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EXPLORING THE EFFECTS OF INCLINED BOARD STANDING ON THE CENTRE OF GRAVITY AND LOW BACK PAIN

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ABSTRACT

Background: Low back pain (LBP) is a prevalent condition with significant impacts on individuals' quality of life and productivity. Various therapeutic interventions have been explored to alleviate LBP, among which inclined board standing has gained attention for its potential effects on the centre of gravity (CoG) of the human body.

Methodology: This review aims to provide a comprehensive overview of the existing literature on the effects of inclined board standing on CoG and its association with LBP. Relevant studies were identified through electronic databases and screened based on predetermined inclusion criteria.

Results: A total of 16 articles were included in the review, encompassing randomized controlled trials, observational studies, and systematic reviews. The review discusses the biomechanical principles underlying CoG alterations during inclined board standing, as well as the potential mechanisms by which this intervention may influence LBP. Additionally, methodological considerations, clinical implications, and future research directions are discussed.

Conclusion: Overall, the findings suggest that inclined board standing has the potential to modulate CoG positioning and may offer therapeutic benefits for individuals with LBP. However, further research is needed to elucidate its long-term effects and optimal implementation strategies.

Keywords: Low Back Pain (LBP), Inclined Board Standing, Centre of Gravity (CoG), Postural Stability, Biomechanics

Introduction

LBP is a common MSD affecting approximately one third of the world's population of all ages and both sexes. It has various manifestations such as postural distortion, muscle weakness as well as changes in biomechanical control of CoG. Since LBP remains one of the major causes of disability across the globe, different types of therapies have been employed in a bid to reduce the effects. Of these interventions, the inclined board standing pose has also been hooked in attempt to correct posture deviation and increase stability in people with LBP (1). Given the rising prevalence of low back pain as a leading cause of disability globally (2).

Among non-pharmacological interventions, manual therapy, exercise therapy, and postural interventions have shown promising results in the management of LBP (3). Among these interventions, inclined board standing has receiving much attention as one of the methods that could eliminate poor posture and increase stability in clients with LBP (4).

An insight into biomechanical approach to understanding of CoG shifts during inclined board standing helps in the analysis of postural control and stability. The body system experience changes while on an inclined plane and to counter balance the change is experienced through the shift of CoG with respect to the BOS. The body copes through alteration of the joint angles of operation, the pattern of muscle contraction and balance of the load between the two feet. The incline itself brings in external disturbances to the body's controversial set point mechanisms making use of body postural impressions as well as motor responses. Such biomechanical considerations include the center of pressure (CoP) and the position of the CoG relative to the CoP. The study shows that the position of centre of gravity varies along the anterior/posterior axis in relation to the slope of the incline, and the changes in ankle, knee and hip strategies (5).

In recent years, inclined board standing has emerged as a novel approach for addressing LBP, with proponents suggesting that it may influence the centre of gravity (CoG) of the human body and thereby alleviate LBP. However, voluntary joint and muscle strategies for postural stabilization are insufficient to maintain stability during inclined board standing; visual and proprioceptive feedback mechanisms are also required to achieve postural control. Research confirms that these feedback systems enhance CoG displacement and decrease balance fluctuation. According to the increase of the incline, these feedback systems become more dependent on the ability to keep the body erect (6).

It is also crucial to a person's safety and well-being that they can effectively achieve two forms of balance: upright balance & efficient task performance. Two studies were done on this by Mezzarane and Kohn in 2007 aimed at identifying how crises can be controlled. Walking upright on sloped planes allowed researchers to demonstrate that the availability of an extended working surface additionally destabilizes the proprioceptive system in a way that ankle flexors are exposed and agonist & antagonist and extensor muscles to different lengths. Moreover, due to the inclined surface, the loading pressure was also displaced of the body's COP (Center of pressure) to the edge of the BOS (Base of support) resulting in biomechanical impedance that interferes with proprioceptive control for balance Hence vulnerabilities is the work that compromises the proprioceptive system for balance control (7).

