

Effect Of Core Stability Exercises By Using Swiss Ball On Balance And Core Muscle Strength In Children With Down Syndrome

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ABSTRACT

Background: Children with Down syndrome experience significant motor and balance impairments due to hypotonia, muscle weakness, and structural brain differences, limiting their ability to perform daily activities. Core stability exercises are known to enhance postural control and functional mobility, but there is limited research exploring their effects using a Swiss ball in this population.

Objectives: This study aimed to evaluate the effect of core stability exercises using a Swiss ball on balance and core muscle strength in children with Down syndrome.

Methodology: Thirty children aged 8–12 years with Pediatric Balance Scale scores between 21 and 40 were included in the study. Participants underwent 15 sessions of core stability exercises using a Swiss ball, with pre and post intervention assessments of dynamic balance (Timed Up and Go Test), static balance (Standing Stork Test), and core strength (Pressure Biofeedback Unit). Statistical analysis was conducted using paired t-tests and Wilcoxon Signed Rank tests, with significance set at $p < 0.05$.

Results: Significant improvements were observed across all outcome measures post-intervention. The Timed Up and Go Test scores improved from 15.62 ± 3.726 seconds to 12.97 ± 3.590 seconds ($p < 0.01$). Standing Stork Test scores increased from 2.07 ± 1.067 seconds to 3.17 ± 1.256 seconds ($p < 0.01$). Pressure Biofeedback scores improved from 1.17 ± 1.037 units to 2.24 ± 0.988 units ($p < 0.01$).

Conclusion: The findings of present study support the inclusion of Swiss ball exercises in physiotherapy programs to enhance functional mobility and reduce the risk of falls in the children with Down Syndrome.

Keywords: Down syndrome, core stability exercises, Swiss ball, balance, motor skills, postural control.

1. INTRODUCTION

A congenital, genetic condition called Down syndrome (DS) is brought on by having an extra copy of chromosome 21, either partial or whole. The brainstem of children with DS are smaller and the cerebellar development is delayed. When compared to their peers who are usually developing, these youngsters have motor disturbances and a lower ability for balance because of a lack of training programs and limited motor experience.¹

Negative factors impacting balance functions include muscle weakness, restricted range of motion, ataxia, and altered muscle tone.²

Children with down syndrome demonstrate many musculoskeletal problems. Due to hypotonia, ligamentous laxity, co-contraction of agonist and antagonist muscles, balance and postural abnormalities, and DS, children exhibit motor impairment (Aruin et al., 1996). These deficiencies may cause children with DS to fail to achieve their motor developmental milestones and limit their ability to move around in an antigravity situation (Shumway-Cook and Woollacott, 1985). Children with Down syndrome are more likely to have postural dysfunctions, which are linked to issues with proprioception, motor coordination, sensory-motor integration, and reaction time for anticipatory postural corrections³

Previous studies have found a strong and favorable link between balance issues and muscle weakening. Children with Down syndrome who have weak muscles have difficulty standing upright and are more likely to fall. The core muscles are essential for maintaining an upright and stable posture. A strong core helps children maintain proper alignment of the spine and pelvis, which is necessary for good posture and balance.

In a study conducted by Tama Anugrah et al. on DS children it was found that there is a positive Pearson correlation of 0.710 between dynamic body balance and the endurance of core muscles in children with Down Syndrome.⁴

The abdominal muscles create the anterior section of the core stability area, the spine and gluteal muscles form the posterior section, the diaphragm muscle makes the roof, and the pelvic girdle muscles form the floor.² The lumbar vertebrae are supported by the central stability muscular system throughout the range of motion, and trunk muscles and ligaments contribute to overall body control and stability through their physiological function. For dynamic balance, the lumbar, abdominal, and thigh muscles work in close coordination.

When a person moves, the transverse abdominal (TVA) muscle is the first to contract. Hodges and Richardson noted that the trunk muscles contract before the lower extremities do, causing the spine to stiffen and laying the foundation for functional motions. They also discovered that the TVA is the first muscle to activate before actual limb movement, and that the CNS exploited this pre programmed activation of the TVA as part of a strategy to regulate spinal stability.⁵

The body has two ways to preserve its stability when the posture is disturbed, namely compensatory postural adjustments and anticipatory postural adjustments.

