European Journal of Physical and Rehabilitation Medicine 2025 February;61(1):72-81
DOI: 10.23736/S1973-9087.25.08383-2

SYSTEMATIC REVIEW

Is dynamic balance impaired in people with non-specific low back pain when compared to healthy people? A systematic review

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ABSTRACT

INTRODUCTION: Low back pain (LBP) represents a frequent health issue in most of the countries; in recent years, there was a growing interest concerning the role of balance and postural stability in individuals with non-specific LBP (NS-LBP). The aim of this systematic review is to provide a synthesis of the evidence on the association between NS-LBP and an impaired dynamic balance.

EVIDENCE ACQUISITION: The reporting of this study followed the 2020 PRISMA statement. Analytical observational studies, investigating the dynamic balance performance via functional or motor-tasks tests in LBP in comparison to healthy people, were searched in PubMed, Embase and Scopus up to December 2023. Their characteristics were reported in a standardized form, and their methodological quality was evaluated using the Joanna Briggs Institute Critical Appraisal Checklist for cross-sectional studies.

EVIDENCE SYNTHESIS: A qualitative synthesis of the study findings and a discussion of the results are provided. 19 cross-sectional studies were included in this review, with an overall sample size of 894. A meta-analysis was not possible due to high levels of heterogeneity across the studies. None of the included studies were deemed to be of a good methodological quality. Overall, most studies reported differences between NS-LBP and healthy people in terms of dynamic balance, showing worst performances in NS-LBP, both at motor-task tests and at the posturography.

CONCLUSIONS: Impaired dynamic balance seems to be correlated to NS-LBP. However, due to the presence of methodological issues in the included studies, further confirmations are needed. Clinicians should take into consideration the importance of a balance assessment in NS-LBP, by implementing proper functional tests. High-quality observational research is recommended, to assess dynamic balance with standardized and uniform modalities, in relation to specific stages of the condition.

(*Cite this article as:* Dal Farra F, Arippa F, Arru M, Cocco M, Porcu E, Solla F, *et al*. Is dynamic balance impaired in people with non-specific low back pain when compared to healthy people? A systematic review. Eur J Phys Rehabil Med 2025;61:72-81. DOI: 10.23736/S1973-9087.25.08383-2)

KEY WORDS: Postural balance; Low back pain; Spine; Exercise; Rehabilitation.

Introduction

Low back pain (LBP) is a frequent health issue that affects many individuals across the globe, with an estimated global point prevalence of limitation in activities of daily living (ADL) reaching approximately 7%.[1] Further, LBP is also the leading cause of functional impairment in adults, significantly impacting the physical capabilities and limiting their ability to engage in work and social activities.[1] In the vast majority of cases, there is no specific cause that can explain the presence of pain, thus it is preferable to name it "non-specific LBP" (NS-LBP), with its tendency to last over time and turning into a chronic state. Main functions impaired in people with NS-LBP are posture, strength, and mobility.[2] A physical assessment is essential for developing effective exercise-based rehabilitation programs.[3]

In recent years, there has been a growing interest in the role of balance and postural stability in NS-LBP.[4] Balance is a complex neuromotor skill involving the interactions between external forces acting on the spine, and the corresponding responses of the trunk muscles. Achieving and maintaining balance requires a variety of sensorimotor adjustments to sustain a stable upright posture, both in static and in dynamic activities.[4, 5] The importance of postural stability can be experienced in everyday tasks such as maintaining one- or two-leg stances, while dynamic balance plays a crucial role in several activities like reaching out to grasp objects, or squatting down to pick something up.[6, 7] In such a context, it becomes clear how both static and dynamic balance are essential motor abilities for the spine to guarantee postural stability.

A recent systematic review suggested that exercise-based programs could be effective in improving static balance in people with NS-LBP, with postural stability being the most crucial elements that are positively influenced by physical training.[8]

While dynamic balance is a relevant factor, evaluable through clinical functional tests and bioengineering tools, a significant knowledge gap is present concerning how LBP could affect it.[9-15] Despite a growing interest in literature, a synthesis of the evidence on this matter is missing at the moment. Highlighting this potential association is of utmost importance, since more tailored rehabilitative strategies could be developed in clinical and research settings.

