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Effectiveness of Neuromuscular Exercise in Individuals with Low Back Pain: A Narrative Review
Efectividad del Ejercicio Neuromuscular en Individuos con Dolor Lumbar: Una Revisión Narrativa

*Ehsan Alvani, **Alireza Shamsoddini, *Amir Letafatkar, ***Shahnaz Shahrbanian, ****Jorge Hugo Villafañe, ****Giacomo Rossettini
*Kharazmi University (Iran), **Baqiyatallah University of Medical Sciences (Iran), ***Tarbiat Modares University (Iran), ****Universidad Europea de Madrid (Spain)

Abstract. Aim: Low back pain (LBP) is one of the leading causes of disability worldwide, with a huge economic burden on public health. Neuro-muscular (NMS) exercises may reduce LBP recurrence, but the most effective program has not been established. This narrative review aimed to collect evidence on the effect of NMS exercises in patients with LBP. Methods: A narrative review of the electronic literature from April 2000 to July 2023 was conducted. The electronic search was performed on five databases (PubMed, Scopus, Web of Scien-ce, Google Scholar, and Science Direct). All articles analysed in this study were randomized controlled trials (RCTs). The PEDro scale was used to assess the methodological quality of the articles. Results: Five RCTs were selected and included. The RCTs showed that NMS exercises reduce pain intensity, improve lumbar movement control and physical function, and prevent LBP. Studies also showed that NMS exercises are targeted to improve the control, flexibility, and strength of lumbar muscles. The PEDro score ranges from 5 to 7, highlighting several methodological issues. Conclusion: The findings of this narrative review indicate that NMS exer-cises can reduce pain intensity in LBP. However, the research on NMS exercises' effects on LBP is very limited and should be interpre-ted with caution due to the methodological limitations.
Keywords: Neuromuscular exercises, Low back pain, Lumbar posture, Stabilization, Rehabilitation, Core stability, Motor control.

Resumen. Objetivo: La lumbalgia, una de las principales causas de discapacidad a nivel mundial, impone una considerable carga económica en el ámbito de la salud pública. Los ejercicios neuromusculares (NMS) pueden reducir la recurrencia del dolor lumbar, pero no se ha establecido el programa más eficáz. Esta revisión narrativa tuvo como objetivoevaluar la evidencia sobre el efecto de los ejercicios NMS en pacientes con dolor lumbar. Métodos: Se realizó una revisión narrativa de la literatura electrónica desde abril de 2000 hasta julio de 2023. La búsqueda bibliografica se realizó en cinco bases de datos (PubMed, Scopus, Web of Science, Google Scholar y Science Direct). Todos los artículos analizados en este estudio fueron ensayos controlados aleatorios (ECA). Se utilizó la escala PEDro para evaluar la calidad metodológica de los artículos. Resultados: Se seleccionaron e incluyeron cinco ECA. Los ECA mostraron que los ejercicios NMS reducen la intensidad del dolor, mejoran el control del movimiento lumbar y la función física y previenen el dolor lumbar. Los estudios también demostraron que los ejercicios NMS son ejercicios dirigidos a mejorar el control, la flexibilidad y la fuerza de los músculos lumbares. La puntuación de PEDro oscila entre 5 y 7, lo que destaca varias cuestiones metodológicas. Conclusión: Los resultados de este estudi sugiere que los ejercicios NMS pueden tener un impacto positivo en la intensidad del dolor en el dolor lumbar.
Palabras clave: Lumbalgia, Ejercicios neuromusculares, Dolor lumbar, Postura lumbar, Estabilización, Rehabilitación, Estabilidad central, Control motor.

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Ehsan Alvani
ehsanalvani90@gmail.com

Introduction

Low back pain (LBP) is an increasingly common disorder that can cause significant disability. It is the most frequently reported chronic pain condition globally (Smit, Mayorga, Rogers, Nizio, & Zvolensky, 2023; Villafane et al., 2016; Weissenfels et al., 2018) and is a major contributor to healthcare expenses in many developed and developing countries (Bauer, Kankaanpää, Meichtry, Rissanen, & Suni, 2019). LBP is a leading cause of disability (George et al., 2021) and affects 80-90% of individuals worldwide to some extent (Bier, Ostelo, Van Hooff, Koes, & Verhagen, 2017). The economic burden of this condition increases healthcare costs and reduces work productivity (Azevedo et al., 2015). Furthermore, it affects all aspects of life, including biological, psychological, and social dimensions (Araque-Martínez, Ruiz-Montero, & Artés-Rodríguez, , 2021; Pillastrini et al., 2016; Villafane et al., 2016).

