trials published in the last five years on neuromuscular taping, proprioception, and postural control. The PRISMA guidelines for systematic reviews were followed, and the PEDro scale, Van Tulder criteria, and Cochrane Collaboration's risk of bias analysis were used for bias and methodological quality analysis.

Results and discussion: A total of 22 articles were included for analysis, with an average PEDro score of 6.45. The studies analyzed various variables, with a focus on the effects of neuromuscular taping on proprioception, balance, postural control, and static posture. Significant results were obtained for at least one variable in 16 articles.

Conclusion: Neuromuscular taping lacks solid evidence to support its use as the sole treatment technique for addressing postural control, balance, or proprioception. The variability in applications and the obtained results do not allow for determining the ideal technique to be applied in each situation, emphasizing the need for individualized approaches in clinical practice. Due to the contradictions observed in the scientific evidence, further research is necessary to investigate the effects of neuromuscular taping on proprioception, balance, and postural control.

Keywords: *posture, postural control, balance, proprioception, neuromuscular taping*

Introduction

Neuromuscular taping (NMT) or Kinesio taping is an adhesive elastic tape designed to provide mechanical support to soft tissues and joints without restricting the range of motion.[1,2] Currently, the use of NMT is widespread, and its application is suggested to provide clinical benefits.[3] However, recent systematic reviews on the effect of NMT highlight the limited number of studies with statistically significant effects.[1,3,6–8]

The physiological effects attributed to NMT are diverse and are primarily related to the characteristics of the tape and the method of application.[3] Theoretically, NMT can help reduce pain, facilitate both blood and lymphatic circulation, increase or decrease muscle tone, improve joint position, and enhance proprioception.[3,4] Similarly, a placebo component cannot be ruled out among its effects.[5]

On the other hand, although the exact mechanisms of action of NMT are still unclear, a notable therapeutic target is balance and postural adjustments. Nevertheless, there is limited information documenting the effects of NMT on posture correction and balance.[9,10]

In principle, when NMT adheres to the skin, it activates peripheral nerve endings, which could improve proprioception through stimulation of mechanoreceptors.[10]

Some studies hypothesize that the use of NMT produces significant improvements in proprioception, balance, or postural control.[10,14] These effects could be utilized to prevent the risk of injuries or falls, enhance sports performance, or increase stability in both healthy individuals and those with musculoskeletal disorders. However, other studies indicate that NMT does not affect balance and posture.[15,16] Furthermore, research focuses on applications in the lower limb,[15,17] without considering the effect on stability when NMT is applied in other regions, such as the spine.

Based on the aforementioned, it is evident that the scientific knowledge regarding the efficacy of NMT in postural control and balance is still uncertain. Therefore, the objective of this study is to conduct an updated systematic review that analyzes different types of NMT applications to determine their effectiveness on proprioception and postural control, both in healthy individuals and those with musculoskeletal disorders. Additionally, the level of scientific evidence in the included publications will be analyzed.

Materials and Methods

Search strategy

The systematic review conducted in this study followed the guidelines of the PRISMA statement (*Preferred Reporting Items for Systematic Reviews and Meta-Analyses*). A literature search was conducted during the months of October and November 2021, consulting the following databases: PubMed, Web of Science (WOS), Physiotherapy Evidence Database (PEDro), and Scopus.

The descriptors were selected based on the topics addressed in this review. The search terms used for NMT were: neuromuscular taping, kinesiotape, kinesiotaping, taping, kinesio tape, kinesio-tape, kinesio taping, kinesio-taping, musculoskeletal tape, kinaesthetic taping, kinaesthetic tape, athletic tape, kinesiology taping, kinesiology tape, elastic therapeutic tape. Additionally, truncation was employed (using the asterisk symbol) for terms that provided greater variability: kinesiotap*, kinesio tap*, kinesio-tap*, kinaesthetic tap*, athletic tap*, and kinesiology tap*. Year filters were applied, restricted to the last five years: 2016-2021, and the study type was limited to randomized controlled trials (RCTs). Furthermore, the MeSH terms "Posture," "Postural Balance," and "Proprioception" were used for the search.

The above-described terms or keywords were combined in the different databases using relevant Boolean operators. The search equations used in the databases were as follows:

- PubMed: ("kinesiotap*" OR "taping" OR "kinesio tap*" OR "kinaesthetic tap*" OR "Athletic Tape"[Mesh] OR "kinesiology tap*" OR "elastic therapeutic tape" OR "neuromuscular taping") AND ("Postural Balance"[Mesh] OR "Posture"[Mesh]) AND ("Proprioception"[Mesh]).
- WOS: ("kinesiotap*" OR "taping" OR "kinesio-tap*" OR "musculoskeletal tape" OR "kinaesthetic tap*" OR "athletic tap*" OR "kinesiology tap*" OR "elastic therapeutic tape" OR "neuromuscular taping") AND ("Posture" OR "Postural Balance") AND Proprioception.
- PEDro: Kinesio Taping AND Posture.
- Scopus: ("Athletic Tape" OR "Kinesio Tap*") AND (Posture OR "Postural Balance") AND Proprioception.

The main data extracted from the studies included: basic characteristics of the studies (samples, experimental groups, experimental design, and proprioception variable analyzed), application of NMT, and the main significant results reported by the authors.

Selection criteria

The studies that met the following criteria were selected:

- Randomized controlled trials (RCTs) with a parallel design and at least one group treated with NMT, providing details on the application of the taping.
- Published within the last five years (2016-2021).
- Studies whose primary objective was to analyze the effect of NMT on posture, balance, and/or proprioception.
- Studies conducted exclusively in healthy individuals or individuals with musculoskeletal disorders.

On the other hand, the following were excluded:

- Articles for which full-text access was not possible.
- Publications in languages other than English or Spanish.

For article screening and removal of duplicates, an Excel spreadsheet (2013) was used.