Therefore, this review aims to address the following question: is impaired dynamic balance associated with NS-LBP? If such an association exists, what type of relationship can be established between NS-LBP and dynamic balance? To answer these points, we conducted a systematic review to synthesize the current evidence available on this topic.

Evidence acquisition

Protocol registration

We conducted this research following the protocol registration on PROSPERO website. The protocol was stored with the following registration number: CRD42022316669). For reporting, the "2020 Preferred Reporting Items for Systematic Reviews and Meta-Analysis" (PRISMA 2020)[16] checklist was considered.

Search strategy

A systematic search was conducted in the following databases: PubMed, Embase, and Scopus. The Supplementary Digital Material 1 (Supplementary Text File 1) shows the search strategy in detail.

The initial search included the studies published from inception to 30 March 2022. An update has been made in December 2023. Cross-referencing, Google web searching and clinicaltrials.gov consultation were further performed, in order to retrieve any possible missing study.

Eligibility criteria

The following inclusion criteria were considered: 1) primary observational research (*i.e.*, cross-sectional, cohort, case-control and prognostic studies) written in English; 2) investigating the association between dynamic balance and NS-LBP;[16] 3) comparing NS-LBP *vs.* healthy individuals; and 4) considering outcome measures related to dynamic balance.

Experimental studies such as randomized, quasi-randomized or non-randomized clinical trials and single-subject protocols were excluded, as these are study designs not suitable to answer our research question, the nature of which is observational. Other studies such as case reports, case series and any form of secondary research such as reviews, commentaries, letters and editorials, were also excluded. All the studies dealing with specific or peculiar conditions (such as deformity, infection, fracture, malignancy, or previous spinal surgery),[17] elderly[18] (>65 years old) or childhood[19] (<18 years old), were not included. Finally, studies assessing joint kinematics were excluded, in order to avoid the influence of potential confounding factors (*e.g.* joint motion, muscle actions).

Study selection

Records obtained from databases were managed using "Rayyan, Intelligent Systematic Review" (www.rayyan.ai). Title, abstract and full texts were independently screened by four reviewers (F.A., M.A., M.C., E.P.) to verify the eligibility of the studies. Any conflict was resolved by discussing with another reviewer (F.D.F.). The main characteristics of the included studies were extracted in a standardized form by collecting: first author's name, sample size, socio-demographics, pain assessment and outcome measures for dynamic balance.

Outcomes

In the current review any possible indicator of dynamic balance performance, such as dynamic posturography, were considered. This examination might include perturbations or the execution of specific tasks while standing. In addition, also studies adopting validated motor-task tests were considered, as star excursion balance test (SEBT) or Y balance test (YBT).

Methodological bias assessment

The Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Analytical Cross-Sectional Studies was implemented to assess the methodological quality of the studies included in this SR. Three blinded reviewers (M.A., M.C., E.P.) independently evaluated full-texts. Any discrepancy was resolved following a subsequent discussion with three other reviewers (F.D.F., F.A., M.M.). The JBI tool includes eight items: clarity of inclusion criteria, subject and setting description level, exposure method evaluation, condition assessment, confounding factors identification and treatment, reliability of outcome measures and appropriateness of statistical method. Each item is ranked with 4 possible grades: yes, no, unclear, not applicable.

Measures and synthesis of results

In the current review, descriptive statistics were implemented to overall summarize frequencies' distributions regarding the characteristics of the included studies. A qualitative synthesis of the study findings and a discussion of the results were provided. When available, effect sizes were reported as originally presented in the included research. Meta-analysis was considered, however it was not applicable because of higher levels of methodological heterogeneity detected across the studies. The quality of the evidence was rated by using the GRADE method,[20] as recommended by the Cochrane Handbook.[21] This framework considers five main domains (methodological limitations, indirectness, imprecision, inconsistency and likelihood of publication bias), enabling the raters to downgrade the quality of the evidence on the basis of the issues detected in the studies.