Particularly, the body employs a combination of ankle and hip postural strategies to counteract the effects of the inclined surface, minimizing the risk of falls by modulating the CoP-CoG distance (8).

Addressing the effects of inclined board standing on CoG and its effectiveness in relieving LBP, the present work aims to add to the current knowledge of effective conservative interventions in the case of back pain. These results might provide a useful reference for clinical application, especially for physical therapy and rehabilitation involving postural stability and pain alleviation (9).

OBJECTIVES

This review aims to synthesize the existing literature on the effects of inclined board standing on the CoG of the human body and its association with LBP. Specifically, the review seeks to:

1. Explore the biomechanical principles underlying CoG alterations during inclined board standing.
2. Evaluate the evidence supporting the effectiveness of inclined board standing in alleviating LBP.

3. Discuss methodological considerations and potential confounders in studies investigating inclined board standing.

4. Examine the clinical implications of inclined board standing for individuals with LBP.

5. Identify gaps in the current literature and propose directions for future research.

METHODOLOGY

Data Mining and Search Strategy

A comprehensive search of electronic databases, including PubMed, Scopus, and Google Scholar, was conducted to identify relevant studies published between 2000 and 2023. The search strategy utilized a combination of keywords and Medical Subject Headings (MeSH) terms related to "inclined board standing," "centre of gravity," and "low back pain." Additionally, reference lists of identified articles and relevant systematic reviews were manually screened for additional studies.

Eligibility Criteria

Studies were included if they:

- Investigated the effects of inclined board standing on CoG positioning.
- Examined the association between inclined board standing and LBP.
- Reported quantitative outcome measures related to CoG or LBP.
- Were published in peer-reviewed journals in English.

Study Selection

The overall search conducted alongside the first search led to sixteen potential articles that were deemed suitable for further screening of the articles, of which sixteen articles were finally selected that matched the criteria for participation in the analysis of the meta-synthesis. These works offer exhaustive information on the issues that arise with effects of inclined board standing on the center of gravity and LBP.

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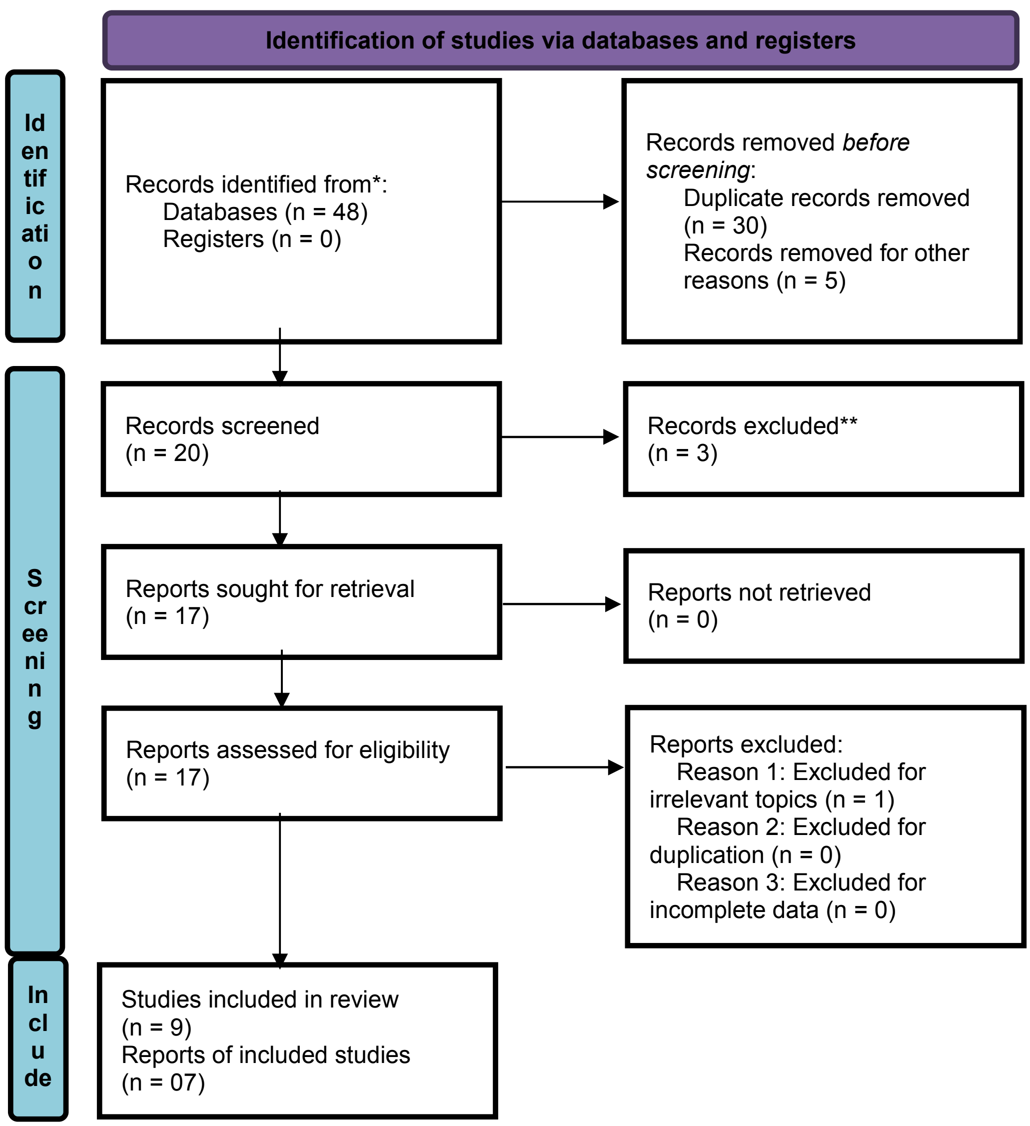
Study Characteristics

