Factors that influence motor control in individuals with nonspecific low back pain: A scoping review

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ABSTRACT

Introduction: One of the most common musculoskeletal pain that causes disability in healthcare settings is low back pain that presents without a specific cause and is known as nonspecific low back pain (NSLBP). NSLBP can cause impairment in motor control, which is the ability of the body to execute a precise and stabilized movement in space. Many factors affect motor control dysfunction and lead to different physical impairments, consequently requiring different approaches in clinical settings. However, the study regarding the alteration of motor control and the factors coming with NSLBP are still limited. Thus, this study is aimed to determine the factors affecting motor control in NSLBP conditions.

Materials and Methods: This is a scoping review of articles published from January 2012 to November 2022. This review follows the PRISMA guideline. The articles were searched through Scopus and Web of Sciences using the keywords "motor control" and "nonspecific low back pain". After finding the articles, the information was extracted, including authors, year of publication, country, objective, type of study, and motor control analysis summary.

Results: The search retrieved 1318 articles; however, after a thorough selection process, only eight articles were included for further review. The factors that affect motor control were related to trunk neuromuscular adaption, the precision of trunk control, motor control changes, motor abundance, and motor control impairment in the LBP population with or without comparison to healthy subjects.

Conclusion: Motor control in NSLBP is affected by various factors. The pain can lead to changes in motor behavior, alignment, postural control, proprioception, and stability strategy. If the changes happen for a long time, it will cause further structural and core control changes as an adaptation.

KEYWORDS:
Nonspecific low back pain, motor control, posture, stability

INTRODUCTION

Low back pain (LBP) is one of the most common disabling symptoms worldwide, with multiple known and unknown causes affecting all age groups. The most often found type of LBP is nonspecific.[1] Nonspecific low back pain (NSLBP) is frequently diagnosed when there is no known exact cause, such as infection, tumor, osteoporosis, fracture, structural deformity, an inflammatory disorder, radicular syndrome, and cauda equina syndrome.[2] NSLBP can be a complicated biopsychosocial problem with various manifestations (e.g., structural and functional cortical reorganization, the alteration or changes of muscle activity in the lumbopelvic), leading to chronic pain.[3]

The lifetime prevalence of LBP has reached up to 84%, with an estimated percentage of 23% chronic LBP, and 11 to 12% of the population has been disabled.[3] LBP has been an issue for both developed and developing countries, where in industrial countries 84% of the population complains of LBP at least once in their lifetime, and 85% are classified as nonspecific.[4] Moreover, LBP has been an issue globally and was in the top 10 causes of years lived with disability (YLDs) in 188 assessed countries based on the 2016 Global Burden of Disease Study.[5] In Malaysia, the main burden of musculoskeletal complaints was related to pain in the knee (9.3%) and lower back (11.6%).[6] Even for the developed country like the United Kingdom, the number of patients registered for LBP consultation was up to 417 from 10,000 registered patients each year, varying in the age group from 0 to 14 years old (30 from 10,000) until 45 to 64 years old in every 536 cases from 10,000 total cases.[2] Meanwhile, the Japanese population has the higher rates of LBP compared to other parts of the world with point prevalence up to 37.7%.[7]

LBP is suggested to be associated with muscular control of body function.[8] Understanding motor control is derived from studying each movement's nature and control. In short, motor control can be defined as regulating or directing the mechanisms essential for each movement.[9] Motor systems are responsible for generating sufficient coordinated forces of inappropriate muscles in controlling the oriented and stable body position during a movement.[9] This includes systems involved in higher-level planning, coordination, and generation of forces that produce movements and can effectively control the body's position in space.[9]

MATERIALS AND METHODS

Numerous factors contribute to the ability to maintain stability and ensure the postural sway is within the base of support (BOS).[10-12] In order to minimize gravitational force, body alignment held a vital role in maintaining a good erect posture as a part of the biomechanical process of the trunk.[10-

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[11] Good body segmental alignment is crucial because it can decrease stress on body structures, including bones, ligaments, muscles, and tendons. It can also improve body functions and, at the same time, decrease the amount of muscle energy needed to keep the body upright.[11] The other factor is muscle tone which is able to keep the body from collapsing as a response to the pull of gravity.[10]

