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NARRATIVE REVIEW PAPER

Effectiveness of Core Stability and Balance Training on Postural Control in Children with Down Syndrome: A Narrative Review

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Abstract

Children with Down syndrome (DS) often experience reduced muscle tone, joint instability, and coordination challenges, which can affect their balance, movement, and physical independence. This narrative review examines the effectiveness of core stability and balance training in improving postural control. A literature search of EBSCOhost, ProQuest, and Google Scholar identified randomized controlled trials (RCTs) following PRISMA guidelines. Findings indicate that while both interventions enhance stability, core stability training leads to greater improvements in trunk control and neuromuscular coordination, resulting in superior reductions in anteroposterior and mediolateral sway. Balance training supports functional adaptation but may be less effective in activating deep postural muscles. However, variations in study protocols, intervention durations, and outcome measures present challenges in determining the most effective rehabilitation strategy. While emerging evidence suggests that combining approaches could further optimize results, questions remain about long-term retention and real-world implementation. Future research should explore structured, hybrid interventions that maximize postural improvements and functional mobility for children with DS. Identifying the most effective rehabilitation model could transform therapy programs and significantly enhance their quality of life.

Keywords: *Down syndrome, core stability training, balance training, postural control, rehabilitation*

Introduction

Down Syndrome (DS), caused by trisomy 21, affects about 1 in 700 live births globally (Beshay et al., 2019; Vandoni et al., 2023). Maternal age increases the risk, with older mothers more likely to have children with DS (Grieco et al., 2015). DS involves physical, motor, and cognitive impairments affecting development. Hypotonia, or low muscle tone, delays sitting, standing, and walking (Jain et al., 2021). Joint hypermobility and muscle weakness, especially in core muscles, impede postural control and balance (Horvat et al., 2016). These physical limitations hinder motor skills development, making core stability and balance interventions crucial for improving functional independence and motor performance in children with DS.

Cognitive impairments, including executive functioning, memory deficits, and sensory processing difficulties, exacerbate motor coordination issues in children with DS, hindering the acquisition of new motor skills (Schott & Holfelder, 2015; Alesi & Battaglia, 2019). These challenges limit learning and adapting to motor tasks, creating a cycle where motor delays worsen cognitive outcomes, and vice versa. Deficits in postural control, stemming from these impairments, increase fall risks and limit physical activity participation (Leite et al., 2018). Enhancing postural control is crucial for improving motor function, social engagement, and physical independence, ultimately boosting the quality of life for children with DS (Vandoni et al., 2023).

Core stability and balance training are key for improving motor function and independence in children with DS, who face challenges due to hypotonia and joint hypermobility, leading to poor postural control (Zulfiqar et al., 2022; Alsakhawi & Elshafey, 2019). These exercises target muscles around the spine and pel-

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vis, helping to compensate for low muscle tone and reduce strain on other body parts, enhancing motor function and coordination (Aly & Abonour, 2016). Strengthening these muscles improves trunk stability and provides a foundation for better movement, vital for fostering independence in daily activities (Rahmayanti et al., 2022). Balance training targets static and dynamic stability to reduce fall risks and improve motor performance (Kamatchi et al., 2022). Combining core stability and balance exercises enhances physical and motor improvements, boosting children's confidence and enabling greater participation in social activities (Cheema et al., 2023; Eid et al., 2017; Leite et al., 2018).The review aims to examine the effectiveness of core stability training and balance training in enhancing postural control and balance in children with DS, compares their benefits, and identifies research gaps for optimizing interventions. It provides evidence-based insights for rehabilitation specialists, educators, and policymakers to improve therapy programs and inclusive rehabilitation policies. This review refines rehabilitation strategies and enhances functional mobility and quality of life for children with DS.

Methods

This review examines the effects of core stability training and balance training on balance and postural control in children with DS. Studies were included based on comprehensive searches conducted on the EBSCOhost, ProQuest and Google Scholar databases using the keywords "Core Stability Training", "Balance Training", "Postural Control", and "Down Syndrome" with a time limitation between 2014 and 2024. The following Boolean operators were used to ensure a comprehensive capture of relevant literature: ((("Down Syndrome" AND "Core Stability Training" AND "Balance Training") OR ("Down Syndrome" AND "Postural Control" AND "Randomized Controlled Trial")). The article selection followed PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (Moher et al., 2009) and is shown in Figure 1.