Analysis of methodological quality and assessment of the risk of bias

A methodological quality analysis was conducted using the PEDro scale, which allows for determining the internal and external validity of RCTs. The scale was created in 1999 to support an evidence-based approach for both teaching and clinical practice in physiotherapy. Each trial is assigned a score ranging from 0 to 10, which serves as a guide to identify trials with higher methodological quality.[18]

Additionally, based on the scores obtained from the PEDro scale, the Van Tulder criteria were used to establish the levels of scientific evidence for the studies included in this systematic review.[19]

The included studies underwent an assessment to determine the risk of bias following the recommendations of the Cochrane Collaboration. Seven domains, supported by scientific evidence, were used to evaluate the risk of bias, and each domain was assigned a response option based on the potential risk of bias: "low risk of bias," "high risk of bias," or "uncertainty about possible bias".[20]

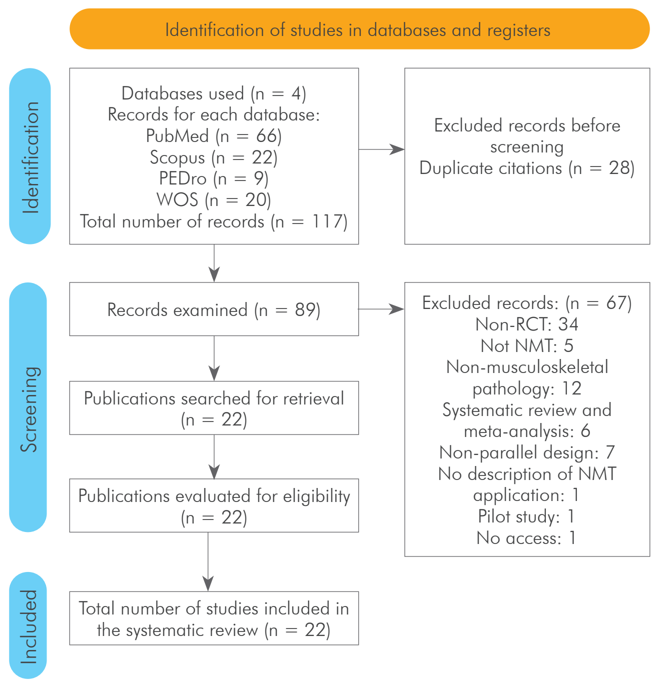
The risk of bias analysis and corresponding graphical representation was performed using the Robvisvisualization tool (available at www.riskofbias.info/welcome/robvis-visualization-tool).

The process of search, selection, and determination of the risk of bias was conducted by two reviewers without blinding.

Results

The search strategy provided a total of 117 results: 66 from PubMed, 20 from WOS, 9 from PEDro, and 22 from Scopus. Out of the 117 articles, 28 were eliminated due to duplication across databases. Of the remaining 89 articles, a total of 67 articles were excluded when applying the eligibility criteria. Finally, a total of 22 articles were included in this review.[21–42] The flow diagram of included studies according to the PRISMA 2020 guidelines is presented in Figure 1.[43]

Figure 1. Flow diagram: study selection according to PRISMA guidelines



Regarding the sample characteristics, ten of the analyzed articles assessed healthy subjects. In the remaining twelve articles, the evaluated subjects had some musculoskeletal disorders. The most prevalent pathologies in the studies were chronic low back pain,[22,31] chronic ankle instability,[28,29] or forward head posture.[34,41]

All articles had a sample size equal to or greater than 30 individuals, except for two articles[34,37] that had sample sizes of 28 and 26, respectively. The total number of evaluated subjects was 1183.

Out of the 22 evaluated studies, 18 provided information on the gender of the participants. In eleven of them, both women and men were included. Out of the remaining seven studies, three had a sample composed entirely of women,[23,26,36] and the other four had a sample composed entirely of men.[27,30,37,38]

Regarding the assessment of methodological quality, the mean score obtained on the PEDro scale was 6.45 ± 1.14 (standard deviation of the mean). The results of the PEDro scale application according to the criteria are presented in Table 1.

It is worth noting that none of the analyzed studies had blinding of the physiotherapists/experimenters. However, five studies had blinding of the subjects,[21,27,30,32,37] and nine had blinding of the assessors.[21,22,26,30–32,40–42]

The main variables analyzed in the studies were balance or postural control, evaluated in 68% of the studies. The main data collection tool used was a platform or pressure measurement system, utilized in 45% of the articles. Additionally, active range of motion (AROM) was measured using goniometry in four articles,[23,24,39,41] pain was assessed using the visual analog

Table 1. Assessment of methodological quality according to the PEDro scale

	PEDro scale criteria											
Article	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**Total**
Aguilar et al.[21] (2016)	+	+	-	+	+	-	+	+	-	+	+	7
Bernardelli et al.[22] (2019)	+	+	+	+	-	-	+	-	-	+	+	6
Bulut et al.[23] (2019)	-	+	-	+	-	-	-	+	+	+	+	6
Chang et al.[24] (2018)	+	+	-	+	-	-	-	+	+	+	+	6
Correia et al.[25] (2016)	+	+	+	+	-	-	-	+	-	+	+	6
Espí et al.[26] (2019)	+	+	+	+	-	-	+	+	+	+	+	8
Espí et al.[27] (2020)	+	+	+	+	+	-	-	+	-	+	+	7
Hadadi et al.[28] (2020)	+	+	+	+	-	-	-	+	-	+	+	6
Hadadi et al.[29] (2020)	+	+	+	+	-	-	-	+	-	+	+	6
Inglés et al.[30] (2019)	+	+	+	+	+	-	+	+	-	+	+	8
Jassi et al.[31](2021)	+	+	+	+	-	-	+	-	+	+	+	7
Kang et al.[32] (2019)	+	+	+	+	+	-	+	+	-	+	+	8
Kim et al.[33] (2020)	+	+	+	+	-	-	-	+	+	+	+	7
Kim et al.[34] (2018)	+	+	-	+	-	-	-	+	-	+	+	5
Kocahan et al.[35] (2020)	+	+	-	+	-	-	-	-	-	+	+	4
Lenart et al.[36] (2020)	+	+	-	+	-	-	-	+	-	+	+	5
Magalhães et al.[37] (2016)	+	+	+	+	+	-	-	-	-	+	+	6
Oliveira et al.[38] (2016)	+	+	-	+	-	-	-	+	-	+	+	5
Rahlf et al.[39] (2019)	+	+	+	+	-	-	-	+	+	+	+	7
Shafizadegan et al.[40] (2020)	+	+	-	+	-	-	+	+	-	+	+	6
Shih et al.[41] (2017)	+	+	+	+	-	-	+	+	+	+	+	8
Tekin et al.[42] (2018)	+	+	+	+	-	-	+	+	+	+	+	8