Evidence synthesis

Study Selection and sample characteristics

The initial search found 1461 articles, resulting in a total of 979 records following the duplicate removal. Among

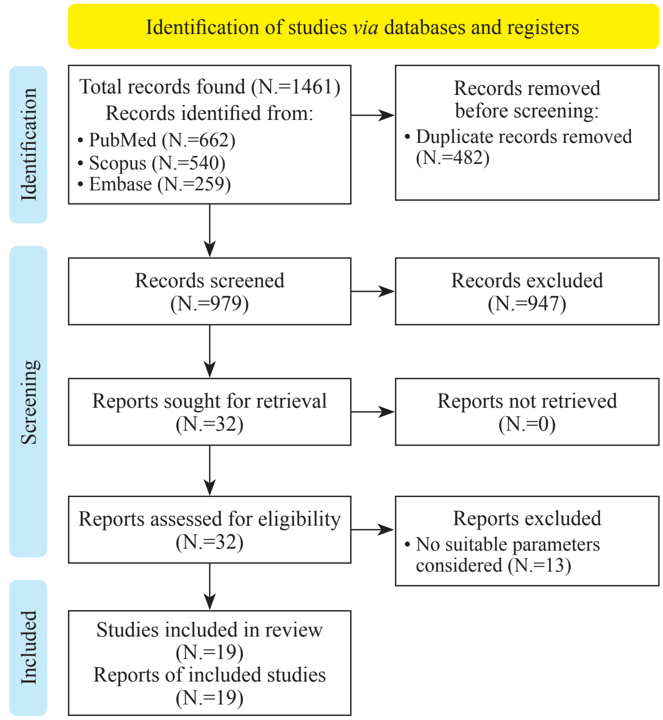

Figure 1.—Flow chart of study selection.

these, 947 studies were excluded and the remaining 32 were assessed by full-text reading for eligibility, resulting in the inclusion of 19 studies.[22-40] Details of the study selection process are provided in the PRISMA 2020 flow diagram (Figure 1).

The investigations ranged from 1999 to 2023 and encompassed a total of 894 participants, including both individuals with NS-LBP and healthy people (HP). The sample sizes per study ranged from 15 to 80 participants (mean 47.05±22.34). Pain was assessed by various measurements including visual analogue scales (N.=7, 36.8%), numeric rating scales (N.=2, 10.5%) the McGill Pain Questionnaire (N.=1, 5.3%), and Neck Pain Index (N.=1, 5.3%); 9 studies did not report pain evaluation scales (N.=9, 47.4%); pain duration was also reported in few cases (N.=7, 36.8%). Detailed characteristics of the included studies can be found in Table I.[20-38]

Outcomes

The selected studies employed a variety of outcome measures to assess dynamic balance. Perturbations while standing (N.=6, 31.6%), SEBT (N.=4, 21.1%), Biodex Balance System (N.=1, 5.3%), Posturography during upper limb movement (N.=1, 5.3%), Equitest (N.=1, 5.3%),

TABLE I.—*Characteristics of the included studies.*[20-38]

