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Core Stability Training and Child-Centered Play Therapy contribute to Static and Dynamic Balance Improvement; a Randomized Comparative Clinical Trial in Female Deaf Children

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Abstract

Background

Poor postural control in children increases the likelihood of falls, motor skill impairments, academic difficulties, and social consequences. Additionally, hearing-impaired children experience balance and coordination issues, which affect their sensory integration, communication, and overall physical development. Regarding the non-invasive/non-pharmacological effects of exercise training, we aimed to investigate the effects of Core Stability Training (CST) and Child-Centered Play Therapy (CCPT) on the static and dynamic balance of deaf children.

Methods

Thirty-six deaf female students, aged 10 to 15 years, participated and were randomly assigned to one of three groups (n = 12/group): CCPT, CST, or control. Both interventions were conducted for a total time of eight weeks. The Balance Error Scoring System (BESS) and Time Up & Go (TUG) tests were utilized to measure static and dynamic balances prior to and following the training protocol (pre- and post-testing). Data were analyzed using paired T-tests (between groups), ANOVA (within groups), and Bonferroni (post-hoc test) at a significant level of $P < 0.05$.

Results

According to the results of ANOVA, both training protocols were able to improve Standing with one foot on a hard surface ($P = 0.001$), Standing with one foot on a soft surface ($P = 0.001$), Standing tandem on a hard surface ($P = 0.001$), Standing tandem on a soft surface ($P = 0.001$) and Dynamic Balance ($P = 0.001$) compared to the control group. Furthermore, CST showed the most significant impact on improvement of both static and dynamic balance ($P < 0.05$). This study highlights the effectiveness of both therapies in improving balance in deaf youngsters.

Conclusion

It is suggested that CST offers focused approach to muscle strength and stability and CCPT provides comprehensive improvements in sensory integration and motor coordination both of which are crucial for maintaining postural control in static environments.

1. Introduction

Children with hearing disability are profoundly affected in communication and social integration, frequently arising from hereditary factors, birth complications, or inner ear disorders (1). Hearing impairment can hinder personality development and adversely affect overall health, leading to atypical

physical behaviors, particularly in coordination and balance (2). Approximately 80% of deaf individuals experience difficulties in situations with poor lighting, which affects their mobility and stability (3). Additionally, deaf children demonstrate inferior dynamic balance and reduced physical fitness compared to their hearing counterparts (4, 5).

Postural control is essential for deaf children as it facilitates sensory integration, communication, safety, academic concentration, motor skills development, and general physical growth; A robust balance facilitates interaction, learning, and safety by incorporating sensory stimuli and augmenting social engagement and physical activity (6–8) that needs an intricate connection between sensory receptors and appropriate motor responses for postural control (6). The deaf population requires body positions that maintain stability and orientation, which is essential for skills that require symmetrical alignment in both gross and fine motor control (9). This is accomplished through synchronized muscle contractions and sensory feedback (9, 10).

In this respect, stability training, as a non-invasive and non-pharmacological approach, has been highly recommended as an effective therapeutic strategy for vestibular system problems and balance concerns in deaf children (11). Core stability training (CST) is a systematic core-base physical training program designed to strengthen the deep musculature that stabilizes the spine, pelvis, and hips and improve the coordination, endurance, proprioception and neuromuscular control of the core musculature which aids in motor control, and the vestibular system interprets spatial information to promote postural balance through its subset exercises, including planks, bridges, and abdominal crunches (12, 13). In this regard, Hedayatjoo et al. (2020) reported that a 12-session balance and vestibular sensory motor exercise program improved the static balance capabilities of deaf children (14). Likewise, Zarei et al. (2023) compared the effects of chronic (8 weeks) CST and proprioception training on the gait test of deaf adolescents and reported an improvement in stride length, Stride time, stance time, and swing time in the CST training group compared to the control group (15). Also, Tarighi et al (2023) compared the chronic (8 weeks) effects of dynamic and static core stability training on deaf students; these authors reported that both training protocols significantly improve lower extremities strength, leading to stabilization of the spine and pelvis, as well as decreasing risk and probable injuries in deaf children (16). On the other hand, movement-based games designed for children that incorporate movement typically feature a variety of dynamic actions such as walking, running, and jumping, which are more comprehensible to children's worlds since they are entertaining and inspiring (17, 18). Several modalities of movement-based games have been proposed for balance development, such as *Adlerian play therapy*, *Time-limited play therapy*, *Cognitive-behavioral play therapy*, and the final edition, which is related to *Child-centered play therapy* (CCPT), as a non-directive, evidence-based counseling approach, differs from other play therapies primarily in the degree to which it allows the child to direct the content and progress of therapy (19). The suggested therapy recognizes play as the child's natural language and uses therapeutic play to combine sensory experiences, incorporates fun learning activities, promotes skill development, and enhances self-esteem and family relationships by immersing children in engaging activities (17). In this regard, Ray et al. (2019) investigated the effects of introducing CCPT as an efficient training modality for improving fundamental movement skills in the deaf population (20).

The present study has taken the potentially application of the Balance Error Scoring System (BESS) test that evaluates balance through a sequence of three single-legs and tandem-leg stances for evaluating postural stability (due to high validity and reliability in both clinical and research environments) (21, 22); as well as, Timed Up and Go (TUG) test that is commonly evaluate mobility and balance in clinical environments (22–24) to investigate the effectiveness of CCPT and CST on enhancing static and dynamic balance in deaf children. Despite all the conquered new knowledge and the complex etiology of factors affecting balance stabilization and impairment in deaf individuals, linking exercise properties to balance improvement, the puzzle remains incomplete, and several pieces of information about the factors responsible for balance improvement in deaf children appear to be missing. We hypothesize that the adoption of CCPT and CST will improve balance in deaf children.