Besides good body segmental alignment, the automatic activation of the lumbopelvic musculature, particularly core muscles, is essential in dynamically stabilizing and helping the spine function.[12] In order to prevent musculoskeletal injuries, precise control of body posture and balance is needed during activities of daily living and higher levels of physical activity.[12] This control and balance are obtained through the afferent input from the visual, vestibular, and proprioceptive systems delivered toward the CNS, resulting in motor output.[12]

During a task with high precision demands, motor control will be challenged since signal-dependent neuromuscular noise causes errors, and proprioceptive feedback is required for optimal performance. Meanwhile, pain may affect proprioception, muscle activation patterns, and kinematics.[9] Thus, motor control in LBP condition is generally altered to protect damaged tissue from further injuries in the acute phase via load redistribution. While this alteration may sound good, it could affect tissue health and the restoration of normal function in the future.[13] Furthermore, low-level co-contraction of trunk muscles has been found in patients with LBP even at rest, showing that even spine compression is still going on during recovery.[8]

These factors can lead to different mechanisms of motor control changes and also different physical interpretations of NSLPB.[8] Understanding the intricate dynamics influencing motor control in individuals with low back pain is essential for delivering comprehensive and effective care. This knowledge will help physiotherapists in prescribing individualized treatment strategies that target the underlying causes of motor control issues, manage the pain, and comprehend functional recovery.[8] However, there is still limited study that directly explains the alteration of motor control in those populations and the factors affecting the changes. Thus, this review will investigate the factors affecting motor control in nonspecific low back pain patients.

MATERIALS AND METHODS

This scoping review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline by 14 in The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. The search was conducted in two electronic databases, Scopus and Web of Science, available from the university's library. These databases were chosen because of their accessibility and ability to provide broader results. Meanwhile, the search from other databases, such as Cochrane and PubMed, did not show any results and thus did not included in this study. The search keywords were "low back pain", "nonspecific low back pain", "motor control", and "motor control impairment". The search included Boolean operators such as "low back pain" OR "nonspecific low back pain" OR "lower back pain" AND "motor control" OR "motor control impairment" OR "postural control".

The articles included in this study were those published from January 2012 to November 12th, 2022. An article was included when it met the following criteria: (1) the study population was patients with nonspecific low back pain; (2) analyzing motor control in nonspecific low back pain condition. Meanwhile, the article was excluded when: (1) designed as a study protocol; (2) full text is unavailable, which is only available in the form of abstracts, dissertations, conference proceeding abstracts, editorials, opinion pieces, review papers, letters, single-case studies, short communication, or technical notes. The information was extracted from each article, including author, year of publication, country, objective, type of study, results, factors, and conclusion.

Ethics Approval and Informed Consent

This review does not require ethical approval.

RESULTS

There were 1318 articles retrieved from the two databases. After removing duplicates, 1281 articles were removed through the eligibility based on title, abstract, and full text. Finally, only eight articles were included for further review. The details of the articles' selection process are illustrated in the flow chart in Figure 1.

The design of the study found in the eight reviewed articles included cross-sectional (n=4), literature review (n=2), systematic review (n=1), and case-control (n=1). Their study objectives vary but included one or more of the following: (1) identifying trunk neuromuscular adaption, (2) the precision of trunk control, (3) motor control changes, (4) motor abundance, and (5) motor control impairment in the low back pain population with or without comparison to healthy subjects. Further information about the reviewed article is demonstrated in Table I. Among eight articles, two studies assessed the precision of trunk control, two identified motor control changes, and the rest assessed trunk neuromuscular adaptation, motor abundance, and motor control impairment.