Study	Groups	Sample size	Gender: F/M	Age (years)	Height (cm)	Weight (kg)	Pain evaluation and duration
Shahbazi (2023)[20]	CLBP (FP, AEP) HC	72	-	FP (34.71±8.05) AEP (32.45±9.97) HC (31.75±7.43)	FP (175.27±7.15) AEP (173.69±7.02) HC (175.52±5.10)	FP (78.85±11.22) AEP (100.23±118.65) HC (78.05±8.72)	-
Mofateh (2023)[21]	CLBP (LPC, HPC) HC	60	M 21 F 39	LPC (25.70±5.74) HPC (26.32±6.86) HC (24.35±4.25)	-	-	VAS score LP (2.80±0.83) HC (4.05±0.97) Pain duration LP (28.60±24.25) HP (53.00±47.20)
Papcke (2022)[22]	CLBP HC	36	M 11 F 25	CLBP 29.93±8.12 HC 24.57±7.12	CLBP 1.64±0.07 (m) HC 1.7±0.09 (m)	CLBP 66.13±11.69 HC 66.39±12.47	CLBP: 1-year duration
Sung (2021)[23]	CLBP HC	80	-	CLBP 30.30±13.53 HC 25.68±8.65		-	-
Peng (2021)[24]	CLBP HC	15	-	CLBP 21.33±0.75 HC 22.78±2.70	CLBP 1.77±0.04 HC 1.75±0.03	CLBP 72.50±11.12 HC 73.78±4.71	-
Sung (2020)[25]	CLBP HC	72	M 33 F 39	CLBP (30.30±2.47) HC (25.43±9.47)	-	-	VAS score 17.30±0.28 mm
Seraj (2019)[26]	CLBP (FP, AE) HC	50	M 50	FP 32.42±8.36 AEP 33.05±9.01 HC 31.06±8.00	FP 175±8.45 AEP 173.21±6.75 HC 175.73±5.36	FP 76.75±12.14 AE 79.63±18.70 HC 70.46±9.47	VAS less than 5 to at least 1
Behennah (2018)[27]	CLBP HC	64	-	CLBP 28±12 HC 30±12	CLBP 172.9±9.6 HC 173.4±10.4	CLBP 75.0±12.8 HC 74.5±12.5	VAS score 35.0±23.2 mm
Soliman (2017)[28]	CLPB (LP, MP, HP) HC	60	M 38 F 22	LP: 42.57±6.2 MP: 43.1±5.7 HP: 46.1±7.39 HC: 45±5.9	LP: 170.1±5.1 MP: 170.9±4.3 HP: 172.3±5.1 HC: 171.75±4.9	LP: 74.4±4.9 MP: 76.1±5.1 HP: 77.3±6.5 HC: 76.75±4.7	VAS score LP: 5-44 mm MP: 45-74 mm HP: 75-100 mm HC: 0-4 mm
Hemmati (2017)[29]	CLBP HC	80	-	CLBP 24.20±6.09 HC 23.52±4.84	CLBP 171.80±9.35 HC 172±6.00	CLBP 70.68±11.04 HC 71.87±12.53	NRS lower than 3
Tsigkanos (2016)[30]	CLBP HC	33	M 18 F 15	CLBP 46.4±12.9 HC 40.4±11.5	-	-	CLBP 6-months duration
Hooper (2016)[31]	CLBP HC	42	M 24 F 18	30.9±8.2	173.1±8.1 174.0±10.6	-	VAS 3.0±1.4 cm
Ganesh (2015)[32]	CLBP HC	20	M 10 F 10.	34.30±8.67	-	-	-
Sipko (2013)[33]	CLBP (LP, HP) HC	68	ND	LP 51.4±8.0 HP 50.2±7.8 HC 44.6±8.6	LP 1.75±0.01 HP 1.69±0.09 HC 1.7±0.09	LP 85.7±16.0 HP 74.1±11.5 HC 68.4±13.8	CLBP for at least 3 months
Mok (2011)[34]	CLPB HC	26	-	LPB: 28.8±5.3 HC: 27.7±4.2	LPB 1.74±0.12. HC 1.75±0.06	LPB 75.1±14.7 HC 70.4±12.0	VAS score 19±18 mm
Popa (2007)[35]	CLBP HC	26	CLBP M 7	CLBP 35.1±11.9 HC 32.2±7.2	CLBP 174.3±9.1 HC 174.4±7.5	CLBP 76.5±17.9 HC 69.5±12.7	CLBP for more than 6 months
Henry (2006)[36]	CLBP HC	50	M 24 F 26	CLBP 39±13 HC 33±11	CLBP 1.74±0.12 HC 1.70±0.08	CLBP 75.3±15.2 HC 67.5±12.5	Pain duration longer than 6 months. CLBP - NPI 1.9±1.51 - McGill pain questionnaire 3.5±2.93
Della Volpe (2006)[37]	CLBP HC	24	M 7 F 5	CLBP 35.42±11.84 HC: N/A	CLBP 174.92±8.84	-	-
Mientjes (1999)[38]	CLBP HC	16	M 5 F 7 ND 4	CLBP 38.4±12.5 HC 37.1±13.1	CLBP 179±0.11 HC 171±0.12	-	CLBP: Before testing: 2,6±0.92 After testing: 3.1±0.89 HCs: Before testing: 0.5±0.5 After testing: 1.0±0.76. (no scale specified)

CLBP: chronic low back pain; HC: healthy controls; M: males; F: females; LP: low pain; MP: moderate pain; HP: high pain; FP: flexion pattern; AEP: active extension pattern; NPI: Numeric Pain Index; HPC; high pain catastrophizing; LPC: low pain catastrophizing; VAS: Visual Analog Scale; NRS: Numerical Rating Scale; ND: not defined.