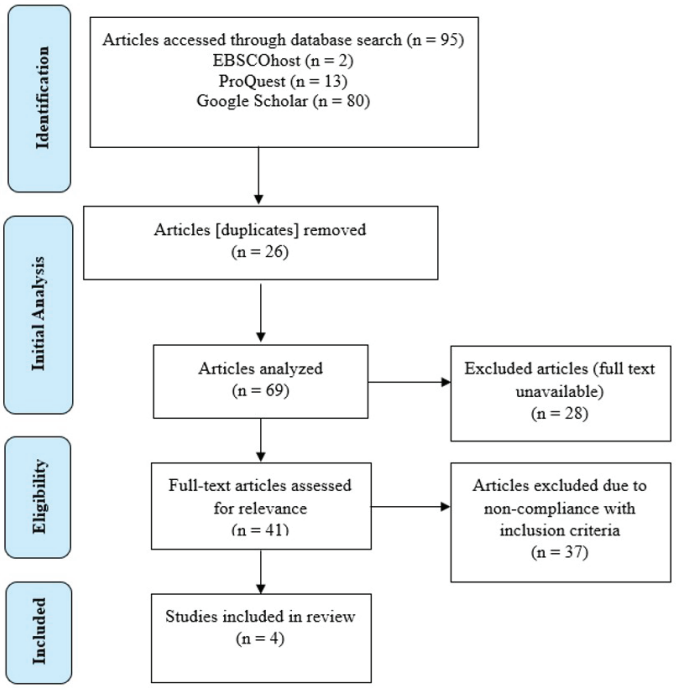

FIGURE 1. PRISMA flow chart of the article selection process

Inclusion Criteria

This review includes studies that investigate the effects of core stability exercises on balance and postural control in children with Down Syndrome, aged 4 to 17 years. Eligible studies must be randomized controlled trials (RCTs) or quasi-experimental designs with pre-test and post-test assessments, published in peer-reviewed journals from the year 2014 to 2024, and written in English. The intervention must involve a structured core stability exercise program lasting at least 6 weeks, with a minimum frequency of three sessions per week. Studies must compare core stability exercises with balance training, treadmill training, or conventional therapy, or include a control group. Outcome measures must assess balance and postural control using validated tools such as the Berg Balance Scale, Biodex Balance System, or Modified Stork Stand Test, with quantitative results reported. Studies lacking a clear intervention protocol, balance-related outcomes, or statistical comparisons will be excluded.

Exclusion Criteria

This review excludes studies that do not focus on children with Down Syndrome, specifically those involving adults or individuals with other neurological or musculoskeletal disorders that could impact balance training outcomes. Studies that primarily assess strength training without a balance component, general physical activity programs, or interventions that do not explicitly include core stability exercises are excluded. Research that lacks balance or postural control assessments using validated tools such as the Berg Balance Scale, Biodex Balance System, or Modified Stork Stand Test, or fails to report quantitative statistical analyses is also excluded. Additionally, review articles, case studies, opinion pieces, conference abstracts, and non-peer-reviewed publications are not considered to ensure the inclusion of high-quality evidence. Studies that fail to provide clear intervention protocols, pre-test and post-test assessments, or structured training regimens lasting at least six weeks with a minimum of three sessions per week are excluded. Finally, research that does not include a control group or a comparative intervention (e.g., balance training, treadmill training, or conventional therapy) is also excluded.