The presence of an item is indicated by (+), and its absence is indicated by (-). Items: 1) Eligibility criteria specified; 2) Random allocation; 3) Concealed allocation; 4) Baseline comparability; 5) Subject blinding; 6) Therapist blinding; 7) Assessor blinding; 8) Results above 85%; 9) Intention-to-treat analysis; 10) Between-group comparisons; 11) Point measures and variability.
*Note: Item 1 (eligibility criteria specified) does not contribute to the total score.

scale (VAS) in five articles,[23,26,31,32] and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) was used in one article,[39] while strength was measured using dynamometry in three studies.[24,38,39]

The main characteristics of the included clinical trials in this review are summarized in Table 2. The effect of taping yielded significant results for at least one variable in 16 studies (73% of the studies), among which, in six studies, the results were significant compared to the control group or another group.[23,24,28,31,39,41] In another five studies, the results were significant compared to the patient's initial state (pretest).[21,26,27,32,34,42] In the remaining five studies, NMT achieved significant results compared to other groups and the patient's initial state.[22,29,33,36,42]

In the NMT groups, the most commonly used application technique by the experimenters was the muscle technique, employed in ten studies.[22,24–26,33,35,37,38,40,41] However, another application option to consider is the correction technique, employed in eight studies.[21,23,26–28,30,32,42]

Table 2. Study characteristics

Article	Sample, groups, and country	Experimental design	Variable - measurement record
Aguilar et al.21 (2016)	Amateur runners with pronated foot n: 73 NMTG: 49 PG: 24 Spain	Measurements of plantar pressure and Foot Posture Index (FPI) were conducted on subjects after running for 45 minutes at an average speed of 12 km/h. The **NMTG** group received neuromuscular taping while the **PG** group received a placebo.	Plantar pressures - pedobarography using insole system Static posture (foot) - FPI
Bernardelli et al.22 (2019)	Subjects with chronic low back pain n: 40 NMTG: 25 CG: 15 Brazil	The participants underwent 4 baropodometric evaluations. **NMTG** group: Initial evaluation and 3 subsequent evaluations at 10 minutes, 48 hours, and 10 days after the application of the taping. **CG** group: No intervention. Initial evaluation and 3 subsequent evaluations at 10 minutes, 48 hours, and 10 days after the 1st evaluation.	Postural control - Baropodometric evaluation using a pressure platform (Plantar pressure, plantar surface area, and mass distribution)
Bulut et al.23 (2019)	Women with thoracic kyphosis associated with postmenopausal osteoporosis. n: 42♀ NMTG: 20 CG: 22 Turkey	All participants receive an exercise program. Assessments are conducted at baseline, 3 weeks, and 6 weeks. NMTG: Additionally, they receive spinal mobilization exercises, with 3 applications over 3 weeks. CG: Exercise program only.	Static balance - Berg Balance Scale and SportKAT Kyphosis angle - goniometry (digital inclinometer) Pain - Visual Analog Scale (VAS)
Chang et al.24 (2018)	Healthy athlete subjects n: 32 (24♂ / 8♀) FTG: 16 NMTG: 16 Germany	Participants from both groups were assessed for ankle range of motion (AROM), plantar flexion strength and endurance, vertical jump, and dynamic balance. The tests were performed twice with a 4-hour interval, before and after the application of the bandages. **FTG**: Received functional taping. **NMTG**: Received NMT.	AROM - goniometry Strength - dynamometer Endurance - number of repetitions Vertical jump (cm) Dynamic balance - error score after unipodal Hop test.
Correia et al.25 (2016)	Healthy subjects n: 30 (15♂ / 15♀) NMTG1: 10 NMTG2: 10 CG: 10 Portugal	Measurements of postural control and latency time of the peroneus longus muscle are taken (before and 20 minutes after the intervention). **NMTG1** and **NMTG2** receive taping, while **CG** does not.	Peroneus longus latency time - surface electromyography.
Espí et al.26 (2019)	Women with fibromyalgia n: 35♀ NMTG1: 18 NMTG2: 17 Spain	The intervention lasted for 3 weeks. Two evaluations were conducted: one at the beginning and another upon completion of the study. **NMTG1**: Superior application on the trunk. **NMTG2**: Global application on the trunk.	Pain - Visual Analog Scale (VAS) Comfort - VAS in different regions Static posture (trunk) - length (cm) of the pectoralis minor muscle Quality of life - Fibromyalgia Impact Questionnaire.