2. Materials and methods

2.1 Ethical approval

and Clinical Trial registration

The present investigation received approval from the local institutional ethics committee (ethical code: SSRI.REC-2510-3062) and adhered strictly to the most recent version of the Declaration of Helsinki during the implementation of procedures and was registered on 2025-12-30 according to the principles of Clinical Trials (IRCT20240513061779N3).

2.2 Study design, subjects, inclusion, and exclusion criteria

In this Randomized Clinical Trial with a pre-test and post-test methodology, deaf children from a disabled school were recruited as voluntary participants, based on CONSORT guidelines. The inclusion criteria were: a documented history of absolute or severe deafness, the ability to walk independently, and no physical disabilities. As a result, thirty-six deaf female students aged 10–15 years were chosen for the study (Fig. 1). First, the (parents of) participants filled out the consent form and provided their personal information, and were then standardized based on individual characteristics such as height, age, weight, and body mass index. They were granted the ability to dispute any aspect of the research methodology and withdraw from the trial without facing any consequences. The exclusion criteria consisted of individuals who irregularly participated in exercise and/or supplementation regimens. The participants (Table 1) were randomly assigned to three groups (n = 12/group): (i) Core Stability Training (CST), (ii) Child-Centered Play Therapy (CCPT), and (iii) Control group. The randomization list was generated using "Random allocation" software. Block randomization was used, with each block consisting of 3 items, divided between the groups.

2.3 Training protocol and load measurements

During a preliminary session, participants were introduced to the research process and implementation of training protocols. A physiotherapist fully supervised the implementation of both the CST and the

CCPT training protocols. Each session of CST and CCPT included a warm-up (5 minutes of walking and stretching exercises), the main intervention (i.e., 30 minutes in the initial 3 weeks, increasing to 3 sessions/week, and then to 45 minutes in the final 5 weeks), and a cool-down (5 minutes). The CST protocol (Fig. 1) involved performing 11 different exercises adopted from previous studies (8, 23).

CCPT sessions had embarked on a diverse journey of physical challenges and skill-building activities (9). Sessions involved unstructured play where the child led. While the therapist observed the children, they provided empathy and acceptance. Beginning with a game called “Moving on a straight path”), they navigated a marked route, fostering coordination. Next, they hopped with a second game (i.e., “Like a rabbit on one leg”) to promote agility. “Jumping in a children’s balance game” followed, challenging their balance with diverse jumping activities. “Bowling for children’s balance” had integrated fun and balance as they aimed for targets. The iconic “Twister” game had tested flexibility and agility. “Standing on one leg and balancing” had promoted stability, while “Children’s hoop jumping” had enhanced coordination. Lastly, they had conquered “The Balance Beam Walk,” refining concentration and balance. The game duration had gradually elevated from two rounds in the first week to five rounds in the eighth week. The control group had not participated in any intervention program. The children had no experience of any falls during the intervention and not any adverse effects observed through the training protocol.

Table 1
Anthropometric characteristics of study participants

Groups	BMI (kg/m^2)	Body mass (kg)	Height (m)	Age (years)
CST (n = 12)	23.22 ± 3.79	51.58 ± 6.77	1.49 ± 0.08	13.16 ± 1.69
CCPT (n = 12)	22.43 ± 4.72	48.58 ± 13.38	1.46 ± 0.1	12.66 ± 1.55
Control (n = 12)	22.09 ± 3.28	45.05 ± 4.56	1.44 ± 0.07	13.00 ± 1.41

Values are mean ± standard deviation. Body mass index (BMI), Core stability training (CST), Child-Centered Play Therapy (CCPT).

2.4 Data collection

Before and about 48 hours after the final training session, static and dynamic balance tests were assessed. The BESS test was employed to assess static balance (21). Six different positions were considered, which included three standing positions on a hard surface (i.e., ground) and three standing positions on a soft surface (i.e., foam). The six positions are the following: i) Stand with both feet together on a hard surface; ii) Stand with both feet together on a soft surface (i.e., foam); iii) Stand in a tandem stance on a hard surface (i.e, one foot directly in front of the other); iv) Stand in a tandem stance on a soft surface (i.e., foam); v) Stand on one leg with eyes closed on a hard surface and vi) Stand on one leg with eyes closed on a soft surface (i.e., foam). During all postures, participants kept their eyes closed and their hands clasped at their sides. Subjects performed each position for 20 s, and the total number of errors committed in these six situations was accounted for. A lower error score indicated

better performance. Errors included detaching the hands from the waist, opening the eyes, raising either the heel or toe of the foot from the ground, abducting or adducting the thigh beyond 30º, colliding the suspended foot with the ground, or losing balance for any reason (21, 25). Prior to performing the test, each student practiced the test three times to familiarize themselves with the procedure. The final score of each person was calculated as the average of the three evaluations (21, 25).

The TUG test was used to assess dynamic balance (3). This method assessed the time required to complete these stages, assisting in the evaluation of dynamic balance. Participants began by sitting on a 46cm high chair. Upon receiving an instruction (i.e, "start"), they rose, walked along a straight 3m path at their own pace, and returned to the seated position. A stopwatch (Finis Pace Clock 3X-300M, California, United States) was used to measure the time taken from standing up to sitting down. This three-stage test involved actions such as getting up, walking, and returning, all of which were scored concurrently with the chair rise. Three trials were conducted, and their average was calculated to determine the final score, offering an evaluation of an individual's performance in this movements (3).

2.5 Statistical analysis

Paired T-tests were employed to compare pre-test and post-test changes. At the same time, ANOVA was used to assess group differences, followed by the Bonferroni post-hoc test at a significance level of $P < 0.05$.