Different physical and psychological treatments are available for managing LBP (e.g., core stability exercises, motor control exercises, strengthening exercises) (Pillastrini et al., 2015; Kusnanik, 2023; Wnuk-Scardaccione, Zawojska, Barłowska-Trybulec, & Mazur-Biały, 2023). However, these treatments only have a minor impact on reducing pain and disability (Malfliet et al., 2018). The Guidelines for managing LBP recommend supervised exercise therapy as a first-line treatment (Negrini, Imperio, Villafañe, Negrini, & Zaina, 2013; Saner et al., 2015). Studies have shown that exercise therapy can increase flexibility, abdominal endurance, and lumbar extensor (Alvani, Shirvani, & Shamsoddini, 2021).

Therefore, performing movement therapy with the mentioned goals is part of the usual program for people with LBP (Smidt, de Vet, Bouter, & Dekker, 2005). According to evidence on comparative effectiveness, training that includes strength, coordination, and stabilisation is likely to be the most effective type of exercise in managing LBP (Hayden et al., 2021; Owen et al., 2020). From a clinical perspective, all these training modalities improve motor control. For this reason, movements have been considered in recent years to improve and develop sensory-motor control of the lumbar spine and pelvis (Van Dieën, Reeves, Kawchuk, Van Dillen,

& Hodges, 2019).

Neuromuscular (NMS) exercises increase the subconscious motor response by stimulating afferent signals and the reactions of central mechanisms for dynamic joint control)Khorshid Sokhangu, Rahnama, Etemadifar, & Rafeii, 2018). NMS exercises are important in improving coordination, strength, range of motion and deep sensory function)(Myer, Ford, PALUMBO, Hewett, & Research, 2005). NMS exercises include a combination of flexibility, central stability, balance, strength, agility and plyometric training (Khorshid Sokhangu et al., 2018). These exercises play a role in strengthening the sensory receptors in the joints, which receive information about the body's position and movements (Tsai, Sigward, Pollard, Fletcher, & Powers, 2009). NMS exercises can potentially increase the number of lumbar movement patterns available to an individual. This would allow them to undertake repetitive tasks in a variable manner, reducing cumulative stress on specific tissues (Bauer, Kankaanpää, Meichtry, Rissanen, & Suni, 2019). Studies show that NMS exercises are targeted to improve the lumbar muscles' control, flexibility and strength (Bauer, Kankaanpää, Meichtry, Rissanen, Suni, et al., 2019). One of the benefits of NMS is the ability to provide warmth, avoid fatigue, and increase the load ability of musculoskeletal systems, which can be a potential factor in the success of this type of program (Sinatti et al., 2022). The general goal of NMS exercises is to restore the musculoskeletal disorders caused by pain and increase the muscle strength and endurance required in activities (Jaana H Suni et al., 2016). Previous studies have reported positive effects of NMS exercises in people with LBP (Alvani et al., 2021; Jaana Helena Suni et al., 2018; Jaana H Suni et al., 2016; Jaana H Suni et al., 2013; Taulaniemi, Kankaanpää, Tokola, Parkkari, & Suni, 2019). However, there is a lack of a summary regarding the role of NMS exercises in LBP. Therefore, the main purpose of this narrative review was to summarise the effect of NMS exercises on LBP.

Materials and methods

This is a narrative literature review of studies investigating the effectiveness of NMS exercises in patients with LBP. The current study was developed based on the PRISMA statement 2020 and checklist (Page et al., 2021).

Search strategies

Initially, the Cochrane Library and the Database of Abstracts of Reviews of Effectiveness were searched to determine whether a narrative study on this topic had been completed, and none was found. Subsequently, an extensive review of the scientific literature was performed by two of the investigators (EA, GR).