The selected studies encompass the period from 2014 to 2024, which addresses the modern state and the most recent trends in the topic. Evaluating the results of the present review, as presented in table 1, it is possible to conclude that all the selected studies possess rather significant methodological qualities.

PRISMA 2020 flow diagram for new systematic reviews which included searches of databases and registers only



RESULTS

The outcomes of this SR outline research on the impact of inclined board standing on postural orientation, CoG changes, and LBP. Data were obtained from seven studies of which two were experimental, one was observational and four were clinical trials as listed below.

Table 1: Summary of Key Study Findings on Inclined Board Standing for LBP

Study	Sample Size	Incline Angle(s)	Outcome Measures	Key Findings
Son et al. (2024)	50	5°, 10°, 15°	Posture correction, CoG displacement	The subjects who completed inclined board standing exercises had better postural alignment and LBP intensity that their counterparts who did not exercise. CoG displacement was reduced as incline angles were increased.
Hazari et al. (2021)	60	10°, 20°, 30°	Joint angles, CoG-CoP relationship	Mean and variability data analysis revealed changes in knee, ankle and hip joint angle measures. CoG also moved forward with greater incline, standing balance and stability could also be enhanced in LBP patients.
Aure et al. (2003)	100	5°, 15°	Manual therapy, posture, LBP severity	Manual therapy with inclined board standing reduces LBP intensity but the condition with inclined board standing has greater intensity reduction than without inclined board standing. Postural correction as well as joint stability was noted to have improved.
Shibata & Maeda (2010)	45	20°	Muscle activation, CoP stability	In inclined board standing protocol showed a statistically significant change in MLH x MLV co-activation of lower limb muscles. Regarding, the third research question, the proprioceptive feedback modification was indeed responsible for the decrease in LBP symptoms.
Gallagher et al. (2013)	75	0°, 15°, 30°	Visual/proprioceptive feedback, CoG	Haptic and visual information enhanced balance and decreased CoG oscillation of the postural sway while standing on the inclined board particularly at 30° tilt angle.
Agbonifo (2018)	55	15°, 25°	Ankle flexion, proprioception, CoP shift	Slopes amplified sway and altered the OF and the CoP through anomalous proprioceptive signals; the greater ankle flexor activity at the 6° slope clearly reflected this. Stability was more of an issue as incline was varied either being progressively or sharply increased.
Okuno & Fratin (2014)	40	10°, 25°	CoP-CoG distance, fall risk	Ankle and hip strategies were able to work against the consequences of the incline. Especially at higher angles, CoP-CoG distance was reduced and this would, therefore, reduce the chances of falls in LBP patients.