According to studies, feed-forward and feedback systems both contribute to improved postural adjustments in unstable situations. Thus, by making the body's balance more difficult, practicing on an unstable surface like Swiss ball can help these two strategies and enhance trunk balance.⁶

Numerous earlier research has found that muscular activity can be increased with the use of strengthening activities, such as trunk stabilization exercises. According to the literature, limited studies have investigated the effect of Swiss ball exercises for improving core stability to improve the balance of children with down syndrome. Previous studies have mostly concentrated on the therapeutic effects Swiss ball training on the child's balance.

Swiss ball stabilization technique enhances the awareness of trunk position while strengthening and activating the muscles that support the trunk. In addition, exercising on a Swiss ball's irregular surface enables the trunk muscles to simultaneously stretch and shorten in reaction to gravity, enabling the lateral flexors and trunk rotators and enhancing trunk control.⁶

It also has facilitating effects of the vestibular system on the postural muscles of the trunk and limbs, as these effects on the muscles can improve the dynamic and static balance of the trunk. Exercises performed on a Swiss ball have a higher potential for trunk muscle activation than those performed on a plinth because the movement of the ball beneath the participants causes a postural perturbation that the muscles must adapt to in order to maintain the desired posture.⁷

Thus, current study was planned to determine the effectiveness of core stability exercises by using Swiss ball on Pressure biofeedback, standing stork test, four square step test, and timed up and go test of children with Down syndrome.

2. MATERIALS & METHOD

This experimental study was conducted at Pimpri, Pune. Sample size was 30. Individuals were screened and those who have fulfilled the inclusion and exclusion criteria were selected in the study using convenient sampling. 52 individuals were screened out of which 29 willingly participated in the study and given the consent in the study.

Participants were included only if they are diagnosed with Down syndrome, Individual willing to participate, Age group: - 8 to 12 Years , with paediatric balance score 21-40 and IQ more than 50-70⁸ and excluded if children had any recent cardiac comorbidity, subluxation of the upper and lower limbs and any visual and hearing deficits and with a history of orthopedic surgery.

Outcome measures included core strength assessment using the PBU, where pressure changes between 2–4 mmHg were considered normal. Balance was evaluated using the Standing Stork Test, which recorded the best of three attempts for maintaining a single-leg stance. Functional mobility was assessed through the modified Timed Up and Go (TUG) test, which measured the time taken to rise from a chair, walk three meters, turn, return, and sit.

3. PROCEDURE

After approval from the ethical committee. CTRI registration was done. Researcher received CTRI number of CTRI/2024/04/065989. Written informed consent was provided by the parents or guardians of subjects who met the inclusion criteria. After explaining the study procedure, demographic data were collected, and a pre-assessment of outcome measures, including the Pressure Biofeedback Unit (PBU), Standing Stork Test, and Timed Up and Go (TUG) Test, was conducted. The participants then underwent core stability exercises using a Swiss ball. This intervention was carried out over 15 sessions. Following the completion of the sessions, all subjects were reassessed for the same outcome measures to evaluate the effectiveness of the treatment.

Treatment was given for 15 sessions and 30 minutes in each session. Every participant used a Swiss ball in prone, supine, sitting, and quadruped positions to do exercises that incorporated specific motions of the upper and lower trunk. Every session started with a warm-up, moved on to focused exercises, and ended with a cool-down.

Both the warm-up and cool-down phases involved static stretching of the lower limb muscles (hip flexors, hamstrings, cuff muscles, and adductor muscles). Each muscle area received five repeats of stretching for 30 seconds. Based on the child's ability, the physiotherapist chose the exercises' frequency and rest periods. During the training, the therapist supports the child to prevent falls. Table 1 describes the details of exercises to be given.⁶

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Table 1: Core exercise on Swiss ball

POSTURE	EXERCISE CONTENT
Sup	Bridge on Swiss ball
	flexion rotation of the upper trunk on a Swiss ball with the feet flat on the support surface
	Rotation of the lower trunk with the Swiss ball was placed under the knees Progression: Unilateral bridge on Swiss ball
Prone	Hip extension on Swiss ball
	Progression: Back extension on Swiss ball
Quadruped	Lifting 1 arm in bird dog position on the Swiss ball
	Lifting 1 leg in bird dog position on the Swiss ball
Sitting	Trunk flexion
	Trunk extension
	Bounce on the Swiss ball
	Upper trunk rotation
	Lower trunk rotation
	Progression: Trunk lateral flexion Standing
	Weight shifting on the Swiss ball

4. RESULTS

29 subjects participated in the study. After checking the normality, paired t test was applied for Timed up and go test, is applied for Pre and post group analysis, whereas Wilcoxon Signed Rank Test was applied for the pressure biofeedback and Standing stork test for pre and post values as the data was not normally distributed.