3. Results

The results of the ANOVA indicated that there no significant difference in the participants' record of balance values before intervention. Both CST and CCPT interventions influenced the three postures, both on soft and hard surfaces, of static balance and dynamic balance of deaf female students. Besides, the control group maintained similar values when comparing pre- and post-tests (Table 2).

Table 2
Comparisons between pre- and post-tests regarding static and dynamic balance among the study groups

Standing with one foot on a hard surface	**CST (N = 12)**	**CCPT (N = 12)**	**Control (N = 12)**	**P_{value}**
Pre	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	
Post	**22.91 ± 3.16**	**23.91 ± 2.99**	**24.16 ± 3.02**	**0.43[a]**
Change from Pre	**44.50 ± 1.77**	**51.25 ± 0.96**	**25.58 ± 1.96**	**0.001[b]**
P_{value}	**-22.41 ± 1.24**	**-27.34 ± 1.08**	**-1.42 ± 1.28**	
	0.001*	**0.001***	**0.28**	
Standing with one foot on a soft surface	**17.16 ± 2.91**	**17.08 ± 3.68**	**17.33 ± 3.55**	**0.54[a]**
Pre	**34.25 ± 1.62**	**45.91 ± 1.78**	**18.25 ± 2.46**	**0.001[b]**
Post	**-17.09 ± 1.37**	**-28.83 ± 1.78**	**-0.92 ± 0.97**	
Change from Pre	**0.001***	**0.001***	**0.85**	
P_{value}				
Standing tandem on a hard surface	27.16 ± 3.75	25.08 ± 3.24	28.50 ± 3.51	0.96[a]
Pre	51.45 ± 2.18	57.50 ± 2.27	28.75 ± 2.46	0.001[b]
Post	-24.29 ± 1.17	-32.42 ± 1.09	-0.25 ± 1.25	
Change from Pre	0.007*	0.12*	0.58	
P_{value}				
Standing tandem on a soft surface	24.08 ± 2.65	22.16 ± 2.66	23.58 ± 3.24	0.78[a]
Pre	46.66 ± 1.83	53.50 ± 1.52	22.45 ± 2.26	0.001[b]
Post	-22.58 ± 1.17	-31.34 ± 1.14	0.13 ± 1.12	
Change from Pre	0.001*	0.001*	0.67	
P_{value}				
Dynamic Balance	4.36 ± 0.74	4.17 ± 0.83	4.25 ± 0.75	0.81[a]
Pre	6.28 ± 0.62	7.50 ± 0.67	4.16 ± 0.69	0.001[b]
Post	-1.92 ± 0.20	-3.33 ± 0.24	0.09 ± 0.23	
Change from Pre	0.001*	0.001*	0.52	
P_{value}				

Data are expressed as Mean ± SD; [a] Significant group difference at Pre-test; [b] Significant group difference at Post-test; * and ** Significance level of paired t-test for comparing Pre-test and Post-test differences

The results obtained in Table 2 of the ANOVA test indicate that there is no significant difference between the groups in the dependent variables of the study: standing with one foot on a hard surface (*P* = 0.43), standing with one foot on a soft surface (*P* = 0.54), standing with two feet on a hard surface (*P* = 0.96), standing with two feet on a soft surface (*P* = 0.78), and dynamic balance (*P* = 0.81). However, in the post-test, there was a significant difference between the groups in the pre-test in the dependent variables of the study: standing with one foot on a hard surface (*P* = 0.001), standing with one foot on a soft surface (*P* = 0.001), standing with two feet on a hard surface (*P* = 0.001), standing with two feet on a soft surface (*P* = 0.001), and dynamic balance (*P* = 0.001). Also, the results obtained from the paired t-test for the dependent variables of the study indicated that the difference between the pre-test and post-test in the CST group also decreased significantly for the dependent variables of standing with one foot on a hard surface (P = 0.001, MD = -27.34), standing with one foot on a soft surface (*P* = 0.001, MD = -28.83), standing with two feet on a hard surface (*P* = 0.001, MD = -32.42), standing with two feet on a soft surface (*P* = 0.001, MD = -31.34), and dynamic balance (*P* = 0.001, MD = -33.3). In the CCPT group, there was a significant decrease in the dependent variables of standing with one foot on a hard surface (P = 0.01, MD = -18.41), standing with two feet on a hard surface (P = 0.001, CP=-19.29), standing with two feet on a soft surface (*P* = 0.047, MD = -13.58), and dynamic balance (*P* = 0.001, MD = -1.92), but no significant difference was observed in standing with one foot on a soft surface (*P* = 0.056, MD = -10.09). In the control group, there was a significant decrease in the dependent variables of standing with one foot on a hard surface (P = 0.31, MD = -1.42), standing with one foot on a soft surface (*P* = 0.77, MD = -0.92), standing with two feet on a soft surface (*P* = 0.12, MD = -0.25), There was no significant increase or decrease in standing with two legs on a hard surface (P = 0.67, MD = 0.13) and dynamic balance (*P* = 0.23, MD = 0.09).

Table 3
Results of the Bonferroni post hoc test for the dependent variables of the study

Variable	Groups	Mean Difference	SD	P_{value}
Standing with one foot on a hard surface	CST vs. Control	25.67	0.45	0.001 β
	CCPT vs. Control	6.92	0.46	0.045β
	CCPT vs. CST	18.75	0.45	0.03*
Standing with one foot on a soft surface	CST vs. Control	27.66	0.31	0.001 β
	CCPT vs. Control	9	0.31	0.038 β
	CCPT vs. CST	18.66	0.31	0.03*
Standing tandem on a hard surface	CST vs. Control	28.75	0.24	0.001 β
	CCPT vs. Control	17.70	0.24	0.01 β
	CCPT vs. CST	11.05	0.25	0.04*
Stand the tandem on a soft surface	CST vs. Control	31.05	0.36	0.001 β
	CCPT vs. Control	15.21	0.36	0.041 β
	CCPT vs. CST	15.84	0.37	0.04*
Dynamic Balance	CST vs. Control	3.34	0.26	0.001 β
	CCPT vs. Control	2.12	0.26	0.02 β
	CCPT vs. CST	1.22	0.25	0.370