DISCUSSION

This review investigates the factors affecting motor control in patients with nonspecific low back pain. All eight studies demonstrated alteration of motor control in the LBP population and primarily compared with the healthy population, except for one study.[17] The identified factors are muscle endurance[15], pain intensity[4,8,10,15,17,18,19], neuromuscular changes[4,8,15,18,19], fear of mevement[8,16], speed and the complexity of the task given[4,17,16,18,19], environmental condition[17] (e.g. predictable and unpredictable perturbation8), changes in muscle structure (muscle type, muscle atrophy, fatty infiltration of the muscle)[8], and changes in body alignment and unstable lumbal segment.[8]

The most common factors that found in the studies are pain intensity and neuromuscular changes. The pain will lead to

Table I: Table of Evidence

Author (Year); Countryref. no.	Type of Study	Objective	Result	Factors	Conclusion
Abboud (2014); Canada[15]	Cross-sectional	Identify and characterize trunk neuromuscular adaptations during sustained isometric muscle contractions in patients with CLBP compared to healthy adult participants	After a trunk muscle fatigue protocol, both groups showed increased muscle variability, but a tremendous increase was found in the healthy group. Increased muscle variability as a response to muscle fatigue suggests the adaptation of motor control strategy in order to maintain the optimum task performance. However, due to the pain in LBP groups, there are motor control strategy changes to avoid pain and possible further tissue damage.	• Muscle endurance • Pain intensity • Neuromuscular changes	Patients with LBP showed less motor variability compared to healthy participants after a trunk muscle fatigue protocol.
Alsubaie (2021); United Kingdom[16]	Cross-sectional	Assessing the precision of trunk control during repetitive flexion-extension tasks with varying speeds in people with and without NSCLBP	There is a significant positive correlation between the tracking variability of the lumbar segment and the FABQ-PA score during slow-speed tasks. During faster movements, both groups showed an anticipatory response, but the response of the LBP group tended to be delayed compared to the healthy group.	• Fear of movement • Speed of the task	People with LBP showed more delayed responses compared to healthy participants. There is an association between tracking variability of the lumbar segment and the degree of fear of movement during slow-speed tasks.
Dieën (2019); Netherland[8]	Literature review	Finding the differences in postural control parameters between people with and without NSLBP during quiet standing	Three highlighted parameters were discussed in this study (CoP displacement, postural control strategy, and muscle activation pattern). Higher CoP sway in LBP groups during standing with higher demands was found compared to the healthy population. There was higher dependence on ankle proprioception in LBP, and the reliance on proprioception of the lower back and thigh muscles was restricted. Meanwhile, muscle activation patterns showed higher bilateral co-activation of GM in persons with back pain during prolonged standing.	• Predictable and unpredictable perturbation • Changes in muscle structure (muscle type, muscle atrophy, fatty infiltration of the muscle) • Changes in body alignment and unstable lumbal segment • Neuromuscular function • Pain and fear	There were differences in postural control between individuals with and without NSLBP in quiet standing, which became more evident in situations with higher demands.
Koch (2019); Germany[7]	Systematic review	To identify the differences in motor control between individuals with and without LBP during quiet standing	The procedure of quiet standing was performed in three conditions: standing on a stable surface with eyes open (EO), on a stable surface with eyes closed (EC), and on a foam surface with eyes open (FO) by assessing the muscle activity (EMG) and CoP. The result showed a main effect in each condition but no significant differences between groups. CoP sway was higher during the FO condition.	• Pain intensity • Neuromuscular changes • Task demands	During quiet standing, there are no motor control differences between individuals with and without LBP. The findings suggest that the populations may assume the task is manageable.
Koch (2022); Germany[17]	Case-control	To identify the differences in motor control between individuals with and without LBP during quiet standing	The procedure of quiet standing was performed in three conditions: standing on a stable surface with eyes open (EO), on a stable surface with eyes closed (EC), and on a foam surface with eyes open (FO) by assessing the muscle activity (EMG) and CoP. The result showed a main effect in each condition but no significant differences between groups. CoP sway was higher during the FO condition.	• Pain intensity • Task demands • Environmental condition	During quiet standing, there are no motor control differences between individuals with and without LBP. The findings suggest that the populations may assume the task is manageable.