Y-Balance test (N.=1, 5.3%), Box lifting (N.=2, 10.5%), Modified SEBT (N.=2, 10.5%), Perturbations on a platform (N.=6, 31.6%), and Dynamic posturography during voluntary leaning forward (N.=1, 5.3%) were among the tests utilized.[20-38] The most frequently considered parameter was the center of pressure (COP) sway during the execution of different motor tasks (Supplementary Digital Material 2: Supplementary Table I).

Methodological quality

None of the included studies was completely judged free from methodological issues.

In detail, two studies (11%)[32, 38] did not describe properly the sample characteristics or the study setting and 14 (74%)[20-23, 25, 26, 29-32, 34, 35, 37, 38] out of 19 did not guarantee that the participant condition (NS-LBP) was clinically assessed by a qualified clinician (risk of selection bias). In 15 (79%)[20-26, 28-31, 35-38] studies the potential confounding factors appeared not to be completely identified; other two papers (11%)[32, 33] did not report any mention to this aspect, whereas only 6 works (32%)[23, 25, 26, 29, 30, 34] showed a proper statistical management for those factors. Finally, only one study (1%)[27] presented some issues related to data analysis.

All the studies[20-38] satisfactorily addressed key aspects such as the definition of the inclusion criteria and the use of reliable and valid outcome measurements. The item on exposure was considered as "not applicable" with regards to the nature of the selected studies (cross-sectional design).

Results are detailed in Table II.

Synthesis of results

A comprehensive synthesis of the included studies highlights crucial insights into the dynamic balance characteristics of individuals with NS-LBP (Supplementary Digital Material 2: Supplementary Table I).[20-38]

None of the included works specifically dealt with acute pain, while all the 19 studies recruited individuals suffering from generic NS-LBP.

Most studies (17 out of 19, 89%) showed differences between people with NS-LBP and HP. Behennah *et al.*[27] underlined reduced strength of extensor muscles during task-oriented activities. Sung *et al.*[23, 25] spotlighted an increased rate of adaptive responses to perturbations, with shorter step times in initial treadmill-induced perturbations. Peng[24] unveiled worse dynamic performance, pointing out

Table II.—*Methodological quality of the included studies based on the JBI Critical Appraisal Checklist for Analytical Cross Sectional Studies.*[20-38]

Study	Items for quality assessment							
	1	2	3	4	5	6	7	8
	Were the criteria for inclusion in the sample clearly defined?	Were the study subjects and the setting described in detail?	Was the exposure measured in a valid and reliable way?	Were objective, standard criteria used for measurement of the condition?	Were confounding factors identified?	Were strategies to deal with confounding factors stated?	Were the outcomes measured in a valid and reliable way?	Was appropriate statistical analysis used?
Shahbazi (2024)[20]	Yes	Yes	NA	NC	NC	No	Yes	Yes
Mofateh (2023)[21]	Yes	Yes	NA	NC	NC	No	Yes	Yes
Papcke (2022)[22]	NC	Yes	NA	NC	NC	No	Yes	Yes
Sung (2021)[23]	Yes	Yes	NA	NC	NC	Yes	Yes	Yes
Peng (2021)[24]	Yes	Yes	NA	Yes	NC	No	Yes	Yes
Sung (2020)[25]	Yes	Yes	NA	NC	NC	Yes	Yes	Yes
Seraj (2019)[26]	Yes	Yes	NA	NC	NC	Yes	Yes	Yes
Behennah (2018)[27]	Yes	Yes	NA	Yes	NA	No	Yes	No
Soliman (2017)[28]	Yes	Yes	NA	Yes	NC	No	Yes	Yes
Hemmati (2017)[29]	Yes	Yes	NA	NC	NC	Yes	Yes	Yes
Tsigkanos (2016)[30]	Yes	Yes	NA	NC	NC	Yes	Yes	Yes
Hooper (2016)[31]	Yes	Yes	NA	NC	NC	No	Yes	Yes
Ganesh (2015)[32]	Yes	No	NA	NC	No	No	Yes	NC
Sipko (2013)[33]	Yes	Yes	NA	Yes	No	No	Yes	Yes
Mok (2011)[34]	Yes	Yes	NA	NC	Yes	Yes	Yes	Yes
Popa (2007)[35]	Yes	Yes	NA	NC	NC	No	Yes	Yes
Henry (2006)[36]	Yes	Yes	NA	Yes	NC	No	Yes	Yes
Della Volpe (2006)[37]	Yes	Yes	NA	NC	NC	No	Yes	Yes
Mientjes (1999)[38]	Yes	No	NA	No	NC	No	Yes	Yes