Data are expressed as Mean ± SD; * significant group difference at $P < 0.05$ and β at $P < 0.01$

The data from Table 3 and Fig. 2 show that there is a significant difference in the dependent variable of standing with one foot on a hard surface between the CST and control groups ($P = 0.001$, MD = 25.67), CCPT and control groups ($P = 0.045$, MD = 6.92), and CCPT and CST ($P = 0.03$, MD = 18.75); there is a significant difference in the variable of standing with one foot on a soft surface between the CST and control groups ($P = 0.001$, MD = 27.66), CCPT and control groups ($P = 0.038$, MD = 9.00), and CCPT and CST ($P = 0.03$, MD = 18.66); There was a significant difference in bipedal standing on a hard surface between the CST and control groups ($P = 0.001$, MD = 28.75), CCPT and control groups ($P = 0.01$, MD = 70.17), and CCPT and CST ($P = 0.04$, MD = 11.05); there was a significant difference in bipedal standing on a soft surface between the CST and control groups ($P = 0.001$, MD = 31.05), CCPT and control groups ($P = 0.041$, MD = 21.15), and CCPT and CST ($P = 0.04$, MD = 84.15); and there was a significant difference in dynamic balance between the CST and control groups ($P = 0.001$, MD = 34.3), CCPT and control

groups (*P* = 0.02, MD = 12.2). However, there is no significant difference in dynamic balance between CCPT and CST (*P* = 0.37, MD = 1.22).

4. Discussion

This is the first study to investigate the comparative effects of Core Stability Training (CST) and Child-Centered Play Therapy (CCPT) on static and dynamic balance in deaf children. The novel findings of the present study emphasized that the regular implementation of CST and/or CCPT protocols, even in deaf individuals, improved static and dynamic balance, with CST showing greater improvement, in part due to improvements in musculoskeletal and neuromuscular systems. All these changes lead to improvement in balance performance in deaf children.

It is well known that one of the major concerns for deaf children is the obstacles they face in developing a strong sense of identity and self-determination. Deaf children frequently compensate for vestibular impairments by increasing their reliance on proprioceptive and visual systems (4). Additionally, postural control in deaf children with vestibular dysfunction often exhibits inadequate balance, especially in dynamic contexts (27). Interventions like CST, which focus on enhancing proprioception and strengthening postural muscles, are highly effective in these situations. Parallel to previous studies (28–30), the chronic (8-week) implementation of CST and/or CCPT in the present study exerted significant improvements in balance outcomes following both interventions, albeit with distinct impacts on different aspects of balance. Specifically, the ANOVA results revealed that CST outperformed CCPT in both static and dynamic balance measures. The targeted approach of CST, which engages core muscles essential for postural control and movement coordination, resulted in significant improvements in both the BESS (static) and TUG (dynamic) tests. In contrast, although CCPT enhanced overall motor coordination and sensory integration, it did not achieve comparable improvements in dynamic balance, likely because it emphasized broader developmental outcomes over specific postural muscle training. The study suggests that CST may be more effective in addressing specific balance deficits. In contrast, CCPT may serve as a complementary therapy to other treatments focused on overall functional development and sensory integration. Therefore, it can be inferred that the degree and type of improvements vary based on the nature of the intervention, highlighting the significance of customizing programs to address specific balancing issues.

CCPT has been suggested to be uniquely suited as an intervention for the particular needs of deaf children by the mechanism of reducing anxiety and fear, building self-efficacy and confidence, enhancing body awareness (sensory integration) and improving emotional regulation that increases willingness to attempt tasks and improved quality of movement that finally leads to carry over into daily life (19). Given that CCPT theoretically targets a person's sense of self and that it has been indicated as effective in improving children's sense of self-efficacy (32),

Virginia Axline, the innovator of child-centered play therapy (CCPT), described the therapeutic powers of play as being classified into eight broad categories: communication, emotional regulation, relationship

enhancement, moral judgment, stress management, ego boosting, preparation for life, and self-actualization (33). The possible mechanism by which CCPT improves the balance skills of deaf children is particularly related to the roles of sensory integration, core stability, and motor coordination. The unique physical demands of core stability are reflected in CCPT's superior outcomes in enhancing dynamic balance through a psychological and sensory-integrative approach. It improves balance indirectly by reducing anxiety, building self-confidence, enhancing body awareness, and facilitating sensory integration within a safe, relational context.

According to anecdotal evidence, core stability exercises enhance the strength and endurance of the muscles that stabilize the spine and pelvis, leading to improved postural alignment and balance control (30). In this study, CST likely strengthened these muscles, enabling participants to move more effectively and maintain balance while performing dynamic tasks, such as the Timed Up and Go (TUG) test. Parallel to this, Hibbs et al. discovered that core stability training improves both posture and functional fitness, which explains why CST participants completed TUG tasks faster, showing better dynamic movement control (34). The significant improvement in static balance for both groups, as indicated by reduced errors in the Balance Error Scoring System (BESS), may be attributed to the sensory integration process outlined in previous studies. Postural control relies on the integration of visual, vestibular, and somatosensory inputs to generate motor responses (27). Both CST and CCPT likely engaged these compensatory processes, helping participants in the enhanced integration of sensory signals to improve their static balance.