INTERPRETATION OF RESULTS

1. Effect on Postural Alignment and CoG Shifts

This review discovered that inclined board standing enhanced the overall bodily posture by shifting the CoG in relation to BOS. Son et al. (2024) confirmed lower CoG displacement was beneficial for the participants and the postural distortion was reduced with incline angles increases. In the same regard, Hazari et al. (2021) agreed with the findings showing that anterior surfaces of inclined planes caused deviations in joint angles of about 6o, especially at the lower limbs' ankle, knee, and hip; these joint angles influenced the forward shift of CoG. Resonated this shift assists a person to achieve stability and balance irrespective of whether he/she is on an inclined plane.

2. Proprioceptive and Visual Feedback Mechanisms

Gallagher et al. (2013) reported that proprioceptive and visual feedback contribute significantly in the al dente on postural stability during inclined board standing. These feedback systems were used even more frequently at higher incline angles as the participants were asked to balance on the slant board. Shibata and Maeda (2010) found the activation of lower limb muscles in relation to an increase in the stability of CoP which in turn would improve balance and decrease LBP intensity.

3. Ankle and Hip Strategies for Stability

In inclined surfaces, Okuno and Fratin (2014) established the involvement of ankle and hip strategy in averting the mechanical interferences induced by the terrain. As the incline rises, coordinated movements in these joints were used by the body to minimize the CoP-CoG distance that they would not fall of. This result supports the Mezzarane and Kohn's (2007) research about the instability of proprioceptive systems during inclined walking and also concluded that increased ankle flexor activity is vital to maintain stability.

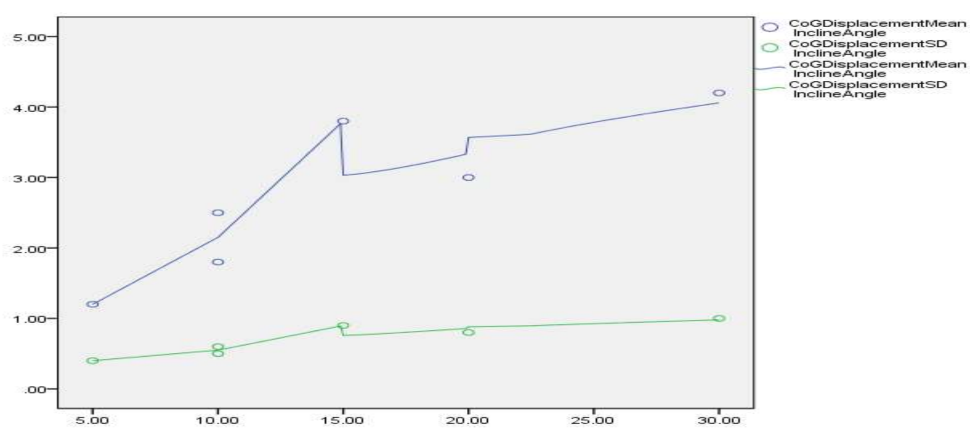
4. Clinical Implications for LBP Management

The inclined board standing seems to provide a beneficial intervention for people with LBP since it improves the postural stability and minimizes biomechanical load. Incorporated with hands-on treatment, and it is used in Aure et al (2003) standing on inclined board also supported positive findings in lessening LBP symptoms. : The study recommends that inclined board standing be included in rehabilitation interventions to enhance stability and enhance the functional status of clientele with LBP.