Espí et al.27 (2020)	Healthy amateur soccer players n: 46♂ NMTG: 14 NMTG + exercises: 17 PG + exercises: 15 Spain	4 weeks of intervention. Three evaluations were conducted: at the beginning, 2 weeks in, and at the end. **NMTG**: Only taping is applied. **NMTG** + **exercises**: Taping + balance exercises. **PG** + **exercises**: Placebo taping + exercises.	Static balance - UST Dynamic balance - Y-Balance Test Flexibility - TTT Knee disability and symptoms – KOOS.
Hadadi et al.28 (2020)	Subjects with chronic ankle instability n: 60 CG: 20 NMTG: 20 PG: 20 Iran	Participants underwent 3 functional tests to measure static and dynamic balance. **CG**: No intervention. **NMTG**: 3 taping applications per week for 2 weeks. Subjects performed the tests before and one day after the last taping application. **PG**: Placebo taping. Applied with the same frequency as **NMTG**.	Equilibrio estático – SLS test Equilibrio dinámico – SEBT modificado y Hop Test unipodal
Hadadi et al.29 (2020)	Subjects with chronic ankle instability n: 60 CG: 15 NMTG: 15 OG soft: 15 OG semi-rigid: 15 Iran	Intervention period of 4 weeks. Participants undergo pre- and post-intervention assessments of static and dynamic balance. **CG**: No treatment. **NMTG**: Receive application of NMT every 48 hours for 4 weeks. **Soft Orthosis** and **Semi-rigid Orthosis**: Participants in both groups are required to wear the orthoses during their physical activities for the 4-week duration.	Static balance - SLS Dynamic balance - Modified SEBT and Unipodal Hop Test.
Inglés et al.30 (2019)	Healthy amateur soccer players n: 51♂ NMTG: 18 NMTG + exercises: 16 PG + exercises: 17 Spain	The intervention period lasted for 4 weeks. Participants underwent assessments of balance and flexibility at the beginning, 2 weeks into the intervention, and at the end of the intervention. NMTG + exercises: Receive taping and a balance and control exercise program. NMTG: Receive taping. PG + exercises: Receive placebo taping and an exercise program.	Static balance - UST Dynamic balance - SEBT Flexibility - TTT.
Jassi et al.31 (2021)	Subjects with chronic non-specific low back pain n: 120 (55♂ / 65♀) NMTG: 40 PG: 40 CG: 40 Brazil	Measurements are taken before and immediately after the intervention. After 7 days, measurements are repeated in the same manner. One month later, follow-up measurements are taken without any intervention. **NMTG**: Receives application of neuromuscular taping. **PG**: Receives placebo taping. **CG**: Minimal intervention.	Pain - VAS Postural control - Pressure platform Disability - Oswestry Index.
Kang et al.32 (2019)	Subjects with subacromial impingement and shoulder impingement n: 34 (10♂ / 24♀) NMTG: 18 PG: 16 Taiwan	Both groups underwent a shoulder disorder exercise protocol three times a week for four weeks. **NMTG**: Receives neuromuscular taping application. **PG**: Receives placebo taping. The taping in both groups is applied twice a week during the four-week intervention. Assessments are conducted at baseline, 2 weeks, and 4 weeks post-intervention.	Static shoulder posture - Angle measured using computer software (intersection between the horizontal line the and line between the midpoint of the humerus and the spinous process of C7) Pain - VAS Shoulder function and disability - FLEX-SF.
Kim et al.33 (2020)	Healthy subjects n: 32 (16♂ / 16♀) NMTG1: 16 NMTG2: 16 South Korea	All participants underwent the Biering-Sorensen Test (BST) 1 week before and immediately after the application of neuromuscular taping. NMTG1: Taping is applied over the erector spinae muscles. NMTG2: Taping is applied for the erector spinae, latissimus dorsi, lower trapezius, and external and internal oblique abdominal muscles.	Back extensor muscle endurance - BST.
Kim et al.34 (2018)	Subjects with forward head posture n: 28 (15♂ / 13♀) EG + MR: 10 EG + NMT: 9 EG + NMT + MR: 9 South Korea	All participants undergo a head posture exercise program, 3 times a week for 4 weeks, with a follow-up at 2 weeks. Additionally, they receive: **EG** + **MR**: Myofascial release treatment. **EG** + **NMT**: Neuromuscular taping treatment. **EG** + **NMT** + MR: Both treatments.	Static posture - Distance from tragus of the ear to acromion (cm) and craniovertebral angle and cranial rotation (analysis of anatomical references in photography). Functional disability - NDI.

Kocahan et al.35 (2020)	Healthy elite athletes (Taekwondo) n: 53 (27♂ / 26♀) CG: 25 NMTG: 28 Turkey	Each participant undergoes 2 balance evaluation sessions with a 48-hour separation. **CG**: No treatment. **NMTG**: The subjects were taped after the first evaluation. 48 hours later, they underwent the second evaluation with the taping.	Postural control - Pressure platform
Lenart et al.36 (2020)	Young and healthy women n: 50♀ NMTG: 25 CG: 25 Poland	The participants perform the Romberg test 4 times on a stabilometric platform, with a duration of 2 minutes each time. It is conducted twice without any intervention and another 2 times with taping (**NMTG**) or without it (**CG**).	Postural control and proprioception - Romberg test on a stabilometric platform
Magalhães et al.37 (2016)	Physically active, young, and healthy men n: 26 ♂ NMTG: 12 PG: 14 Brazil	The **NMTG** group receives a taping application, while the **PG** group receives a placebo taping. Both groups undergo measurements before, immediately after, 24 hours, and 48 hours after the intervention.	Functional and proprioceptive performance - SHT, THT Unipodal vertical jump (height, force, and Rate Of Force Development) - Pressure platform.
Oliveira et al.38 (2016)	Men undergoing anterior cruciate ligament reconstruction n: 45♂ NMTG: 15 CG: 15 PG: 15 Brazil	After a warm-up, participants perform concentric and eccentric isokinetic contractions of the knee extensors on a pressure platform. **NMTG**: receives NMT. **CG**: rests before the test. **PG**: receives placebo.	Postural control – Pressure platform. Force – dynamometry Muscle activation – electromyography.
Rahlf et al.39 (2019)	Subjects with knee osteoarthritis n: 141 (67♂ / 74♀) NMTG: 47 CG: 47 PG: 47 Germany	The participants receive knee bracing (**NMTG**), placebo (PG), or no treatment (PG) for three consecutive days. Evaluations were conducted at the beginning and upon completion of the treatment.	Pain and functionality - WOMAC Isometric quadriceps torque - Dynamometry AROM - Goniometry Balance - Balance Error Scoring System Walking speed - Time to complete a 10-meter walk.
Shafizadegan et al.40 (2020)	Healthy young and elderly subjects n: 80 (40 young / 40 elderly) 20♂ and 20♀ in each group NMTG: 20 young and 20 elderly participants. SG: 20 young and 20 elderly participants. Iran	**NMTG**: participants receive inhibitory bracing for the gastrocnemius muscle. **SG**: subjects perform 60 seconds of stretching for the same muscle, repeated 4 times. All participants undergo static balance assessment before and after the interventions.	Static Balance – SLS along with measurements of velocity and displacement of the center of pressure on a pressure platform.
Shih et al.41 (2017)	Subjects with forward head posture n: 60 (29♂ / 31♀) NMTG: 20 CG: 20 EG: 20 Taiwan	5-week intervention. Assessments were conducted at the beginning, end, and 2 weeks after the intervention. All participants received a postural education program. **NMTG**: Received additional NMT. **CG**: Received only postural education. **EG**: Received an exercise program in addition to postural education.	Static posture (horizontal displacement forward, upper and lower cervical angles) - Analysis of anatomical references using photography. AROM - Goniometry. Functional disability - NDI.
Tekin et al.42 (2018)	Healthy contemporary dancers. n: 33 (9♂ / 24♀) CG: 11 NMTG: 11 PNG: 11 Turkey	Participants underwent tests of static, semi-dynamic, and dynamic balance before and after the intervention. **NMTG**: Received taping 1 day after the first assessment. After that, they repeated the evaluation. **PNG**: Engaged in an 8-week proprioceptive training program.	Static balance - 4 single-leg balance exercises Semi-dynamic balance - airplane test Dynamic balance - monopodal exercises on a pressure platform.