Results

Table 1 presents a summary of four randomized controlled trials (RCTs) that examined the effects of core stability training

Table 1. Study characteristics of core stability and balance training in Down Syndrome

Authors	Participant Age (Boys/Girls)	Domains/Focus	Duration and Frequency	Methodology	Salient Findings
Aly & Abonour (2016)	6-10 years (21 boys, 9 girls)	Core stability on postural stability	8 weeks, 3 sessions per week	RCT, 30 children, CST vs. conventional PT	Significant improvement in postural stability using core stability exercises
Alsakhawi & Elshafey (2019)	4-6 years (both sexes)	CST vs. treadmill training on balance	8 weeks, 3 sessions per week	RCT, 45 children, CST vs. treadmill training	Both CST and treadmill training improved balance, no significant difference
Ghaeeni et al. (2015)	8-13 years (10 boys, 6 girls)	CST on static balance	8 weeks, 3 sessions per week	RCT, 16 children, CST vs. control	67% improvement in static balance with core stability training
Zulfiqar et al. (2022)	5-17 years (12 boys, 8 girls)	CST vs.BT on postural control	6 weeks, 3 sessions per week	RCT, 20 children, CST vs. BT	CST showed better results than balance training for postural control

Note. CST: Core Stability Training; BT: Balance Training; RCT: Randomized Controlled Trial; PT: Physical Therapy

and balance training on postural control and balance in children with Down syndrome. The table outlines study characteristics, including participant demographics, intervention types, duration, frequency, assessment tools, and reported outcomes. The interventions varied, incorporating core stability training, balance training, treadmill training, or conventional physical therapy over six to eight weeks. Each study measured postural control and balance using standardized assessment methods, with results documenting changes in stability indices and balance scores across intervention groups.

Discussion

This review examined the effectiveness of core stability training and balance training in enhancing postural control among children with Down syndrome (DS). The primary objective was to compare the benefits of these interventions and identify research gaps that could optimize rehabilitation strategies. The collective findings from the reviewed studies highlight the potential of core stability training as a superior intervention for improving postural stability in this population.

Aly and Abonour (2016) demonstrated significant reductions in anteroposterior and mediolateral sway following an eight-week core stability intervention using the Biodex Balance System, emphasizing its neuromuscular benefits. Similarly, Ghaeeni et al. (2015) reported a 67% progress in static balance within the experimental group and an 84% superiority over the control group in post-test results, reinforcing the role of core training in enhancing postural control. Alsakhawi and Elshafey (2019) found that both core stability and treadmill training significantly improved balance compared to a control group, but there was no significant difference between the two interventions, suggesting that multimodal approaches may be viable alternatives. Zulfiqar et al. (2022) further substantiated the superiority of core stability exercises over traditional balance training for postural control improvements.

Despite these promising findings, several methodological limitations, variations in intervention protocols, and barriers to real-world implementation warrant further investigation. The following discussion critically evaluates these aspects, focusing on methodological considerations, comparative intervention analyses, and practical implications for rehabilitation and future research.

Methodological considerations and limitations

The findings of this review are influenced by several methodological factors, including variations in study designs, sample characteristics, and intervention protocols. While all included studies demonstrated significant improvements in postural control among children with Down syndrome (DS), differences in sample sizes, participant demographics, and training regimens introduce variability in reported outcomes.

Aly and Abonour (2016) included 30 children aged 6–10 years, excluding those with congenital heart defects, thereby limiting generalizability. In contrast, Alsakhawi and Elshafey (2019) recruited younger participants (ages 4–6), increasing internal validity but limiting applicability to higher-functioning children. Ghaeeni et al. (2015) relied on a smaller sample (n=16), raising concerns about statistical power. Zulfiqar et al. (2022) examined a wider age range (5–17 years), which provided developmental insights but introduced variability in balance capabilities. These disparities underscore the need for larger, stratified samples in future research to ensure broader applicability of findings.

Beyond methodological limitations, real-world barriers may hinder the implementation of core stability and balance training interventions. One major challenge is equipment accessibility. The use of specialized devices such as the Biodex Balance System (Aly & Abonour, 2016) or treadmill training (Alsakhawi & Elshafey, 2019) may not be feasible in all rehabilitation settings, particularly in low-resource environments. Furthermore, adherence to training protocols presents another challenge. Children with DS may require continuous supervision and reinforcement, making independent or home-based training difficult. Ghaeeni et al. (2015) emphasized the importance of structured sessions led by trained professionals, highlighting the need for parent and caregiver education to improve adherence. Additionally, participant variability in motor and cognitive abilities impacts intervention effectiveness. Some children may require modified exercise programs based on their functional level. Future research should explore adaptive training strategies that accommodate different abilities while maintaining intervention efficacy.