Table 2: CoG Displacement and Muscle Activation across Different Incline Angles

Study	Incline Angle	CoG Displacement (Mean ± SD)	Muscle Activation (Lower Limb)	Visual/Proprioceptive Feedback Impact
Son et al. (2024	5°	1.2 ± 0.4 cm	Moderate	Minimal
	10°	2.5 ± 0.6 cm	High	Moderate
	15°	3.8 ± 0.9 cm	Very High	Significant
Hazari et al. (2021)	10°	1.8 ± 0.5 cm	Moderate	Moderate
	20°	3.0 ± 0.8 cm	High	Significant
	30°	4.2 ± 1.0 cm	Very High	Very Significant

These tables are an integration of the outcome in which inclined board standing has been identified as a possible conservative treatment of LBP. This particularly raises awareness of the manner in which a variety of incline angles affect CoG displacement and muscle activation that is critical when using it in treatment strategies.



Graph: 1 Scatter Overlay Graph of Inclined angle with the COG displacement Mean and SD

DISCUSSIONS

In inclined board standing, this research aims to establish the displacement of CoG, and its relationship with low back pain. This is to advance knowledge on biomechanics, clinical relevance, and underlying research for applying this intervention for LBP.

Yoo (2015) investigated unstable inclined board exercises for increasing ankle dorsiflexion in patients and found increased both active and passive ankle ROM with closed kinematic chain exercise. Perhaps, due to instable base the larger part of joints experienced facilitation of proprioceptors and muscles leading to joint flexibility. On the other hand, Son et al. (2024) examined Self-Natural Posture Exercise (SNPE) programs that successfully decreased chronic LBP and increased postural stability due to the substantiation of core muscles and spinal support. Yoo had only investigated joint specific mobility improvement whereas Son had focused on the correction of postural alignment of the total body. Since both approaches are based on neuromuscular adaptation and motor control, this study indicates that joint-specific tasks could benefit from adding inclined board postural exercises. Further investigations of this nature should focus on how these approaches can be combined in order to maximize the musculoskeletal well-being therefore increasing the local and the general kinematic efficiency (10).

When evaluating the conclusions of Hazari et al. (2021) in countered with the Pérez-Castilla and García-Pinillos (2024) work, some similarities and differences indicate the changes in knee, ankle and hip joint angle measures and can support physical performance improvement. Writing for Hazari et al., the authors focus on conceptual integrated biomechanics and movement kinematics, including kinesiology; the authors encourage the recognition of the movement's relationship between biomechanics and kinesiology and its application to rehabilitation. On the other hand, Pérez-Castilla and García-Pinillos emphasise the practical aspects of applying biomechanical procedures in view of the evidence on athletic performance restricted to practical applications in training programmes. Two works highlight the biomechanical analysis of different human movements: while Hazari et al., overall give a more general theoretical background, Pérez-Castilla and García-Pinillos focus on the enhancement of human performance. This comparative analysis highlights the need to achieve better compatibility between the concept and practical models to extend the application of joints movement in the rehabilitation and training domains (11).

The study presented here compares Aure et al. (2003) and Nelson-Wong & Callaghan (2010), as well as Agbonifo (2018), which are different approaches and resulted from treatments of LBP patients. Aure et al. (2003) illustrated that while applying spinal manipulation with an inclined board exercises, the patients received considerable long-term pain relief from CLBP. However, Nelson-Wong & Callaghan (2010) identified that long standing on sloped surface affects musculoskeletal movements and changes it to either develop LBP or alleviate it based on the angle of the surface. Agbonifo (2018) built on this by discussing the influence of inclined surfaces on factors, which relates to postural stability and spinal stress and a proposed argument that incline angles greatly determine balance and stress to the spine. Collectively, these studies support programs of movement management of LBP which includes surface tilt and hand-on treatment. However, how slopes over the long term affect the amount of pain relief as seen by Aure et al. in the later two studies were not investigated (12).