AROM: rango de movimiento activo / BST: Biering-Sorensen test / EVA: escala visual analógica / FLEX-SF: Flexilevel Scale of Shoulder Function / FPI: Foot Posture Index / **GC**: grupo control / GE: grupo ejercicio / GO: grupo órtesis / GP: grupo placebo / GPN: grupo propioceptivo-neuromuscular / GS: grupo estiramiento / GVF: grupo de vendaje funcional / GVNM: grupo de vendaje neuromuscular / KOOS: knee injury and osteoarthritis outcome score / LM: liberación miofascial / n: tamaño muestral del estudio / NDI: neck disability index / SEBT: star excursion balance test / SHT: single hop test / SLS: single leg stance test / THT: triple hop test / TTT: toe touch test / UST: unipedal stand test / VJH: vertical jump height / VJP: vertical jump power / VNM: vendaje neuromuscular / WOMAC: Western Ontario and McMaster universities osteoarthritis index.

The applied NMT technique and the most relevant results are described in Table 3.

To assess the risk of bias, recommendations from the Cochrane Collaboration were employed.20 Since one of the inclusion criteria was that the studies must be RCTs, 100% of the articles included randomization, indicating a low risk of selection bias, which is the domain with the lowest risk of bias.

In 64% of the studies, the assessors were not blinded, indicating a potential risk of detection bias. Additionally, 73% of the studies presented a high risk of performance bias, making this the domain with the highest risk of bias.

The following figures provide a summary of the risk of bias assessment for the included studies, both in an overall view (Figure 2) and individually for each study (Figure 3).

Table 3. Taping applications and obtained results

Artículo	Aplicación del VNM	Resultados
Aguilar et al.21	NMTG: Correction technique (Low-Dye taping). Heel: extends from the lateral malleolus to the middle third of the medial tibia, passing over the calcaneus. Midfoot: starts from the base of the 5th metatarsal, crosses the talonavicular joint, wraps around the midfoot, and ascends to the medial side of the middle third of the tibia. Placebo taping: placed identically but without applying tension or mechanical correction.	Significant differences between groups were observed in the measurement of plantar pressure, suggesting that the **PG** had a better effect. Significant differences in FPI were observed between **NMTG** and **PG**, with a reduction in both groups.
Bernardelli et al.22 (2019)	Muscle inhibition technique for the erector spinae muscles. Two parallel tapes are placed on either side of the sacroiliac joint, along the erector spinae muscles. Three additional "I"-shaped tapes are applied in the form of an asterisk over the lumbar spine using the space-increasing technique.	Significant improvements were observed in **NMTG** regarding peak plantar pressure, plantar surface area, and pressure distribution 48 hours after application, with effects lasting up to 10 days in the group compared to the **CG**.
Bulut et al.23 (2019)	Correction technique. It starts from the acromioclavicular joint and advances transversely along the back to the lower limit of the ribs. The taping is applied in the same manner on the contralateral side, creating a cross with both strips.	No significant differences were observed when comparing the kyphosis angle and balance between the two groups. **NMTG** showed a significant improvement in pain compared to the CG between baseline and weeks 3 and 6; there was no such difference when comparing changes between the 3rd and 6th week.
Chang et al.24 (2018)	Three applications were performed using the muscle technique: a "Y" cut to inhibit the gastrocnemius muscle, from insertion to origin, without tension. Two "I"-shaped strips were applied, one for the tibialis anterior muscle, from insertion to origin, without tension. The other strip was applied for the peroneus longus muscle, from the head of the fibula to the base of the 5th toe.	**NMTG** showed less limitation in ankle dorsiflexion range of motion (AROM) and a significant improvement in dynamic balance compared to **FTG**.
Correia et al.25 (2016)	Subjects will maintain plantar flexion and inversion during the taping application to increase tissue tension. Muscle technique. NMTG1: From origin to insertion of the peroneus longus muscle. NMTG2: From insertion to the origin of the peroneus longus muscle.	No significant differences were observed in any of the variables studied.
Espí et al.26 (2019)	NMTG1: Muscle technique. Bilateral. "Y" strip, from the acromion, one tail towards the upper fibers of the trapezius and the other towards the scapular spine, rhomboid minor, and levator scapulae. NMTG2: Correction technique. Bilateral. "C" strip, from the middle fibers of the upper trapezius and perpendicular to them, passing through the paravertebral musculature to the last rib.	There were no significant differences between groups. Both groups showed significant improvements in neck and shoulder pain and comfort. **NMTG2** demonstrated a significant improvement in thoracic comfort. **NMTG1** showed significant improvements in upper trunk position (on the non-dominant side) and quality of life.
Espí et al.27 (2020)	Correction technique. Bilateral. Induces external rotation of the knee, avoiding valgus angulation. Starting from the anterior aspect of the distal third of the thigh, it progresses outward and wraps around the posterior area of the knee. It crosses the medial ligament below the patella and ends at the proximal part of the gastrocnemius. Placebo taping: Placed in the same manner but without applying tension.	Both exercise groups showed significant improvements in static and dynamic balance and flexibility. **NMTG** only showed significant intragroup improvements in static balance. The **PG** + exercise group achieved the best results in physical variables.
Hadadi et al.28 (2020)	Correction technique. Repositioning tape for the fibula. The therapist manually performs a posterior sliding of the lateral malleolus and maintains it while applying the NMT to keep that posterior position of the fibula. Placebo taping: Placed in the same manner, but without tension or mobilization of the fibula.	No significant differences were found among the three groups, except for the modified SEBT where dynamic balance in the posterolateral direction was significantly better in **NMTG** than in **CG**.
Hadadi et al.29 (2020)	Four separate strips of NMT were used. 1st: From the dorsal area of the midfoot to below the tibial tuberosity. 2nd: From the tibial malleolus, it wraps around the heel and ascends to the head of the fibula. 3rd: It covers both the malleoli and the anterior aspect of the joint. 4th: From the navicular tuberosity to the lateral malleolus.	Significant improvements were observed within all three intervention groups in both dynamic and static balance, but not in the **CG**. No significant differences were observed between the three intervention groups, but there were differences between them and the **CG**.
Inglés et al.30 (2019)	Functional correction technique to induce ankle eversion. Bilateral. From the outer part of the dorsal surface, it moves towards the inner part without tension. Then it passes under the foot with 70% tension until reaching the lateral malleolus, where it advances towards the mass of the gastrocnemius. Placebo taping: Bilateral. Applied in the same manner, but without tension.	Significant post-treatment improvements were observed in static and dynamic balance in the **PG** + exercise and **NMTG** + exercise groups, but not in flexibility. In **NMTG**, no significant differences were found in any of the evaluations.