All disagreements between the reviewers were settled with a third author (J.H.V.) (Villafane, 2022). In this narrative study, we included randomized controlled trials (RCTs) on the effect of NMS exercises on LBP published from 2000 to 2023. We searched the literature from April 2000 to July 2023 on five electronic databases, including Scopus, PubMed, Web of Science, Science Direct and Google Scholar. We adopted a sensitive search string including the following search terms combined with the boolean operators: "low back pain" AND "pain" AND "neuromuscular exercise". Abbreviations were also searched. In addition, the bibliography of each article was analysed to identify additional articles. No language restrictions were considered. A search methodology expert was consulted to create the search string.

Eligibility criteria

Eligibility criteria were based on PICOS (patient, intervention, comparison, outcome, and study) using the following parameters (Eriksen & Frandsen, 2018):

- "P" (Population) – including LBP patients worldwide;
- "I" (Intervention) – considering as the intervention the NMS exercises;
- "C" (Comparison) – considering as the control group another treatment commonly adopted in LBP,
- "O" (Outcome) – measuring pain; and
- "S" (Study) – including RCTs.

Only full publications in peer-reviewed journals were analysed. Unpublished data and abstracts were not sought. We excluded all repeated articles, case reports, letters to the editor, pilot studies, editorials, technical notes, and review articles from the analysis.

Data extraction

To facilitate the comparison of findings across studies, the following information was extracted from each study: researcher(s) name(s) and date of publication, study design and quality assessment of the study, participants' characteristics (e.g., sample size, age and sex), outcomes (pain variables and their related measures) and results.

Quality assessment

Two authors (E. A. & S. S.) independently evaluated the methodological quality of the included studies. Any disagreements were resolved through consensus. The methodological quality of randomised controlled trials was assessed by the physiotherapy evidence database (PEDro) scale, which characterises the methodological quality of a study based on 11 criteria and yields a score between 0 and 10 (Maher, Sherrington, Herbert, Moseley, & Elkins, 2003)

Results

Study selection

After the search, a total of 93 articles were found and reviewed. Two were found in PubMed, 19 in Science Direct and 72 in Google Scholar. No article related to our topic was found in Scopus, Web of Science databases. After the screening and eligibility steps, we included five RCTs in the review (Alvani et al., 2021; Jaana Helena Suni et al., 2018; Jaana H Suni et al., 2016; Jaana H Suni et al., 2013; Taulaniemi et al., 2019). The flow chart of the data selection and extraction process is shown in Figure 1 (PRISMA flow diagram).

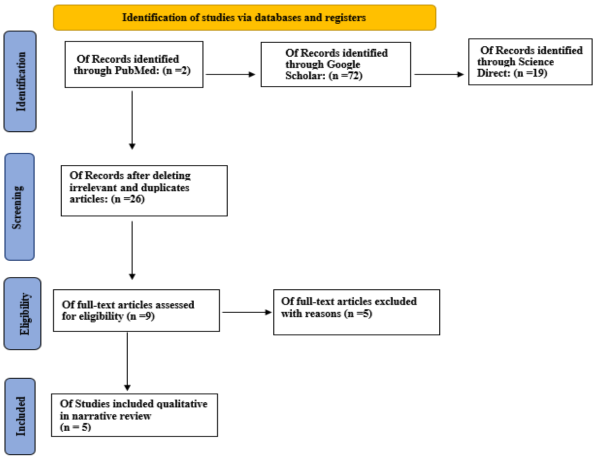

Figure 1. Flowchart of search resources and article selection steps.

Characteristics of the studies

One study examined the effect of NMS exercises and lumbar counselling for female nursing staff with nonspecific LBP (Jaana H Suni et al., 2016). One study investigated the effect of NMS exercises on reducing the severity of LBP and improving physical function in nursing duties among female healthcare care workers (Taulaniemi et al., 2019). One RCT was on the effectiveness and cost-effectiveness of NMS exercises and back care counselling in female healthcare workers with non-specific CLBP (Jaana Helena Suni et al., 2018). An example was the effect of NMS exercises and counselling on reducing the absence of young soldiers with LBP (Jaana H Suni et al., 2013). One study was the effect of NMS exercises on pain intensity, functional disability, proprioception and balance of military personnel with CLBP (Alvani et al., 2021).