As mentioned earlier, dynamic balance refers to the ability to maintain control when transitioning between postures, which primarily rely on proprioception and the coordinated activity of deep postural muscles (33). By specifically targeting these muscles, CST enables participants to control their movements and stabilize their core during dynamic exercises, such as walking or standing up from a seated position. This theory is supported by research since dynamic activities requiring quick posture adjustments are known to require core stability (12).Through balance training exercises, Shavikloo et al. and Zarei et al. demonstrated comparable gains in motor control and balance in children with hearing impairments, highlighting the importance of motor and postural muscle activation in establishing balance during movement tasks (11, 15, 35). Although CCPT demonstrated general enhancements in balance, its effect on dynamic balance was somewhat less pronounced than that of CST. The discrepancy may be attributable to CCPT's extensive emphasis on sensory integration and motor coordination, rather than direct physical conditioning of core muscles (20, 33). As mentioned above, CCPT involves children in enjoyable endeavors that enhance sensory systems, emotional growth, and motor abilities (20, 33). This sensory-based method improves balance and coordination, with enhancements being more evident in static balancing tests, where sensory integration is more significant than in dynamic activities that require greater physical control.

The slight enhancements in static balance shown in CCPT are likely attributed to its focus on improving sensory integration. Research conducted by Zarei et al. and Tarighi et al. indicates that deaf children participating in balance training that incorporates sensory inputs can significantly enhance their postural

stability (11, 15, 16). Nevertheless, the substantial enhancement in dynamic balance relative to CST indicates that the CST modality of treatment is advantageous for sensory and motor coordination, which may have activated the postural muscles, resulting in limited improvements in functional movement tasks, such as the TUG test (20, 33).

CST demonstrated a more pronounced effect on dynamic balance, as evidenced by the TUG results. The CST group demonstrated reduced completion record on the TUG, indicating enhanced capacity for rapid movement and balance maintenance during posture transitions. The CCPT group exhibited enhancements in dynamic balance. This suggests that the physical demands of CST, particularly its emphasis on core stabilization, may have had a more pronounced effect on dynamic postural control (11, 15, 35). Conversely, CCPT's extensive emphasis on motor coordination and sensory integration appeared to yield subtle improvements in balance, which did not significantly affect dynamic balance as much as CST (20, 33).

Improvement of the muscles that support the spine and pelvis during CST is crucial for maintaining an upright posture and stabilizing the body during both static and dynamic activities (30). Research conducted by Farzaneh Hasari et al. and Taheri et al. supports these findings, demonstrating that targeted training, such as CST, directly improves the functionality of postural muscles, resulting in enhanced balance, particularly in static activities for deaf participants (29, 30). The deep postural muscles are crucial for maintaining balance on both rigid and soft surfaces, as demonstrated by Hibbs et al. in their research on the benefits of core training for posture (34).

In contrast, CCPT, which is more comprehensive and focuses on sensory integration and motor coordination, demonstrated improvements in static balance, but these were less significant than those seen with CST. The improvements seen in the CCPT group can be attributed to the therapy's comprehensive approach, which promotes general motor skill development and sensory processing, both of which are critical components of postural control in static settings (36). Additionally, child-centered therapies, such as CCPT, activate sensory systems (visual, vestibular, and proprioceptive), facilitating balance enhancements through sensory pathways rather than focusing on targeted muscle training (37).

The ANOVA analysis demonstrates that CST’s focus on core stability results in more significant improvements in both static and dynamic balance compared to CCPT. This is consistent with research indicating that core stability training directly engages muscles that are critical for postural transitions, which are necessary for tasks measured by the TUG test (22, 31). These results are consistent with those of Hibbs et al., who demonstrated that specific core stability exercises improved functional movement capacities by reducing postural disturbances and improving spinal alignment (34). Since core muscles serve as the basis for the connection between the upper and lower extremity and posture control during dynamic tasks, the CST group's higher performance on the TUG test can be explained by the function that core stability plays in regulating dynamic balance.

However, improvement of dynamic balance time in CCPT was less significant compared to CST, despite being beneficial for general motor coordination and sensory processing. This may be a result of CCPT's comprehensive approach, which prioritizes more general developmental goals, such as emotional stability and sensory integration, over focusing on the particular muscle groups involved in dynamic postural control. Improvements were more subtle in dynamic balance tasks such as the TUG test, which may be explained by the more general way in which CCPT's sensory-based approach improves coordination and balance (38).

5. Advantages and limitations

The research highlights the necessity of choosing interventions that are specifically designed for particular balance deficits in clinical groups, including deaf children. CST is notably effective in improving both static and dynamic balance by focusing on core stability, which is crucial for maintaining postural control and preventing falls. On the other hand, CCPT, with its engaging and developmental approach, offers benefits for overall motor and sensory development, so the study acknowledges several limitations that warrant consideration. The eight-week duration of the intervention may not adequately capture the long-term benefits of CST and CCPT on improving balance in deaf children, underscoring the need for additional studies in a different group and longer follow-up times that could shed light on the interventions' long-term viability. Furthermore, although the Balance BESS and TUG tests are commonly used to evaluate static and dynamic balance, they might not fully capture all aspects of balance impairment in deaf children. To more accurately identify and treat balance impairments, a thorough evaluation should consider a range of sensory inputs, coordination factors, and functional abilities in real-life situations. Future assessments may be more thorough if objective measurements of postural sway and functional balance tests are included.

6. Conclusions

In conclusion, this study highlights the varying effects of CST and CCPT on static and dynamic balance among deaf female students. CST demonstrated notable improvements in static and dynamic balance, highlighting its focused approach to muscle strength and stability. In contrast, CCPT contributed to improvements in sensory integration and motor coordination, demonstrating advantages for static balance, both of which are crucial for maintaining postural control in static environments. The integration of these approaches may provide the most comprehensive balance training for deaf children, offering essential insights for therapists and specialists engaged in optimizing balance rehabilitation strategies for deaf children to address both physical and sensory aspects of balance effectively.