Jassi et al.31 (2021)	Four "I" strips, superimposed in a star pattern over the lumbar region. For the strips, 25% tension is used, adhering and pressing the central part before the ends. Placebo taping: A single "I" strip horizontally over the spinous process of L2, without tension.	Lower pain scores were significantly observed in **NMTG** compared to **CG** immediately and 7 days after the intervention.
Kang et al.32 (2019)	Correction technique. Three tapes for the taping: 1st: Over the upper trapezius, extending posteriorly from the middle third of the clavicle to the lower trapezius belly at the level of T12. 2nd: Overlaps approximately 50% with the 1st tape to reinforce the mechanical correction. 3rd: From the anterior aspect of the acromion towards the spinous process of T10. Placebo taping: Same tape placement but without tension.	Both groups showed significant improvements in shoulder functionality after the intervention. Greater pain reduction was associated with improved shoulder function. No significant findings were found for static shoulder posture.
Kim et al.33 (2020)	Both groups used muscle techniques. NMTG1: Taping for the erector spinae. Two "I" strips on both sides of the spine, from the sacroiliac joint to the 9th/8th rib. NMTG2: Erector spinae: Same as NMTG1. Latissimus dorsi: Along the axillary border, from the intertubercular groove of the humerus to the spinous process of the sacrum. Lower trapezius: From the scapular spine to T12. External oblique: Along the iliac crest to the abdominal aponeurosis. Internal oblique: From the xiphoid process to the posterior superior iliac spine, passing through the 11th/12th rib.	Both groups showed significant differences in muscle endurance after the application of **NMT**. When comparing between groups, a significant improvement in muscle endurance was observed in **NMTG2** compared to **NMTG1**.
Kim et al.34 (2018)	Two "I" strips were applied in a "V" shape around the C7-T1 junction.	The acromion-tragus distance showed significant improvements in all three groups after the intervention. The craniovertebral angle only showed significant improvements after the intervention in the **EG** + **MR** + **NMT** group.
Kocahan et al.35 (2020)	Muscle technique on the gluteus medius. Three strips, all starting from the greater trochanter and each directed towards a different area: iliac crest, anterior superior iliac spine, and posterior third of the iliac crest.	No significant differences were found between groups or within groups in the scores between the first and second evaluations.
Lenart et al.36 (2020)	Three taping strips: 1st: From the head of the fibula to the dorsal area of the heads of the first two metatarsals. 2nd: Starting from the inner, proximal area of the tibia, directed towards the dorsal area of the 4th and 5th metatarsals. 3rd: "Y" shape. Ascends from the calcaneal tuberosity to the medial and lateral parts of the popliteal fossa.	Significant improvements were observed in stabilometric parameters in **NMTG** compared to the initial state of the patient (pretest). Also, compared to **CG**.
Magalhães et al.37 (2016)	Muscle technique to activate the rectus femoris. NMT was placed from origin to insertion with 40% tension. Placebo taping: Same application and technique, but without applying tension.	No significant effects were observed in **NMT** for functional and proprioceptive performance.
Oliveira et al.38 (2016)	Muscle technique on the rectus femoris, vastus medialis, and vastus lateralis, with 50% tension in the muscle belly. Longitudinal direction, from proximal to distal. Placebo taping: Applied in the same manner, but without tension.	None of the analyzed variables showed significant differences between groups or within groups.
Rahlf et al.39 (2019)	Three "I" strips. One strip over the patella, from the tibial tuberosity to the anterior distal third of the thigh. The other two strips are applied along the lateral and medial collateral ligaments. Placebo taping: A single "I" strip is placed horizontally in the popliteal region without tension.	Significant improvements in pain and functionality were observed in **NMTG** compared to **PG** and **CG**.
Shafizadegan et al.40 (2020)	Muscle technique to inhibit the gastrocnemius muscle in both lower limbs. "Y" strip, anchoring on the plantar surface of the calcaneus. With the muscle passively stretched, the two "Y" strips are applied over the popliteal region.	Static balance - no significant differences were found between **NMTG** and **SG**.
Shih et al.41 (2017)	"Y" strip using muscle technique, starting from T2, with the arms of the tape ascending on both sides of the spine up to the hairline. "Y" cut with muscle technique from the acromion, one arm towards the upper trapezius and the other towards the middle trapezius. Bilateral. "I" cut placed horizontally in the cervical spine.	Both **NMTG** and **EG** showed significant improvements in static posture compared to **CG**. EG showed significantly greater improvement in AROM than **NMTG** and **CG** after treatment.
Tekin et al.42 (2018)	Correction technique applied. Two "I" strips at the ankle joint, including the distal area of the peroneal muscles and both malleoli.	**PNG** showed significant differences in most of the analyzed variables, both within the group and compared to **CG** and **NMTG**. In **NMTG**, significant improvements were observed within the group and compared to **CG**.

AROM: rango de movimiento activo / FPI: foot posture index / GC: grupo control / GE: grupo ejercicio / GP: grupo placebo / GPN: grupo propioceptivo-neuromuscular / GS: grupo estiramiento / GVF: grupo de vendaje funcional / GVNM: grupo de vendaje neuromuscular / LM: liberación miofascial / MMII: miembros inferiores / SEBT: star excursion balance test / VNM: vendaje neuromuscular.