At the overall level, three related articles (Jaana Helena Suni et al., 2018; Jaana H Suni et al., 2016; Taulaniemi et al., 2019) were performed on the LBP of female nursing staff, and two (Alvani et al., 2021; Jaana H Suni et al., 2013) analysed the LBP of military personnel. The details of the study characteristics are reported in Table 1.

Table 1.
Summary of selected articles on NMS exercises for LBP

Author and year	Study design/quality	Participants	Intervention/Comparison	Outcomes/Measure	Results
Suni JH, et al (2016) (Jaana H Suni et al., 2016)	RCT	Female nursing personnel LBP (n=240)	Intervention: NMS, NMS + LBP counselling	Pain intensity: VAS	Pain intensity decreased after 6, 12 and 24 months' exercise intervention.
	PEDro score: 7	Age range: 30-55 Group 1: NMS Group 2: LBP	Control: control, LBP counselling	Musculoskeletal pain: NRS	Musculoskeletal pain decreased after 6 ,12 and 24 months in the intervention group compared to the control group
			Treatment period: one times per week for 24 weeks	Follow-up: 6 months, 12 months and 24 months	
Suni JH, et al (2018) (Jaana Helena Suni et al., 2018)	RCT	Female nursing personnel with LBP (n=219)	Intervention: NMS, NMS + LBP counselling	Pain intensity VAS	Pain intensity decreased in the exercise group After 12 months, the Combined-arm showed reduced intensity of LBP (p=0.006)
	PEDro	Age range: 30-55	Control: control, LBP counselling	Bodily pain interfering with work: SF-36 Fear Avoidance Beliefs related to work:FABQ	Bodily pain interfering with work was reduced only in the combination group. After 12 months, the combined-arm showed reduced pain interfering with work (p=0.011)
		Group 1: NMS; Group 2: NMS; +LBP counselling Group 3: LBP counselling; Group 4: Control	Treatment period: one times per week for 24 weeks	Follow-up: 6 months, 12 months	FABs was reduced in both the combined and exercise groups. compared with the Control-arm. Work-related fear of pain was reduced in both the Combined- (p = 0.003) and Exercise-arm (p = 0.002). Physical activity related fear was reduced only in the Exercise-arm (p = 0.008).
Taulaniemi A, et al (2019) (Taulaniemi et al., 2019).	RCT	Female nursing personnel with LBP (n=219)	Intervention: NMS, NMS + LBP counselling	Pain intensity: VAS	The mean pain intensity after 6 and12 months in the exercise group was reduced compared to the non- exercise group. (p = 0.047)
	PEDro score: 7	Age range: 30-55	Control: control, LBP counselling	Pain interfering with work: Subscale from the RAND 36	Pain interfering with work after 6 and12

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				Health Survey Monvement control of the low back: MCI test battery Physical fitness	months was reduced in the exercise group. (p = 0.046)
		Group 1: NMS; Group 2: NMS; +LBP counselling Group 3: LBP counselling; Group 4: Control	Treatment period: one times per week for 24 weeks	Follow-up: 6 months, 12 months	Lumbar MCI after 6 and12 months was more reduced in the exercise group compared.
Suni JH, et al (2013) (Jaana H Suni et al., 2013)	RCT	Young Conscripts (n=1409)	Intervention: Antitank and Engineer (NMS, NMS)	Pain intensity VAS	Pain intensity decreased in the intervention group compared to the control group. (P=0.035)
	PEDro score: 5	Age range: 19 years and above	+ Counselling based on the cognitive-behaviour model-ling)	Follow-up: 180 days or until dropout	
		Group 1: Antitank Group 2: Engineer Group 3: Signal; Group 4: Mortar	Control signal and Mortar Treatment period: three times per week for 24 weeks		
Alvani E, et al (2021) (Alvani et al., 2021)	RCT	Men military personnel with LBP (n=30)	Intervention NMS	Pain intensity VAS	Pain intensity decreased from 5.73 to 3.67 after 8 weeks the intervention in the intervention (P= .001)
	PEDro score: 6	Age range: 20-50	Control: control (non exer-cises	Functional disability: Oswestry questionnaire Dynamic balance: YBT test Static balance: Stork balance test Proprioception: goniometer	The mean disability after 8 weeks the intervention decreased from 16.80 to 9.87. (p=.044)
		Group 1: NMS; Group 2: Control (Non ex-ercises)	Treatment period: three times per week for 8 weeks	Follow-up: No	The mean dynamic bal-ance after 8 weeks the in-tervention increased from 92.15 to 97.84. (p= .015)
					The mean static balance increased from 6.06 to 7.73 after 8 weeks the in-tervention. (p=.015)
					The mean Proprioception decreased from 2.34 to 1.92 after 8 weeks the in-tervention. (p=.021)