Comparative intervention analyses

The reviewed studies demonstrate that core stability training is more effective than traditional balance training in enhancing

postural control among children with DS. Aly and Abonour (2016) and Ghaeeni et al. (2015) reported significant improvements in static balance following core stability exercises, with reductions in anteroposterior and mediolateral sway. Alsakhawi and Elshafey (2019) and Zulfiqar et al. (2022) provided comparative analyses, revealing that core stability exercises offer superior postural control benefits compared to traditional balance training alone.

While the efficacy of core stability training is well-documented, the underlying mechanisms require further exploration. Core stability exercises target deep trunk stabilizers, such as the transversus abdominis and multifidus, enhancing neuromuscular coordination and proprioceptive feedback. Aly and Abonour (2016) attributed improvements in balance to increased spinal stability and enhanced sensory-motor integration. Similarly, Ghaeeni et al. (2015) noted an 84% improvement in static balance, suggesting that enhanced core endurance and trunk control are critical factors in postural adjustments. These findings align with the motor control theory, which posits that strengthening deep postural muscles leads to improved movement efficiency and stability (Brugnaro et al., 2020).

One critical gap in the literature is the long-term sustainability of core stability and balance training benefits. While Zulfiqar et al. (2022) demonstrated greater short-term gains in postural control with core stability training, the review does not provide insight into whether these improvements persist over time. Traditional balance training focuses on task-specific postural adjustments, whereas core stability training may induce neuromuscular adaptations that promote sustained balance improvements. Future longitudinal studies should examine the retention of benefits beyond structured interventions and explore whether hybrid approaches, such as integrating treadmill training, yield superior long-term outcomes.

Practical implications for rehabilitation and future research

The collective evidence supports the integration of core stability training into rehabilitation programs for children with DS. Given its demonstrated effectiveness in improving postural control, therapists should consider incorporating progressive core stability exercises as part of standard treatment protocols. However, intervention strategies must be tailored based on individual motor and cognitive abilities to ensure optimal outcomes.

To maximize the real-world impact of these findings, strategies for practical implementation must be considered. While structured therapy sessions provide an ideal environment for supervised training, home-based programs are essential for maintaining consistency. Alsakhawi and Elshafey (2019) suggested that treadmill training is a viable alternative, but simple home-based core stability exercises, such as Swiss ball training and functional movement drills, can offer similar benefits. Caregiver involvement is crucial in ensuring adherence, and structured instructional materials (e.g., exercise guides, video demonstrations) can enhance program effectiveness. Additionally, modifications based on available resources, such as using stable household objects for balance training, may improve accessibility.

Despite promising findings, several areas require further investigation to strengthen the evidence on core stability training for children with Down syndrome. One key area is the long-term retention of balance improvements, as it remains unclear whether postural stability gains persist beyond structured interventions. Exploring hybrid approaches that integrate core stability training with treadmill-based programs could also provide insights into optimizing rehabilitation strategies. Additionally, standardizing training protocols by establishing uniform guidelines for intensity, duration, and exercise progression would enhance consistency across studies. Finally, recruiting larger and more diverse participant groups is essential to improve the generalizability of findings and identify potential subgroup differences in response to training.

Conclusion

The findings of this review indicate that core stability training is a more effective intervention than traditional balance training for improving postural control in children with DS, primarily due to its superior influence on neuromuscular adaptation and trunk stabilization. Compared to balance training, core stability exercises consistently demonstrated greater improvements in anteroposterior and mediolateral sway, reinforcing their role in enhancing postural control. However, real-world implementation remains challenging, with barriers such as limited equipment accessibility, the need for supervision, and adherence to home-based programs requiring further attention. Future research should assess whether postural control gains from core stability training persist long-term. Evaluating hybrid approaches that combine core stability with treadmill or balance training may enhance rehabilitation outcomes. Standardizing protocols and increasing participant diversity will strengthen clinical applicability and generalizability. Addressing these gaps will improve rehabilitation effectiveness and motor outcomes for children with DS.

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Conflict of Interest

The authors declare no conflicts of interest associated with this study.

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