Declarations

Ethical approval, Clinical Trial registration and consent to participate

The present investigation received approval from the local institutional ethics committee (ethical code: SSRI.REC-2510-3062) and adhered strictly to the most recent version of the Declaration of Helsinki during the implementation of procedures and was registered on 2025-12-30 according to the principles of Clinical Trials (IRCT20240513061779N3). Also, Parents provided written informed consent for their children.

Consent for publication:

Not applicable

Conflict of Interests:

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Author Contribution

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Data Availability:

The data presented in the study is available on request from the corresponding author during submission or after publication.

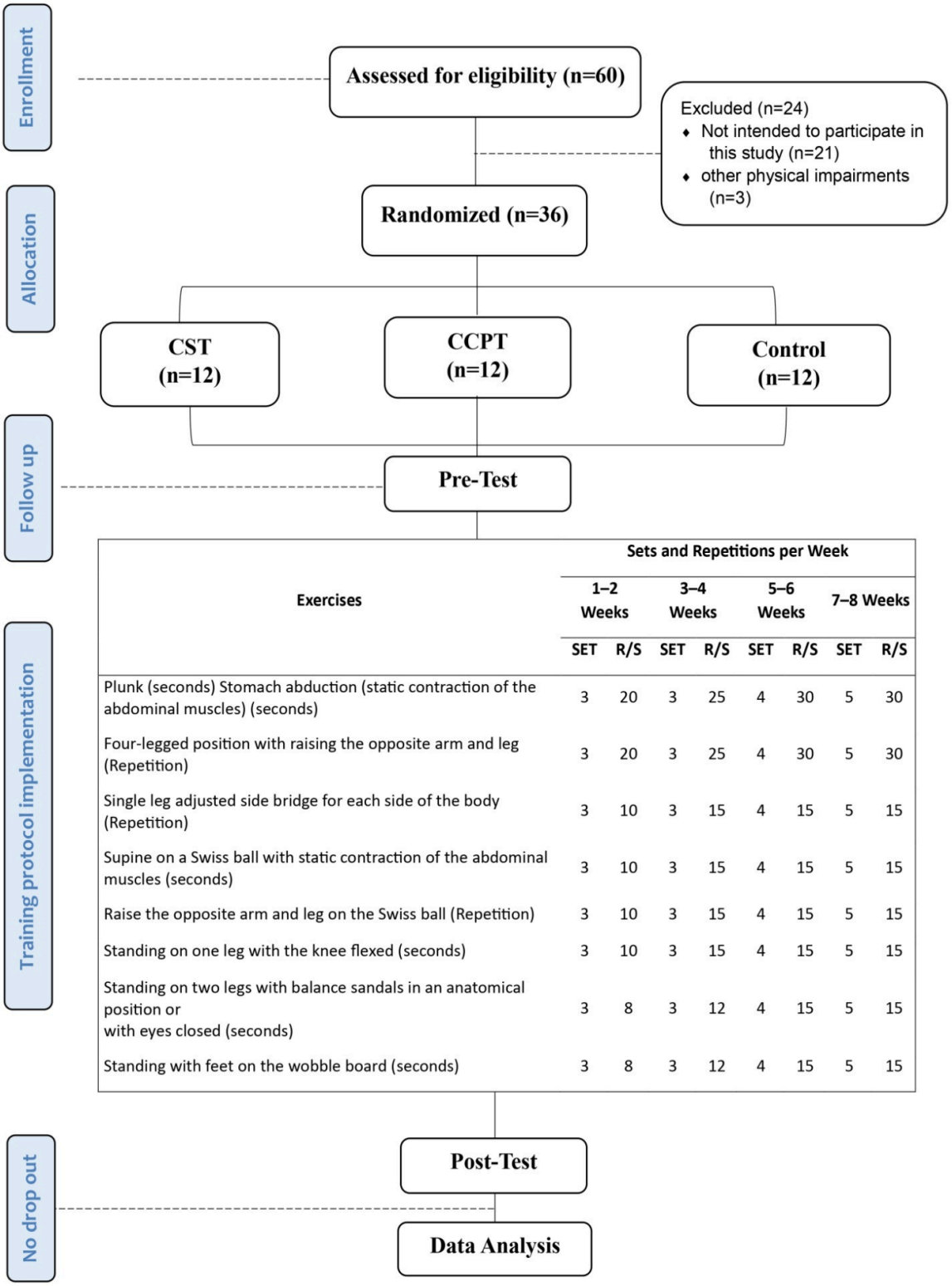
References

1. Podury A, Jiam NT, Kim M, Donnenfield JI, Dhand A. Hearing and sociality: the implications of hearing loss on social life. Frontiers in neuroscience. 2023;17:1245434.
2. Rajendran V, Roy FG. An overview of motor skill performance and balance in hearing impaired children. Italian journal of pediatrics. 2011;37(1):33.
3. Barry E, Galvin R, Keogh C, Horgan F, Fahey T. Is the Timed Up and Go test a useful predictor of risk of falls in community dwelling older adults: a systematic review and meta-analysis. BMC geriatrics. 2014;14(1):14.
4. ODABAŞI CT OB. Motor Skills in Hearing Impaired Children. Journal of Inclusive Educational Research. 2023.
5. Qayoum F, Pirzado MH, Shaikh M, Uman M, Rauf S, Shaikh AQ. To Observe the Dynamic Balance Problem in Deaf Childrens Via Four Square Step Test. Journal of Health and Rehabilitation Research. 2024;4(2):668–75.
6. Soori Z, Heyrani A, Rafie F. Exercise effects on motor skills in hearing-impaired children. Sport Sciences for Health. 2019;15(3):635–9.
7. de Sousa AM, de França Barros J, de Sousa Neto BM. Postural control in children with typical development and children with profound hearing loss. Int J Gen Med. 2012;5:433–9.
8. Özal C, Aksoy S, Kerem Günel M. Postural Control Alterations in Children with Mild Forms of Spastic Cerebral Palsy. Pediatric Health Med Ther. 2022;13:367–76.
9. Peterka RJ. Sensorimotor integration in human postural control. Journal of neurophysiology. 2002.
10. Lopez LD, Reschke PJ, Knothe JM, Walle EA. Postural communication of emotion: Perception of distinct poses of five discrete emotions. Frontiers in psychology. 2017;8:710.
11. Zarei H, Norasteh AA. Effects of core stability training program on trunk muscle endurance in deaf children: a preliminary study. Journal of Bodywork and Movement Therapies. 2021;28:6–12.
12. Zhou J, Zhong Y, Xu W. Effects of core stability exercises on balance ability of children and adolescents with intellectual disabilities: A systematic review and meta-analysis. PLoS One. 2024;19(12):e0314664.
13. Banparvari M, Nazarian A, Salehikiya A. The comparison of the effect of different core stability training on lower extremities strength among deaf children. Journal of Advances in Para-Sport Science. 2023;3(4):580–91.
14. Hedayatjoo M, Rezaee M, Alizadeh Zarei M, Mirzakhany N, Nazeri A, Akbarzadeh Baghban A, et al. Effect of balance training on balance performance, motor coordination, and attention in children with hearing deficits. Arch Neurosci. 2020;7(1):e84869.
15. Zarei H, Norasteh AA, Lieberman LJ, Ertel MW, Brian A. Effects of proprioception and core stability training on gait parameters of deaf adolescents: a randomized controlled trial. Scientific Reports. 2023;13(1):21867.

16. Tarighi RB, Rostami RS. M.(2023). The comparison of the effect of different core stability training on lower extremities strength among deaf children. *Journal of Humanistic approach to sport and exercise studies (HASES)*. 3(4):580–591.