Figure 2. Risk of bias: percentages among all included studies

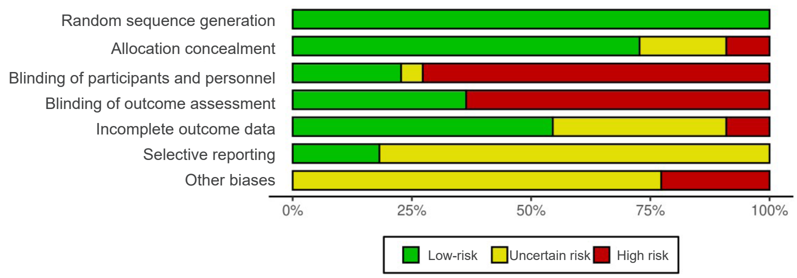
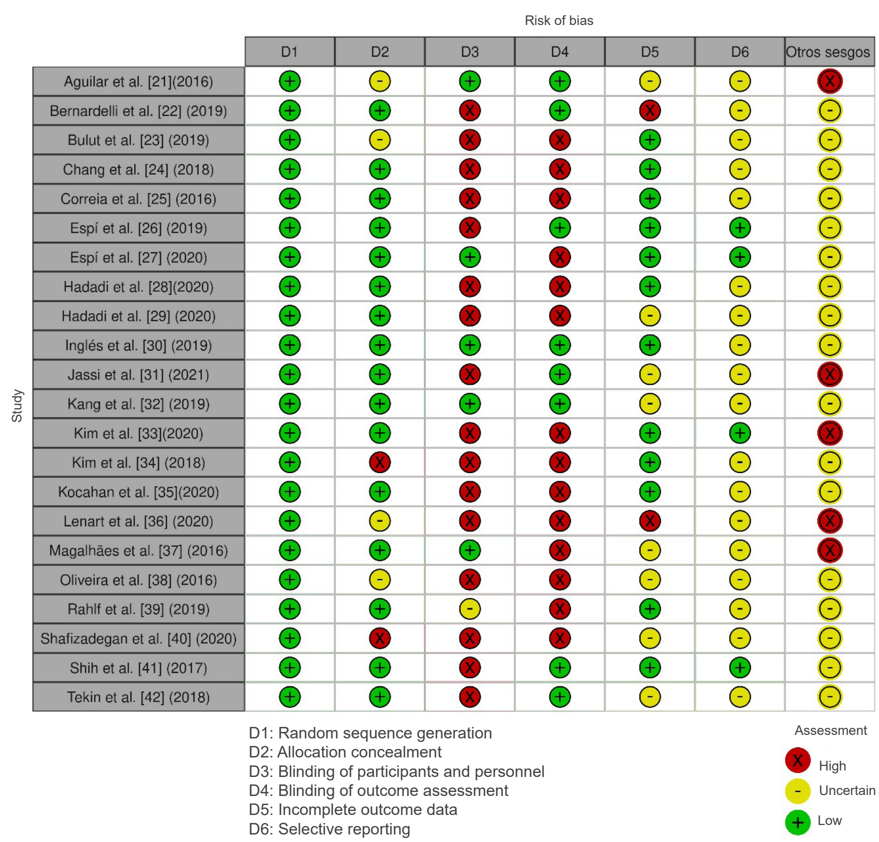


Figure 3. Risk of bias: risk for each included study



Discussion

The principal findings of this systematic review, in accordance with the PRISMA 2020 guidelines,[43] suggest that the application of NMT may have a positive effect on postural control and balance. Eight studies demonstrated significant improvements in these variables in the NMT intervention groups.[22,24,27–29,36,42] However, in seven other studies,[23,25,31,35,38–40] no effects or significant changes were observed after the application of NMT in these variables.

Plantar pressure quantification, measured using platforms or pressure measurement systems, was the most commonly used methodology in the different studies. One article noted that despite the need for standardization, baropodometry can provide reliable information in posture and balance research.[44] In this review, three studies linked better results in plantar pressures to the application of NMT, suggesting beneficial effects on balance or postural control.[22,36,42]

Regarding the balance variable, improvements were observed after the application of NMT in studies by Hadadi et al.[29] and Tekin et al.[42] Espí et al.[27] and Hadadi et al.[28] reported significant differences in some parts of the evaluation, although these differences were not clinically relevant. Various tests, exercises, or scales were used to assess balance (with the most common being the unipedal hop test, unipedal stand test, and single-leg stance test). Unlike plantar pressure measurements, which provide more objective data and facilitate result interpretation, this variation in measurement methods poses limitations when extrapolating conclusions due to differences in interpretation. Regarding the NMT technique, the muscle technique was most frequently used, followed by the correction technique, present in ten and eight studies of the present review, respectively. However, in five studies that employed the muscle technique, no statistically significant results were found.[25,35,37,38,40] Correia et al.[25] evaluated two groups with NMT applied in different directions, from insertion to origin and from origin to insertion, but no effects were observed. Consistent with this, Dolphin et al.[45] stated that the direction of NMT application does not influence muscle performance.

The studies by Espí et al.[26] and Shih et al.[41] showed improvements in static position. Both studies used the muscle technique applied primarily to the trapezius muscle, starting from the acromion with a Y-shaped cut. Bernardelli et al.[22] and Kim et al.[33] analyzed muscle applications at the lumbar paravertebral level. In the first study, NMT demonstrated improvements in postural control in subjects with chronic low back pain, while the second study showed benefits in the strength of the extensor and trunk stabilizer muscles in healthy subjects. According to Behennah et al.[46], this could be interpreted as an improvement in postural control for some cases, as it suggests that the lumbar extensors contribute to motor control dysfunctions.

The study by Chang et al.[24] showed positive results for active range of motion (AROM) and balance with NMT, but only when compared to functional taping, which aims to stabilize the joint. Therefore, these results may be more attributable to the limitations of functional taping rather than a benefit produced by NMT itself.

Regarding studies that specified the use of the correction technique, Aguilar et al.[21] and Tekin et al.[42] reported beneficial effects on static foot posture and balance, respectively. However, the article by Kang et al.[32], which had high methodological quality, did not find improvements in static shoulder posture with the application of this technique. Harput et al.[47] applied the same technique with almost identical parameters and positioning in their study (no control group, sample randomization, or blinding) and observed improvements in static shoulder posture.

Furthermore, Espí et al.[26] analyzed both correction and muscle techniques in their study but did not obtain significant results in the comparison between groups. Based on this, it can be concluded that the use of one technique or another is not justified as a direct relationship between the technique used and the achieved effect has not been demonstrated using standardized application criteria.

In studies that evaluated healthy subjects, six of them involved athletes or physically active individuals. In most of these studies, firm conclusions regarding the effectiveness of NMT on balance or postural control in this population could not be drawn.[24,27,30,35,40,42] This is in line with Drouin et al.[48], who state that NMT, although not harmful, is not an effective method for enhancing athletic performance in healthy individuals. However, Tekin et al.[42] did observe improvements in balance after applying NMT. Despite this, they also analyzed an intervention group where exercise was applied, which yielded better results.

In the aforementioned studies, four articles included at least one exercise intervention. In all of them, the most relevant results were associated with the exercise intervention, primarily showing improvements in balance[27,30] and static posture.[34,41]

These findings are consistent with the review by Logan et al.[49], which states that NMT is not a substitute for physiotherapy or therapeutic exercise, as well as Şimşek et al.[50], who affirm that NMT may be more effective when used as a complementary technique alongside exercise.