NA: not applicable; NC: not clear.

compensatory mechanisms to maintain balance. Soliman *et al.*[28] found issues in terms of dynamic balance related to pain intensity. Ganesh *et al.*[32] reported more functional reach deficits in NS-LBP, whilst Mok *et al.*,[34] Della Volpe *et al*.,[37] Mientjes and Frank[38] described higher degrees of postural instability and sway detected across various tests. Hooper[31] showed reduced or poorer performance in specific directions. Shahbazi Moheb Seraj[26] described higher rates of postural deficits during lifting phases. Tsigkanos *et al.*[30] found issues in dynamic balance performances, while Henry *et al.*[36] reported major deficits with neuromuscular coordination. Papcke[22] and Sipko[33] displayed a higher number of patterns characterized by altered muscle activation along with reduced forward limits of stability. Popa[35] underscored the adoption of more postural motor strategies for maintaining a quiet stance. Hemmati[29] reported comparable performances between LBP and HP. Shahbazi *et al.*[20] found an altered motor control in NS-LBP during functional tasks. Mofateh[21] pointed out the contribution of pain catastrophizing to impair dynamic balance.

The studies included in this review employed a variety of assessment tools to investigate the balance of individuals with NS-LBP compared to HP. Dynamic posturography consistently revealed significant alterations in dynamic balance, primarily due to deficits in trunk control in NS-LBP, with larger sway areas, COP displacements and altered COP velocity.[22, 23, 25, 33-36, 38] Furthermore, the SEBT demonstrated reduced reaching target capabilities among individuals with NS-LBP, indicative of a lower dynamic balance.[21, 24, 27, 29, 30, 32] Similar findings were reported by studies using alternative assessment methods such as Biodex, Equitest, YBT, and box lifting.[20, 26, 28, 31, 37]

Subgroup analysis

A subgroup analysis was performed according to some characteristics of the included studies. In detail, variables such as sample mean age, pain duration, pain levels and applied tests were considered. No specific trends were found: except for two studies,[26, 29] the alterations in dynamic balance were detected across all the other research, independently of such variables. Regarding NS-LBP subgroups, one study[20] reported a worst performance in individuals with high catastrophizing levels, whereas Soliman[28] found a correlation with pain intensity; however, Papcke and Behennah did not find the same result.[22, 27] Only one (1%)[20] out of the twelve studies which assessed dynamic balance *via* dynamic posturography (box lifting task) found no differences in the comparison with healthy people. The only other study with negative results considered the modified SEBT.[29] The remaining six studies (32%) reporting an impaired dynamic balance considered motor-tasks tests such as YBT (N.=2) or SEBT (N.=4).

Quality of the evidence

As suggested by the GRADE framework,[39, 40] we rated the quality of the evidence on the basis of a qualitative synthesis of the results. Actually, a data pooling across the studies (meta-analysis) was not possible because of a wide methodological heterogeneity of the included studies; such a variability was mostly represented by the various methods of assessment employed to measure dynamic balance in terms of nature of the tests, outcome measures and tasks requested.

The quality of the evidence was downgraded by one level for risk of bias, by one level for indirectness and by another level for inconsistency. Conversely, we had no reason to suspect issues related to imprecision. Finally, no elements are present to hypothesize the presence of a high risk of publication bias. Thus, the quality of evidence was rated as "very low" (Table III).

Discussion

To the authors' knowledge, this is the first systematic review investigating the relationship between dynamic balance and NS-LBP. This point is noteworthy and may help physiotherapists during their assessments, providing helpful insights regarding the planning of tailored rehabilitation programs valuable to improve the postural stability of the spine.