17. Elbeltagi R, Al-Beltagi M, Saeed NK, Alhawamdeh R. Play therapy in children with autism: Its role, implications, and limitations. World journal of clinical pediatrics. 2023;12(1):1.
18. Nery M, Sequeira I, Neto C, Rosado A, editors. Movement, play, and games—An essay about youth sports and its benefits for human development. Healthcare; 2023: MDPI.
19. Ray D, Armstrong S, Balkin R, Jayne K. Child-centered play therapy in the schools: Review and meta-analysis. Psychology in the Schools. 2014;52.
20. Ray DC. Culturally and linguistically responsive play therapy: Adapting child-centered play therapy for deaf children. International Journal of Play Therapy. 2019;28(2):79.
21. Bell DR, Guskiewicz KM, Clark MA, Padua DA. Systematic review of the balance error scoring system. Sports health. 2011;3(3):287–95.
22. Smith E, Walsh L, Doyle J, Greene B, Blake C. The reliability of the quantitative timed up and go test (QTUG) measured over five consecutive days under single and dual-task conditions in community dwelling older adults. Gait & Posture. 2016;43:239–44.
23. Ortega-Bastidas P, Gomez B, Aqueveque P, Luarte-Martinez S, Cano-de-la-Cuerda R. Instrumented timed up and go test (iTUG)—more than assessing time to predict falls: a systematic review. Sensors. 2023;23(7):3426.
24. Rodrigues F, Teixeira JE, Forte P, editors. The reliability of the timed up and go test among Portuguese elderly. Healthcare; 2023: MDPI.
25. Lowe L, Castillo F, Gokun Y, Williams DK, Israel M, Yates C. Static and dynamic balance assessment in healthy and concussed adolescent athletes. Clinical Journal of Sport Medicine. 2022;32(4):385–90.
26. Moher D, Schulz KF, Altman DG. Das CONSORT Statement: Überarbeitete Empfehlungen zur Qualitätsverbesserung von Reports randomisierter Studien im Parallel-Design. DMW-Deutsche Medizinische Wochenschrift. 2004;129(S 3):T16-T20.
27. Melo RS, Lemos A, Wiesiolek CC, Soares LGM, Raposo MCF, Lambertz D, et al. Postural sway velocity of deaf children with and without vestibular dysfunction. Sensors. 2024;24(12):3888.
28. Akınoğlu B, Kocahan T. Stabilization training versus equilibrium training in karate athletes with deafness. Journal of exercise rehabilitation. 2019;15(4):576.
29. Farzaneh Hessari A, Daneshmandi H, Mahdavi S. The effect of 8 weeks of core stabilization training program on balance in hearing impaired students. Sport Sciences and Health Research. 2011;3(2):67–83.
30. Taheri M, Irandoust K, Norasteh A, Shaviklo J. The effect of combined core stability and neuromuscular training on postural control in students with congenital hearing loss. Journal of Research in Rehabilitation Sciences. 2017;13(2):80–6.

31. Huxel Bliven KC, Anderson BE. Core stability training for injury prevention. Sports health. 2013;5(6):514–22.
32. Chapel SL. Child-centered play therapy with Deaf children: Exploring linguistic and cultural implications: SUNY College at Brockport; 2005.
33. Cochran NH, Nordling WJ, Cochran JL. The Eight Principles in Child-Centered Play Therapy. Child-Centered Play Therapy: Routledge; 2022. p. 74–84.
34. Hibbs AE, Thompson KG, French D, Wrigley A, Spears I. Optimizing performance by improving core stability and core strength. Sports medicine. 2008;38(12):995–1008.
35. Shavıkloo J, Norasteh A. The effect of aerobic and core stability training combination on respiratory volume and balance of children with congenital deafness. International Journal of Sport Culture and Science. 2018;6(3):298–309.
36. Ferreiro-Pérez M, Abuín-Porras V, Martín-Casas P, Ortiz-Gutiérrez RM. Postural control and sensory processing in preschool children with autistic spectrum disorder: a cross-sectional study. Children. 2024;11(3):303.
37. Alotaibi MS. Game-based learning in early childhood education: a systematic review and meta-analysis. Frontiers in psychology. 2024;15:1307881.
38. Warutkar VB, Kovela RK, Warutkar V. Review of sensory integration therapy for children with cerebral palsy. Cureus. 2022;14(10).