The studies by Espí et al.[27] and Inglés et al.[30] are notable for their similarities in terms of sample, experimental design, and high methodological quality. The former applied NMT to both knees to induce external rotation and prevent valgus angulation, while the latter bilaterally applied NMT to induce ankle eversion. Neither study demonstrated the effects of NMT on balance when applied in isolation to healthy amateur soccer players. However, they did obtain benefits when combining NMT with balance exercises, regardless of whether the applied taping was a placebo or correction technique. According to Mak et al.[5], the placebo effect may contribute to the benefits of NMT. In this review, a total of nine articles included a placebo intervention group for NMT. In most cases, the placebo taping was applied in the same manner as the NMT intervention group, with the difference being that no tension was applied to the tape. In two studies, the placebo taping was not applied in the same manner, but it was applied in the same region without tension.[31,39]

Rahlf et al.[39] observed that NMT showed better results than the placebo taping, while Aguilar et al.[21] obtained better outcomes in plantar pressure measurements in the placebo group compared to the NMT group. In the remaining articles, no significant differences were observed between the two groups. This may be because, despite applying the placebo taping without tension, NMT still stimulates cutaneous mechanoreceptors, providing repetitive feedback to the brain and positively influencing movement, as suggested by the studies of Şimşek et al.[50] and Bae et al.[51]

On the other hand, among the articles that analyzed subjects with musculoskeletal pathologies or disorders, some studies coincided. Two articles examined subjects with chronic low back pain. Bernardelli et al.[22] observed that NMT led to improvements in postural control, while Jassi et al.[31] did not find clinically relevant effects for its application. The study by Bae et al.[51] is in agreement with the former, indicating that NMT positively affected postural control in individuals with chronic low back pain.

The two articles by Hadadi et al.[28,29] evaluated the effects of NMT in individuals with chronic ankle instability, yielding contradictory results. One of them showed positive effects on balance,[29] while the other stated that NMT did not significantly affect the same variable.[28] Yin and Wang[52] found in their study that NMT has a limited effect in facilitating motor control in individuals with chronic ankle instability.

The articles by Kim et al.[34] and Shih et al.[41] examined individuals with forward head posture. Both studies showed improvements in static posture after the application of NMT. In their study, Kim et al.[34] evaluated three groups with exercise interventions, one with myofascial release (MR), another with NMT, and the remaining group with MR and NMT. When multiple interventions are applied, the effects cannot be directly attributed to NMT.

Regarding methodological quality, the evaluation using the PEDro scale obtained an average score of 6.45 ± 1.14 out of a possible ten points, indicating a moderate-to-good overall methodological quality. Recent reviews by Pinheiro et al.[53] and Vilchez and Ortega[54] analyzing the effects of NMT obtained similar scores (7 and 5.41, respectively).

In the present review, it can be said that the gender distribution of the sample is homogeneous (477 males and 463 females). In four articles, the entire sample consists of males. Two of them involve healthy amateur soccer players,[27,30] and in another study, the participants are healthy and active young individuals.[37] This may be due to a higher presence of males than females in samples within the sports field.[55] In three other studies, 100% of the participants are females. However, one of them focuses on postmenopausal osteoporosis,[23] and in another study, the patients have fibromyalgia, a condition with a higher prevalence and incidence in females than males.[26] Based on these observations, it can be concluded that there is no gender bias in the present review.

Furthermore, when analyzing the biases outlined by the Cochrane Collaboration,[20] a high risk of performance bias is observed in most studies due to the difficulty in blinding therapists and patients in the application of NMT.

Previous reviews by Morris et al.[3] and Alonso Martín et al.[7] have shown that studies analyzing the effects of NMT face difficulties in establishing causality regarding its clinical effects. This may be due to predominantly empirical observations and the heterogeneity of criteria in the application of NMT for study, including different tensions, orientations, application techniques, and dosages of the tape itself. This lack of homogeneity in interventions and dosing limits the extrapolation of the results observed in this review. Furthermore, the variability in the parameters of NMT application across studies poses a challenge for comparison.

Another major limitation of the review is the heterogeneity of the analyzed articles, as multiple applications of NMT in different body areas and different types of samples are studied, making it more difficult to extrapolate the results. It is also necessary to acknowledge the limitation of not developing a systematic review protocol in the present work.

Among the limitations of the studies, the lack of consensus on parameters for postural control, balance, or proprioception stands out.

According to the Van Tulder criteria,[19] the overall scientific evidence published in the last five years regarding the application of NMT on balance and posture is contradictory. Studies with higher methodological quality yield discordant results among themselves. In this regard, the application of NMT shows beneficial effects on static posture in three studies of high methodological quality[21,26,41] and one of limited quality.[21] However, a study with high methodological quality does not show relevant effects of NMT application on static posture.[32] In summary, although favorable results are shown, a cautious interpretation of the scientific evidence is warranted.

Regarding the effect of NMT on correcting forward head posture, there is moderate evidence as improvements were observed in one study of high methodological quality[41] and another of limited quality.[34]

Likewise, contradictory evidence is observed regarding the effects of NMT on changes in plantar pressure. Out of ten studies evaluating this, only three of high,[42] moderate,[22] and limited[36] methodological quality show improvements in pressure parameters. The same applies to the effects of NMT on balance, presenting contradictory evidence similarly.

For future research, it is necessary to determine the impact of the placebo effect in interventions and establish standardized application parameters to scientifically demonstrate the different effects attributed to NMT. Additionally, studies without confounding variables or other interventions are needed to determine the specific effect of NMT.

Conclusion

NMT may have beneficial effects on postural control, balance, and proprioception in both healthy individuals and those with musculoskeletal disorders or pathologies. However, NMT lacks solid evidence to support its application as a standalone treatment technique.

Additionally, a clear relationship between the applied NMT technique and the observed effect cannot be established due to the variability of techniques across different studies. Therefore, this review does not allow for determining the optimal technique to address proprioception and balance.

The heterogeneity of interventions and their outcomes suggests that the benefits of NMT may be attributed to contextual factors rather than specific taping parameters, emphasizing the need to individualize each clinical intervention.

In this review, there is no direct relationship observed between the isolated use of NMT and its effects, but its use as an adjunct technique to other more established and evidence-backed interventions, such as therapeutic exercise, is suggested. Due to the contradictory scientific evidence, further research is needed to investigate the effect of NMT on proprioception, balance, and postural control.

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