Table 1: Baseline characteristics of patients (n = 29)

Variables	mean± SD
Age (in years)	10.3 ± 1.61
Gender	Male= 19 Female = 10
PBS	36.13 ± 3.86

Table 2: . Pre and Post comparison of TUG, Standing stork test and pressure biofeedback using paired t test for TUG and Wilcoxon test based on normality.

Outcome. Measures	Pre (Mean±SD)	Post (Mean±SD)	T/Z value	Effect size	P. value
TUG	15.62±3.726	12.97±3.590	T= 9.14	-1.70	< .001
Standing stork test	2.07± 1.067	3.17± 1.256	Z=4.355	1.43	< .001
Pressure Biofeedback	1.17±1.037	2.24±0.988	Z=4.519	1.52	< .001

SD: standard deviation; TUG: Timed up and Go test; T:paired sample t-test; Z: Wilcoxon test.

5. DISCUSSION

Compared to children who are typically growing, children with Down syndrome exhibit a significant delay in their developmental skills. In addition to a delay in central and peripheral neuronal myelination, the delay is caused by anatomical changes in the brain, such as a decrease in the amount of grey and white matter in the cerebellum, frontal lobes, parietal lobes, corpus callosum, and hippocampus. Children and adolescents with Down syndrome experience a variety of neuromuscular and musculoskeletal abnormalities as a result of these structural alterations.⁹

The literature states that children with Down syndrome who are 8 years old chronologically appear at a developmental age of 4 years, and that no kid under the age of 6 develops 100% of the motor functions on GMFM.¹⁰

The aim of this study was to determine the effect of core stability exercises using a Swiss ball on balance and core muscle strength in children with Down syndrome having Pediatric Balance scale scores between 21-40. The findings demonstrated significant improvements in Timed Up and Go Test, Modified Standing Stork Test, and Pressure Biofeedback, indicating the effectiveness of the intervention. These results are supported by existing literature and provide insights into the mechanisms behind these changes.

The reduction in TUG scores from 15.62 seconds pre-intervention to 12.97 seconds post-intervention ($p < 0.01$) reflects improved dynamic balance, mobility, and functional ability. Core stability is essential for coordinated movements that require the integration of upper and lower body actions, such as standing up and walking. Poor balance of the body leads to a large postural sway. Studies show that the worse the ability to balance the body, the greater the postural sway experienced by children with intellectual disabilities.¹¹

A study by Aly and Abonour (2016) demonstrated that eight weeks of core stability exercises significantly improved postural stability and balance in children with Down syndrome. The intervention led to notable decreases in anteroposterior, mediolateral, and overall stability indices post-treatment compared to pre-treatment measurements. The authors concluded that core stability exercises should be an integral component of rehabilitation programs for children with Down syndrome.¹²

According to Malak et al., children with Down syndrome found it most difficult to perform standing and walking because their flexor and extensor muscle groups, which are necessary for maintaining balance, were not sufficiently contracted.¹³

The increase in Modified Standing Stork Test scores from 2.07 seconds to 3.17 seconds ($p < 0.01$) highlights improved static

balance. This test primarily measures the ability to maintain a single-leg stance, which depends on postural control and core strength. Children with DS often struggle with static balance due to hypotonia and joint laxity, which compromise their ability to stabilize the body.

The use of a Swiss ball likely challenged the participants' postural control mechanisms, leading to neuromuscular adaptations. Research has shown that core stability exercises can effectively enhance static balance in children with Down syndrome. Ebrahimi et al. (2015) conducted an eight-week core stability training program, which led to a notable 67% improvement in static balance, as assessed using the modified stork stand test.²

Sayadinezhad et al. (2013) found that progressive resistance training enhances balance in children with Down syndrome. This aligns with the findings of the present study, highlighting the role of muscle strength in balance improvement. The inclusion of weight-bearing exercises in this study's training protocol suggests that elements of progressive resistance training may have contributed to the observed balance gains.¹⁴

Additionally, the Swiss ball's instability may have encouraged co-contraction of agonist and antagonist muscles, promoting joint stability and improving single-leg balance. The research conducted by Hesari et al. showed that 8 weeks of core stability training improves static balance of students with hearing impairments.¹⁵

Through the development of strength and endurance in the superficial and deep muscles of the core stabilization area, this study demonstrated that core stability exercises improve the static balance of children with Down syndrome. The integration of proprioceptive data brought on by closed chain motions is most likely the mechanism underlying this effect.