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Table I: Table of Evidence

Author (Year); Countryref. no.	Type of Study	Objective	Result	actors	Conclusion
Liew (2020); United Kingdom[18]	Cross-sectional	Assessing the difference of motor abundance during low load lifting tasks between LBP and healthy subjects	The IMA was significantly greater during lowering than lifting for pelvic and trunk displacement in the LBP population, indicating worse motor variability compared to the control group which has higher motor abundance during lifting. However, current or previous LBP does not influence motor abundance (meaning there is no correlation between LBP status with control of the pelvis and trunk).	• Task demands • Pain intensity • Neuromuscular changes	LBP subjects had similar overall motor abundance, but different muscle activation profiles and modes compared to the control group during a low-load lifting task.
Sheikhhoseini (2016); Iran[10]	Literature review	Review studies relating to MCI in athletes with LBP	This study reviewed the MCI in cricket, cycling, football, golf, judo, hockey, and tennis athletes with LBP. Among these sports, the most common MCI finding is shown by muscle imbalance, reduction of ROM, increased muscle stiffness, and kinematic changes. In dance, no conclusion can be drawn because of limited sources.	• Pain intensity	Athletes with LBP show MCI while performing functional and non-functional tasks, like non-athletes.
Willigenburg (2013); Netherland[19]	Cross-sectional	Assessing the precision control of trunk movement in patients with LBP using a tracking task	The increased tracking errors with a vibration indicate an adequate proprioceptive function. However, subjects with severe LBP performed worse on the tracking task by showing a slight but not significantly decreased tracking error score (0.422° to 0.409) compared to the control, which showed significantly increased tracking errors with a vibration (0.332° to 0.367°). Hence, the vibration only influenced the control group, indicating an altered proprioception function in the LBP population.	• Pain intensity • Neuromuscular changes • Task demands	LBP is associated with proprioceptive impairments.

CLBP=chronic low back pain; LBP=low back pain; NSCLBP=non specific chronic low back pain; MCI=motor control impairment; FABQ-PA=fear-avoidance beliefs questionnaire-physical activity, CoP=center of pressure, GM=gluteus medius, IMA=index of motor abundance

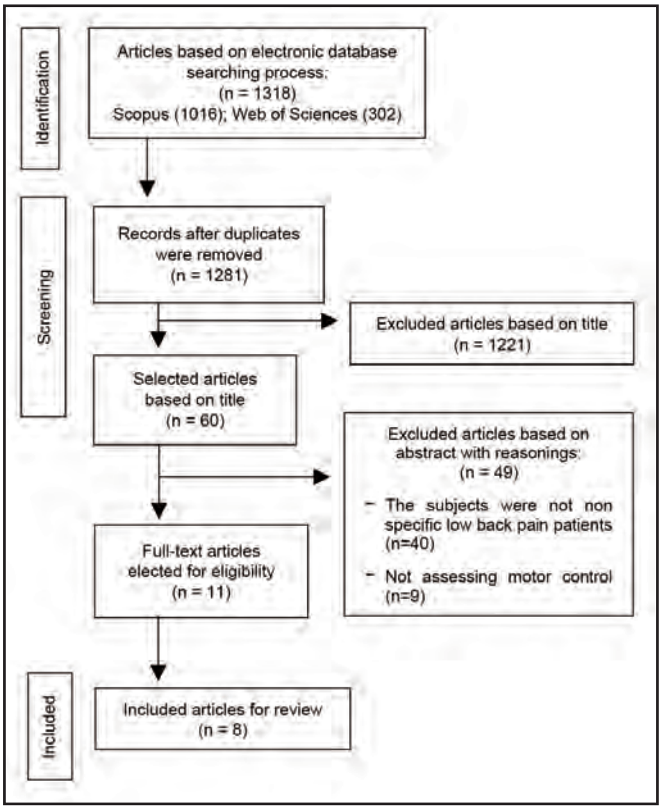

Fig. 1: Articles Selection Process Flowchart.

neuromuscular changes and affect the control of the movement.[15] The movement control is identified in the form of motor variability in two studies.[8,15] Higher motor variability indicates better motor control and neuromuscular function, therefore, less motor variability was found in the LBP population compared to control or healthy participants.[15]

There was one study[17] which unable to identify the difference between groups in assessing the center of mass and muscle activity through electromyography, contrary to the previous systematic review[4] that stated there is a difference in postural control between individuals with and without LBP in quiet standing. It is explained that in quiet standing, there is a higher reliance on ankle strategy for maintaining balance because of impaired hip flexion through a higher co-activation of gluteus maximus (GM) in subjects with LBP. The reliance on ankle strategy was also supported by a study,[15] which found a dominant ankle extensor and upper limb pattern in load-lifting tasks in patients with LBP compared with healthy subjects with a dominant trunk extensor pattern. However, the previous study[17] could not identify any difference in motor control activation between LBP, and the control group, which may be caused by quiet standing was not considered a highly demanding task.