Abbreviations:
RCT: randomized controlled trial, NMS: Neuromuscular exercise, VAS: Visual analogue scale, NRS: Numeric Rating Scale, SF-36: 36-Item Short Form Survey, YBT: Dynamic balance test, MCI: Movement Control Impairment, FABQ: fear-avoidance beliefs questionnaire.

Quality assessment of studies

Scores of the included RCTs on the PEDro scale are presented in Table 2. The eligibility criteria were not presented in one study (Alvani et al., 2021). The allocation was not concealed in all the included studies (Alvani et al., 2021; Jaana Helena Suni et al., 2018; Jaana H Suni et al., 2016; Jaana H Suni et al., 2013; Taulaniemi et al., 2019). The blinding of the therapists was not reported in two studies (Jaana H Suni et al., 2016; Jaana H Suni et al., 2013). Measures of at least one key outcome of the subjects initially allocated to groups were not presented in four study(Alvani et al., 2021; Jaana Helena Suni et al., 2018; Jaana H Suni et al., 2013; Taulaniemi et al., 2019). All the included studies did not report the treatment or control condition as allocated (Alvani et al., 2021; Jaana Helena Suni et al., 2018; Jaana H Suni et al., 2016; Jaana H Suni et al., 2013; Taulaniemi et al., 2019).

Evidence from studies

The study by Suni JH, et al. (2016), compared the effectiveness of NMS exercises and 6-month counselling in treating female nursing personnel with recurrent non-specific LBP. Participants were randomly divided into one of four groups: NMS exercises and LBP counselling, LBP counselling only, NMS exercises only, and control (no intervention). The findings showed that pain intensity decreased after 6, 12 and 24 months in the intervention group compared to the control group. In general, the results showed that the interventions that are carried out after working hours at the workplace may indicate that this approach is useful for reducing chronic pain and disability in female nurses (Jaana H Suni et al., 2016).

The study by Suni JH, et al. (2018) was conducted on female healthcare workers with recurrent non-specific LBP. The subjects were divided into four groups: NMS exercises, combined NMS exercises and LBP counselling, LBP counselling, and control. This study evaluated the effectiveness of interventions compared to a control group on the intensity of LBP, pain interfering with work, and fear-avoidance beliefs and calculated incremental cost-effectiveness ratios for sickness absence. The findings of this study showed that the degree of compliance was different between the intervention arms. After 12 months, the combination arm had reduced LBP intensity and work-interfering pain compared to the control arm. Fear of work-related pain was reduced in both the combination group and the exercise arm. Fear related to physical activity was reduced only in the exercise arm. The mean total costs were lowest during the study period in the combination arm group. Also, the average number of days of absence in any of the intervention arms was not cost-effective for sickness absence (Jaana Helena Suni et al., 2018).

The study of Taulaniemi A, et al. (2019) investigated the effects of 6 months of NMS exercises on pain, lumbar movement control, physical fitness and work-related factors in 6 and 12 months' follow-up among female health personnel with subacute or recurrent LBP. In this study, heal

thcare workers with non-specific LBP were initially divided into four groups (exercise, counselling, combined exercise and counselling, and control). Exercise was performed twice a week (60 minutes) in three progressive phases, focusing on controlling the neutral position of the spine. The study compared people who exercised more with those who exercised less and those who did not. The findings of this study showed NMS exercises in people who exercised reduced pain and pain interference with work and improved back movement control, abdominal strength and physical performance in heavy nursing tasks after 6 and 12 months. However, compared to not exercising, it did not affect other measures of fitness and work. High exercise compliance resulted in less pain and better control of lumbar motion and walking test results(Sánchez Romero et al., 2021; Taulaniemi et al., 2019).