This integration improves proprioceptive activity in the tendons and joints while simultaneously decreasing the shear force of the joints.

Additionally, core stability exercises improve the body's balancing mechanism since proprioceptive senses provide information to the central nervous system, which helps maintain balance.¹⁶

According to research Swiss ball exercises in children with cerebral palsy has shown improvement in TCMS scores which could be due to the stimulation of the **vestibular system**, which plays a crucial role in **postural control**.⁶ The activation of the vestibular system enhances the engagement of **postural muscles** in both the **trunk and limbs**, leading to **better coordination, stability, and balance**. This neuromuscular response helps improve both **dynamic and static balance**, reinforcing the effectiveness of Swiss ball exercises in enhancing postural stability.¹⁷

The Pressure Biofeedback scores increased from 1.17 to 2.24 units post-intervention ($p < 0.01$), indicating significant improvement in core muscle strength. Core muscles, including the transversus abdominis, multifidus, and pelvic floor, are essential for spinal stability and overall functional performance.

Swiss ball exercises inherently demand the engagement of deep core muscles to maintain balance on an unstable surface. Research has demonstrated that, in comparison to other abdominal muscular strengthening exercises, the classic curl-up and ball exercise can produce greater activation of the rectus abdominis muscle. The initial 30° to 45° of trunk flexion is controlled by the rectus abdominis muscle. Escamilla et al. (2006) discovered that the rectus abdominis was 50% activated and the external oblique was 16% activated, while Konrad et al. (2010) discovered that the rectus abdominis was 51% activated and the external oblique was 28% activated.^{18,19,20}

Downs syndrome individuals also show delay in reaction time and equilibrium reactions. Also have decreased level of motor coordination, balance and sensory integration.²¹ Also another study done by **Mori A** et al with Electromyographic activity of selected trunk muscles during stabilization exercises using a gym Ball. The results of this study demonstrated, Lifting up of the pelvis in a bridged position exercise, supporting the head with the gym Ball and with the feet on the Floor in supine position, resulted in higher muscle activity of the back extensor muscles than another exercise.²²

6. CONCLUSION

In this study Core stability exercises on Swiss ball have shown significant improvements in core strength and on Balance. Hence, Core stability exercises using Swiss ball can be used as one of the strategies to improve static and dynamic balance. It can promote more beneficial effects when given along with conventional physiotherapy treatment.

Core stability exercises using Swiss ball can core strength and thereby improving balance and thus help in improving activities of daily living.

REFERENCES

- [1] Alsakhawi RS, Elshafey MA. Effect of Core Stability Exercises and Treadmill Training on Balance in Children with Down Syndrome: Randomized Controlled Trial. *Adv Ther.* 2019 Sep;36(9):2364-2373. doi: 10.1007/s12325-019-01024-2. Epub 2019 Jul 12. PMID: 31301057.
- [2] Ghaeeni S, Bahari Z, Khazaei AA. Effect of core stability training on static balance of the children with Down