Figures



Exercises	Sets and Repetitions per Week							
	1–2 Weeks		3–4 Weeks		5–6 Weeks		7–8 Weeks	
	SET	R/S	SET	R/S	SET	R/S	SET	R/S
Plunk (seconds) Stomach abduction (static contraction of the abdominal muscles) (seconds)	3	20	3	25	4	30	5	30
Four-legged position with raising the opposite arm and leg (Repetition)	3	20	3	25	4	30	5	30
Single leg adjusted side bridge for each side of the body (Repetition)	3	10	3	15	4	15	5	15
Supine on a Swiss ball with static contraction of the abdominal muscles (seconds)	3	10	3	15	4	15	5	15
Raise the opposite arm and leg on the Swiss ball (Repetition)	3	10	3	15	4	15	5	15
Standing on one leg with the knee flexed (seconds)	3	10	3	15	4	15	5	15
Standing on two legs with balance sandals in an anatomical position or with eyes closed (seconds)	3	8	3	12	4	15	5	15
Standing with feet on the wobble board (seconds)	3	8	3	12	4	15	5	15

Figure 1

Flow diagram presenting the progress of the recruits in the study, based on CONSORT guidelines (26)

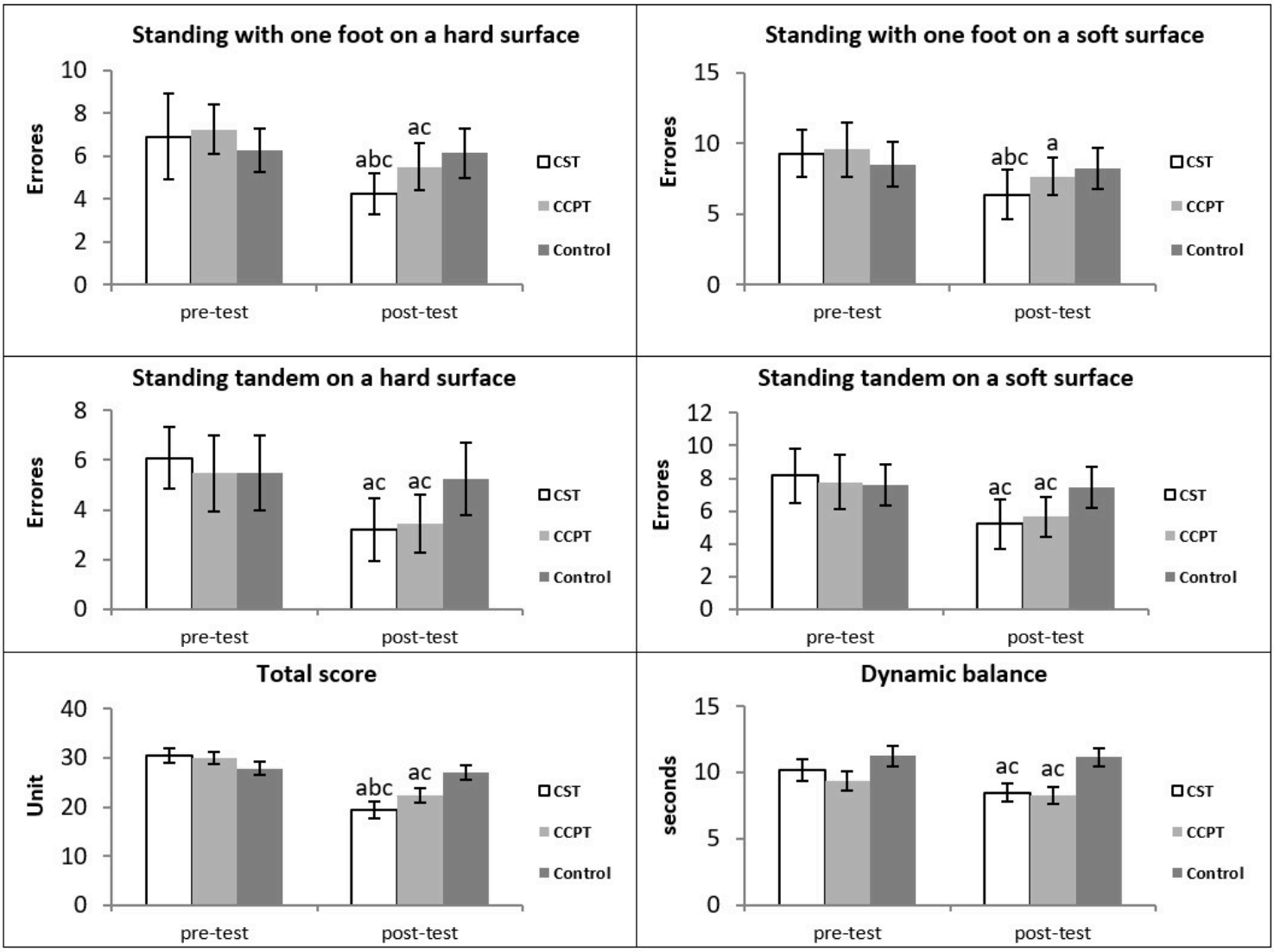


Figure 2

Bonferroni results for Static and dynamic balance tests

Data expressed as Mean ± SD. [a] significant versus the Control group; [b] significant versus the CCPT group; [c] significant versus the pre-test according to Bonferroni.