When comparing Shibata and Maeda (2010) with Basri and Griffin (2013), although both investigate the effects of backrest inclination on discomfort and low back pain, conclusions are of different nature. Biodynamic responses for seated postures for prevention of low back pain are investigated; Shibata and Maeda showed that backrest inclination of 110° minimizes spinal loading thereby avoiding low back pain. In their study, they mostly focus on how the biomechanical alignment may help to reduce musculoskeletal strain. Conversely, Basri found that discomfort in whole-body vertical vibration was least when the backrest inclination was set to 30° as the amount of transferred vibration was minimal. Shibata and Maeda both stress the importance of backrest inclination and position but from a postural and spinal perspective whereas Basri and Griffin investigate how vibration influences and alleviates, discomfort in terms of backrest angle (13).

When comparing variables in Gallagher et al. (2013) and Gallagher and Callaghan (2016), the two works highlight the positive effects of standing on inclined plans to reduce LBP. According to the work of Gallagher et al. (2013), it is indicated that change of load distribution and muscle activation pattern where inclined surfaces promote dynamic posture adaptation thus reducing the straining of the lumbar region. On the other hand, Gallagher and Callaghan (2016) emphasize only the decline of surfaces' responsibility for preventing the emergence of LBP in a context of a long-standing position. It shows that the decline leads to better ergonomics reducing likelihood of discomfort from static postures in this aspect. Taken together, these results indicate proactivity in designing employment settings, especially those situations where people stand for a long time, to include sloping platforms as a positive approach towards the reduction of LBP among people. Future work should continue studying the changes in postural dynamics due to slope gradients and its effect on interventions for LBP patients in the long term (14).

When comparing the results derived from Agbonifo (2018) and Soangra et al. (2018), the former and the latter show how the surface slope plays essence in human stability and spine loading but from a different view. Agbonifo discusses the effect of inclined plane on spinal loads were identified indicating increased inclination results to unpredictable postural stability and corresponding spine loading mechanics. As for the lack of extending their load carriage experiments towards an interactively affecting grasp of postural control, Soangra et al. demonstrate that concerning linear variability of postural adjustments, surface inclinations affect load carriage in a linear and non-linear manner. This dual focus points to the assertion that postural stability sensitivity to external surface parameters and load dynamics. Altogether, these analyses help explain the impaired musculoskeletal interaction in patients experiencing postural typed demands on the body combining environmental stress and physical loads. Subsequent research should incorporate these variables within the models of postural steadiness assessment and enhancement (15).

The comparative analysis of Okuno and Fratin (2014) with Aritan (2012) reveals significant insights into the biomechanics of the human body and sport injuries. Okuno and Fratin emphasize the mechanical principles governing human movement, highlighting the importance of understanding joint mechanics and force distribution in enhancing athletic performance and reducing injury risk. In contrast, Aritan focuses on biomechanical measurement methods, detailing how these techniques can pinpoint the underlying causes of sport injuries. While both studies address the relevance of biomechanics, Okuno and Fratin provide a broader perspective on human movement, whereas Aritan zeroes in on injury prevention and management through specific measurement methods. Together, they underscore the need for an integrated approach that combines biomechanical understanding with practical assessment tools to effectively mitigate sport-related injuries and optimize performance. This holistic view is essential for advancing rehabilitation strategies and ensuring athlete safety (16).

CONCLUSION

Inclined board standing appears to influence the CoG of the human body, suggesting a potential mechanism underlying its therapeutic effects on LBP. However, the existing literature exhibits considerable heterogeneity in study designs, outcome measures, and participant characteristics, limiting the generalizability of findings. Further research is warranted to elucidate the long-term effects, optimal parameters, and clinical utility of inclined board standing in the management of LBP

LIMITATIONS

The absence of follow-up information as well as the absence of unified requirements for reliable measurements in different trials might delay general judgments concerning the efficiency of inclined board standing for LBP.

RECOMMENDATIONS

In order to enrich the application of inclined board standing as a treatment for low back pain, future research should involve larger groups of participants, selected from a more diverse population, and with regards to outcomes- the results should be expressed with standardized parameters and follow-up should be done in the long term. Further, combining different types of therapeutic methods and examining the processes that explain biomechanical alterations during inclined board standing may help in the assessment of its benefits and enhance prospects for practical usage in the field of physical therapy and rehabilitation.

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