The study of Suni JH et al (2013), examined the effectiveness of a 6-month NMS exercises and counselling program in reducing the incidence of LBP and disability in young recruits with healthy backs at the beginning of their military service. The participants were divided into 4 groups (intervention group: anti-tank, engineer, control group: signal, mortar). They were followed up for 6 months. The results showed that the pain intensity in the training group had decreased significantly. Also, the findings of this study showed that the total number and incidence of days off work due to LBP decreased significantly in the intervention group compared to the control group. The number of LBP cases, visits to the health clinic due to back pain and the most severe cases showed a similar decreasing trend. NMS exercises to improve lumbar control had a preventive effect in military environments (Jaana H Suni et al., 2013).

The study of Alvani E, et al. (2021) investigated the effect of NMS exercises on pain intensity, functional disability, proprioception and balance in military personnel with LBP. This study randomly divided military personnel with LBP into two intervention and control groups. The intervention group performed 60 minutes of NMS exercises three times a week for eight weeks, and the control group continued their routine physical activities. The findings of this study showed that the average intensity of pain, disability and proprioceptive error decreased significantly after the intervention in the intervention group. Also, the average scores of static and dynamic balance increased significantly after the intervention(Alvani et al., 2021). This was the only study that did not have a follow-up.

The studies included in this review(Alvani et al., 2021; Jaana Helena Suni et al., 2018; Jaana H Suni et al., 2016; Jaana H Suni et al., 2013; Taulaniemi et al., 2019) reveal that NMS exercises, either alone or in combination with other interventions, are very effective in reducing pain and disability in heavy occupations such as nursing and military occupations. Due to the heavy workload in these jobs, the rate of absenteeism and lost work days due to back pain is very high. Therefore, NMS exercises can be a useful approach to reduce chronic pain and work disability in these people.

Table 2.
Evaluation of input studies based on the PEDro scale.

Items	Pedro scale	(Alvani et al., 2021).	(Taulaniemi et al., 2019).	(Jaana Helena Suni et al., 2018)	(Jaana H Suni et al., 2016)	(Jaana H Suni et al., 2013)
Item1	Eligibility criteria were specified	-	+	+	+	+
Item2	Randomly allocation of subjects	+	+	+	+	+
Item3	Allocation was concealed	-	-	-	-	-
Item4	Group Similar at baseline	+	+	++	+	+
Item5	There was blinding of all subjects	+	+	+	+	+
Item6	Blinding of therapists	+	+	+	-	-
Item7	Blinding of assessors	-	-	-	-	-
Item8	Measures of at least one key outcome were obtained from more than 85 % of the subjects initially allocated to groups	-	-	-	+	-
Item9	All subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analyzed by "Intention to treat"	-	-	-	-	-
Item10	The results of between-group statistical comparisons are reported for at least one key outcome	+	+	+	+	+
Item11	The study provides both point measures and measures of variability for at least one key outcome	+	+	+	+	+
-	Total score	6	7	7	7	5

Discussion

This narrative review analyses the evidence on the effects of NMS exercises in patients with LBP. The included RCTs(Alvani et al., 2021; Jaana Helena Suni et al., 2018; Jaana H Suni et al., 2016; Jaana H Suni et al., 2013; Taulaniemi et al., 2019) have shown that NMS exercises reduce pain intensity and increase function in patients with LBP. Pain is a common challenge for healthcare providers in clinical settings in managing people with LBP (Kamaleri, Natvig, Ihlebaek, Benth, & Bruusgaard, 2009; Virkkunen et al., 2023). Pain can greatly impact the daily lives of people with heavy jobs (Kamaleri et al., 2009). Experiencing pain can increase the risk of poor work ability in the future and reduce productivity at work (de Cássia Pereira Fernandes, da Silva Pataro, De Carvalho, & Burdorf, 2016; Kamaleri et al., 2009). However, our review showed that NMS exercises can reduce pain. The results of this study were consistent with other evidence on different types of exercises. For example, Fabio et al. (2022) reported PNF training is a useful strategy for decreasing pain and improving disability in patients with LBP (Arcanjo et al., 2022). Moreover, a recent meta-analysis based on low-quality evidence revealed that Pilates, stabilization/motor control, resistance, and aerobic training represent effective treatments for patients with LBP (Owen et al., 2020).