The changes in the structure, such as type of muscle fiber, muscle atrophy, and fatty infiltration of the muscle, also can change motor control in patients with NSLBP.[4,8] Reduced muscular function and muscle weakness can result from fatty accumulation in the muscles, which can lead to muscular atrophy (loss of muscle mass).[7] Weakened muscles are less capable of supporting and stabilising the spine during movement, and might cause compensatory patterns that impair motor control and interfere with the alignment of muscle groups.[7] This changed muscle quality can impair the ability of muscles to contract effectively and worsen problems with motor control.[7]

Besides the structural changes, drastic changes in motor behavior were also found in one study[15] as protection from pain and further tissue damage. The pain-related changes also had been demonstrated by another study[8] that mentioned trunk stiffening found in patients with LBP is correlated with the changes in motor control as a purposeful strategy to avoid pain, leading to alignment changes as well as slower trunk movement compared with healthy subjects. This finding aligns with a study by a study[13] stating that poor coordination of muscles due to a disorder followed by low muscle activities, compromised joint laxity, muscle fatigue or other sensory function problems can lead to spinal instability. This spinal instability is correlated with the alignment change and drastic changes in motor behavior to avoid pain and possible further tissue damage.[15] The changes in muscle activities and motor behavior will lead to a higher risk of muscle fatigue and lesser motor variability, showing the inability to quickly search in motor strategy to maintain optimal task performance in individuals with LBP.[15] However, this study also presents the ability of the muscle to adapt to new behavior in patients with chronic LBP.[15]

Two studies[16,19] found proprioception deficits in the population with LBP, especially in high-precision demand conditions, such as load-lifting. Because in this task, proprioception is needed for optimal performance.[9] One of the studies[19] found that the vibration given in the LBP population did not affect the tracking performance since it was not remarkable even before the vibration, in contrast with the healthy subjects, who came with significant changes in tracking performance after the vibration, marking excellent proprioception function. The tracking performance result explained the altered proprioceptive function in the LBP condition, affecting motor control during task performance.[19]

Injury or nociceptive input and pain are potent causes of altering motor control.[8] The existing injury, pain, and fear of movement will change the excitability of motor pathways and muscle activation as a protective response to further tissue damage.[15] The other impact is the changes in proprioception, and the motor control will represent a purposeful strategy of protection instead of precision for functional tasks.[20] This condition can be seen when there is an injury to the spinal structure, the paraspinal muscles and the nociceptors will be stimulated and induce pain. Consecutively, this will cause an individual to be afraid to move and develop less function of the spinal muscles. Indirectly, this scenario alters the motor control of spinal movements.[8]

The motor control of deep core muscles (i.e. transverse abdominus, multifidus) can provide the appropriate movement needed for certain tasks in a specific environment.[20] Thus, it is essential to reeducate the muscle activities toward the physiological function so the body can maintain steady-state stability and keep the postural sway within the base of support.[20] Correcting postural control and motor behavior will slowly return the proprioceptive function and give the correct strategy for stability.[8] Consecutively, a better muscle control strategy will improve the task performance as well.

CONCLUSION

This scoping review showed that numerous factors affecting motor control in patients with NSLBP correlated with one another. The identified factors are muscle endurance, pain intensity, neuromuscular changes, fear of movement, task variability, environmental conditions, perturbations, and structural changes. In the end, the pain-induced adaptation of the motor control will affect daily task performance as the pain will also cause changes in other factors. Thus, it is essential to establish a comprehensive motor control assessment and functional-aimed rehabilitation program. Further research is needed to find the other factors that may contribute to the adaptation of motor control in the LBP population.

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CONFLICT OF INTEREST

No conflict of interest.

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