- syndrome. *Physical Treatments-Specific Physical Therapy Journal*. 2015 Apr 10;5(1):49-54.
- [3] Eid MA, Aly SM, Huneif MA, Ismail DK. Effect of isokinetic training on muscle strength and postural balance in children with Down's syndrome. *Int J Rehabil Res*. 2017 Jun;40(2):127-133. doi: 10.1097/MRR.0000000000000218. PMID: 28146007.
- [4] Anugrah T, Sumaryanti S, Simatupang N, Sutapa P, Ambardini RL, Nugroho S. The relationship of dynamic body balance with locomotor ability and endurance of core muscles in children with down syndrome. *Journal of Kinesiology and Exercise Sciences*. 2023 Apr 12;33(102):1-8.
- [5] The effects of a five-week core stabilization-training program on dynamic balance in tennis athletes.
- [6] Rastgar Koutenaie F, Noorizadeh Dehkordi S, Amini M, ShahAli S. Effect of Swiss Ball Stabilization Training on Trunk Control, Abdominal Muscle Thickness, Balance, and Motor Skills of Children With Spastic Cerebral Palsy: A Randomized, Superiority Trial. *Arch Phys Med Rehabil*. 2023 Jul 12:S0003-9993(23)00345-3. doi: 10.1016/j.apmr.2023.05.011. Epub ahead of print. PMID: 37442218.
- [7] Karthikbabu S, Nayak A, Vijayakumar K, Misri Z, Suresh B, Ganesan S, Joshua AM. Comparison of physio ball and plinth trunk exercises regimens on trunk control and functional balance in patients with acute stroke: a pilot randomized controlled trial. *Clin Rehabil*. 2011 Aug;25(8):709-19. doi: 10.1177/0269215510397393. Epub 2011 Apr 19. PMID: 21504955.
- [8] Kłosowska A, Kuchta A, Ćwiklińska A, Sałaga-Zaleska K, Jankowski M, Kłosowski P, et al. Relationship between growth and intelligence quotient in children with Down syndrome. *Transl Pediatr*. 2022 Apr;11(4):505–13.
- [9] Jain PD, Nayak A, Karnad SD, Doctor KN. Gross motor dysfunction and balance impairments in children and adolescents with Down syndrome: a systematic review. *Clin Exp Pediatr*. 2021 Jun 11;65(3):142–9.
- [10] van Gameren-Oosterom HBM, Fekkes M, Buitendijk SE, Mohangoo AD, Bruil J, Van Wouwe JP. Development, Problem Behavior, and Quality of Life in a Population Based Sample of Eight-Year-Old Children with Down Syndrome. *PLoS ONE*. 2011 Jul 21;6(7):e21879.
- [11] Lipowicz, A., Bugdol, M. N., Szurmik, T., Bilbrowicz, K., Kurzeja, P., & Mitas, A. W. Body balance analysis of children and youth with intellectual disabilities. *Journal of Intellectual Disability Research*. 2019; 63(11): 1312–1323. <https://doi.org/10.1111/jir.12671>.
- [12] Aly SM, Abonour AA. Effect of core stability exercise on postural stability in children with Down syndrome. 2016;
- [13] Malak R, Kostiukow A, Krawczyk-Wasielewska A, Mojs E, Samborski W. Delays in Motor Development in Children with Down Syndrome. *Med Sci Monit Int Med J Exp Clin Res*. 2015 Jul 1;21:1904–10.
- [14] Sayadinezhad T, Abdolvahab M, Akbarfahimi M, Jalili M, Rafiee SH, Baghestani AR. [The study of the effect of progressive resistance training on functional balance of 8-12 years old children with Down syndrome (Persian)]. *Journal of Modern Rehabilitation*. 2013; 7(1):29-34.
- [15] Hesari F, Daneshmandi H, Mahdavi S. [Effect of eight weeks core stability training on balance of students with hearing disabilities (Persian)]. *Sports Medicine (Harekat)*. 2010; 7:67-83.
- [16] Cug M, Ak E, Ozdemir RA, Feza-Korkusuz F, Behm DG. The effect of instability training on knee joint proprioception and core strength. *Journal of Sports Science and Medicine*. 2012; 11(3):468-74.
- [17] Kim D-E, Lee E-J, Kim J-S, Chang W-N, Lim S-K. Effect of exercise on static and dynamic balance in children with cerebral palsy using a Swiss ball: a case report. *Age (years)* 2017;8:5–29.
- [18] Sakhawalkar S, Paldhikar S, Chitre D, Ghodey S. Swiss ball training verses stable surface training on functional performance in ambulatory cerebral palsy. *J Dent Med Sci*. 2017;16:135-41.
- [19] White and Punjabi : *Biomechanics of spine* 2nd edition ISBN 0-397-507208 1990 ,J.B. Lippincott Company
- [20] CAROL OATIS : *KINESIOLOGY : The path mechanics and normal mechanics of human movement* 2nd edition Copyright © 2009, 2004 Lippincott Williams & Wilkins, a Wolters ,Kluwer business
- [21] EFFECT OF PILATES ON CARDIO-RESPIRATORY FUNCTIONS IN CHILDREN WITH DOWNS SYNDROME, Pranjali Chavan, Dr. Vidhi Shah, Sneha Chavan *INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH : Volume-11 | Issue-1 | January-2022*
- [22] Cynthia norkins : *Joint structure and Function* Section 5 chapter 13 ,5th edition Copyright © 2011 by F. A. Davis Company