Exercise is the most effective treatment for managing and preventing LBP (Taulaniemi et al., 2019). Among the general population with LBP, NMS exercises appear to be more effective in reducing pain in the short term and in improving disability in the long term (Taulaniemi et al., 2019). People who suffer from LBP may not be able to improve their disability completely due to pain acting unhelpful avoidance behaviour; thus, NMS may help to restore dysfunctional movements and increase self-efficacy (Bauer, Kankaanpää, Meichtry, Rissanen, & Suni, 2019). The analysis of the included studies has investigated the effects of NMS exercise on hard jobs such as nursing and military, which seem to require high lumbar control and coordination (Frost, Beach, Callaghan, & McGill, 2015). The common feature of all these studies was that the participants were engaged in hard physical work on the back(J. Suni et al., 2006). NMS exercises can improve the ability of the nervous system to generate a fast and desired muscle stimulus pattern that enhances dynamic joint stability, reduces forces exerted on the joint, and improves movement patterns (Alvani et al., 2021).

NMS exercises improve the dynamic response of the muscles to the relevant signals, thereby increasing the dynamic stability of the joint and motor performance (Bushman, 2012; Rodríguez-Grande, Vargas-Pinilla, Torres-Narvaez, & Rodríguez-Malagón, 2022). NMS exercises activate the neurophysiological processes of intermuscular coordination, which helps to stabilize the execution of people's movement patterns by increasing muscle strength and postural responses (Filipa, Byrnes, Paterno, Myer, & Hewett, 2010; Rodríguez-Grande et al., 2022). In general, the protocol used in the analyzed RCTs within this narrative review has shed light on the clinical value of NMS exercises for LBP (Alvani et al., 2021; Jaana Helena Suni et al., 2018; Jaana H Suni et al., 2016; Jaana H Suni et al., 2013; Taulaniemi et al., 2019). Despite the scarcity of evidence on the effects of NMS exercises in people with chronic LBP, our review reported significant changes in the strength and performance of people with back pain when performing NMS exercises (Alvani et al., 2021; Jaana Helena Suni et al., 2018; Jaana H Suni et al., 2016; Jaana H Suni et al., 2013; Taulaniemi et al., 2019). This insight is valuable for understanding the underlying mechanisms of NMS exercises.

Conclusions

The NMS exercises analyzed in this study effectively reduced back pain and lumbar movement control disorders. It also improves the strength of core muscles and core stability in people with low back pain. Generally, the results of this narrative review show that NMS exercises can affect LBP. However, the research on NMS exercises' effects on LBP is limited and should be interpreted cautiously due to methodological limitations.

Practical applications

NMS exercises are a useful therapeutic approach for treating patients with LBP. However, given the limited quality of available evidence, clinicians should only incorporate NMS exercises into LBP treatment plans that are based on international best practices, guidelines, and patient preferences. By doing so, patients with LBP can receive high-quality, evidence-based rehabilitation programs that are tailored to their unique needs.

Future research

To our knowledge, this is the first narrative review to evaluate the effect of NMS exercises considering patients with LBP, which contributes to the knowledge of the current evidence. In addition, it was based on RCTs and their methodological quality was assessed using the PEDro scale. As limitations, we included a few studies characterized by a small sample, limited age range, and heavy occupations, focusing mainly on pain outcomes. Thus, the findings of this review cannot be generalized to other populations (e.g., athletes or normal subjects), with different ages (e.g., adolescents and elderly) and works, offering opportunities for future research. Moreover, future research should also analyse the effect of NMS exercises considering patients' expectations and correlation with strength in patients with LBP and other musculoskeletal disorders (e.g., neck pain, shoulder pain, knee pain) (Ballestra et al., 2022; Baraldo et al., 2023).

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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Datos de los autores y traductor:

Ehsan Alvani	ehsanalvani90@gmail.com	Autor/a
Alireza Shamsoddini	shamseddin23@gmail.com	Autor/a
Amir Letafatkar	letafatkaramir@yahoo.com	Autor/a
Shahnaz Shahrbanian	shahrbanian@gmail.com	Autor/a
Jorge Hugo Villafañe	mail@villafane.it	Autor/a
Giacomo Rossettini	giacomo.rossettini@gmail.com	Autor/a – Traductor/a