Table III.—*Summary of findings: quality of evidence based on GRADE criteria.*

Outcome	Effect	N. of individuals (studies)	Comments	Quality of evidence
Presence of impaired dynamic balance in LBP	Most of the studies (15 out of the included 19 reported impaired dynamic balance performances in persons with LBP)	894 (19 studies)	Downgraded by one level for risk of bias Downgraded by one level for indirectness Downgraded by one level due to inconsistency	■□□□ Very low

LBP: low back pain.

Previous studies showed how balance is affected in individuals with NS-LBP, and a specific assessment was also recommended.[1-4] Nonetheless, a deeper insight into dynamic balance was missing.

Our findings showed that people with NS-LBP display balance issues, as confirmed by the differences frequently observed between people who have backache and those who have not.[20-38] The most involved individuals seem to be those with persistent complaints, probably due to the compromised performance of the lumbar tract.[20-38]

The subgroup analysis did not show any specific trend according to age, pain localization, pain intensity, implemented outcome measures or functional tests used to assess dynamic balance.

It is remarkable that all the included studies were of cross-sectional design. As such, no specific conclusions can be drawn on what leads to this association. In other terms, it is not possible to determine whether LBP causes an impaired dynamic balance, or vice-versa. Only further observational cohort studies might clarify this aspect.

The most widely used tests to evaluate the dynamic balance were dynamic posturography and SEBT, and COP sway being the most considered endpoint. In our review, the analysis of SEBT and COP sway offered crucial insights to better understand the dynamic balance in individuals with NS-LBP.[21-25, 27, 29, 30, 32-36, 38] Actually, these objective measures comprehensively assess both postural control and balance adaptations. Dynamic posturography evaluates postural stability and sway patterns, while SEBT provides information on dynamic balance by a reaching-distance task. As such, implementing both posturography and functional tests (*e.g.* SEBT, YBT) might be a useful clinical strategy to deepen the motor abilities (and relative deficits) in individuals with NS-LBP.

Clinical implications

As detailed above, no specific tendency was observed when some characteristics of the studies were taken into consideration (subgroup analysis). We expected to find positive correlations between an impaired dynamic balance and some of the sample characteristics such as pain intensity, pain duration and age of the participants. However, this hypothesis has not been confirmed. Although these findings deserve caution, a possible explanation could rely on the wide and various clinical presentations of NS-LBP. Actually, the term "non-specific" explains how challenging might be to find out a precise dysfunctional mechanism underlying the presence of pain, and treating it accordingly.

Although it seems difficult to identify the specific cause responsible for an impaired dynamic balance, some cues emerge from literature. For instance, it is known that balance in people with NS-LBP may be altered by flawed muscular reactions and shortfalls of trunk repositioning.[41] Balance is also influenced by altered inputs from peripheral sensitive receptors and, when a vicious circle between central and peripheral neuromotor mechanisms is activated,[42] persisting pain reinforces it.[2] In such a context, it becomes paramount for clinicians to perform a global physical assessment of the spine: muscle strength and elasticity, joint mobility, motor control, and lumbar proprioception are only a few examples of parameters that should be thoroughly evaluated, as they contribute to dynamic balance and subsequently, to postural stability.[43]

One of the included study[21] found a correlation between a poor dynamic balance and a higher pain catastrophizing, which is a maladaptive cognitive strategy commonly present to people with chronic NS-LBP: this aspect could be relevant for clinicians, as a recent analysis[44] highlights the importance of a multidisciplinary rehabilitation program including psychological interventions.[45]

Our findings also suggest how challenging is to provide a specific recommendation on which test could be better than the others to assess dynamic balance. As reported above, higher levels of methodological variability in the included studies prevented us from generalizing the results. Different contextual variables such as the propensity and the clinical background of the professionals, but also the setting of care with its economic resources, may result in determinants to address this clinical decision.

It is noteworthy that studies which implemented posturography and SEBT[21, 22, 24, 25, 30, 32-36, 38] were definitely prevalent (68%) compared to those which considered other tests.[20, 26, 28, 29, 31, 37] In fact, posturography resulted a reliable method to assess balance in people with LBP[46] and, although commonly used as a measure of static performance, our findings provide evidence for its application in the context of the dynamic abilities.[47] However, it should be noted how this examination cannot evaluate common ADL;[48] further, it requires relatively expensive instrumentation and qualified personnel to be properly implemented. On the other hand, SEBT provides useful clinical information such as targeted sway and leg displacements. Furthermore, it is a more reliable, easy-to-use and cost-effective test if compared to posturography;[49, 50] however, SEBT application is generally much more recent and more evidence is needed to consider it as a reference standard.[51-53]

Suggestions for research and healthcare policies

According to the results emerging from the current review, to date there is very-low quality evidence regarding the association between impaired balance and NS-LBP. The first step for future research might be the attempt to uncover the nature of such an association: is it "just" a correlation, is the pain leading to a balance impairment, or is the opposite true? Observational cohort studies might help to answer this fundamental question.

Secondly, the risk of bias suspected to be present in most of the included studies should be controlled by the implementation of strategies aimed to correctly manage the selection of the sample and the confounders.

Thirdly, it could be of interest to analyze the dynamic balance in NS-LBP people according to the temporal stage of the condition (*e.g.* acute, subacute, chronic), or even to correlate some characteristics of these individuals (posture, functional instability, muscle weakness or imbalance, spinal deformities, altered kinematics) with the balance performance.

Finally, there is an urgent need for clinometric studies aimed to identify specific tests and instruments to be considered as new reference standards for assessing balance in NS-LBP. Subsequently, responsiveness and interpretability for those tests would require investigations.

In conclusion, more coordinated and uniform research may lead to higher-quality evidence, helpful to inform healthcare systems about the importance of a global physical assessment of individuals with back complaints.

Quality of evidence

Due to the high level of methodological heterogeneity detected across the included studies, a meta-analysis was not applicable. Thus, it was not possible to rate the quality of evidence on the basis of a quantitative synthesis. However, it is methodologically feasible to judge the level of the evidence only considering the qualitative summary of the results.[54]

The included studies showed some methodological issues, mostly related to the selection of the participants and the management of confounders. Furthermore, a certain degree of indirectness and inconsistency is suspected to be present.

More in detail, the included studies differed in terms of population (age and pain levels) and outcome measures, as different methods of assessment were adopted. These two elements led us to downgrade for indirectness.

In addition, there was not a total agreement across the studies concerning the relationship between dynamic balance and LBP, although the large majority of them reported findings in favor of a positive association. For this reason, we downgraded the evidence for inconsistency.

As a consequence, the overall quality of evidence was rated as "very low" for the existence of a correlation between LBP and a poor dynamic balance.

Limitations of the study

Some limitations are present in this study and are worthy of being discussed.

Although NS-LBP often overlaps with the definition of chronic NS-LBP,[17] not always this distinction appears to be clear in the included studies, so that we cannot completely exclude a form of selection bias.

Despite the research question appearing to be clinically relevant, a wide heterogeneity in methods and protocols was detected, specifically concerning outcome measures and motor tasks implemented to assess dynamic balance. As such, the generalization of the findings became difficult, and conclusions should be drawn carefully. In addition, some records pertinent to the aim of the study might have escaped during the main search and the selection process.

As stated in the selection criteria, studies dealing with joint kinematics and gait analysis were excluded, though these are indicative parameters for dynamic balance.

Finally, as for all the systematic reviews, publication bias might be present; as known, there is no statistical tool completely valid to detect it.[55]

Conclusions

An impaired dynamic balance seems to be correlated to the presence of NS-LBP. However, due to the presence of methodological issues detected in the included studies, the quality of the evidence is very low and further confirmations are needed.

High-quality observational research is recommended, specifically aimed to investigate with standardized protocols the nature of the relationship between dynamic balance and NS-LBP. In this context, validity, easy-practicability and cost-effectiveness of the assessment modalities should be ulteriorly investigated.

All these points could be strategic to increase the quality of the evidence and to help clinicians in building more tailored rehabilitation programs for people with NS-LBP.

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Conflicts of interest
The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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Acknowledgements
To the tightrope walkers of (professional) life, who should firmly plant each step before considering the next.

History
Manuscript accepted: January 7, 2025. - Manuscript revised: September 20, 2024. - Manuscript received: December 19, 2023.

Supplementary data
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