To Compare the Effects of Single-Task and Dual-Task Balance Training on Patients with Cerebellar Ataxia

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ABSTRACT

Aim: This study aimed to compare the effectiveness of single-task versus dual-task balance training in patients with cerebellar ataxia.

Materials and Methods: A quasi-experimental study was conducted by reviewing the clinical records of 30 individuals diagnosed with cerebellar ataxia. All participants underwent assessments using the Berg Balance Scale (BBS) and the Scale for the Assessment and Rating of Ataxia (SARA). Balance and gait were evaluated before and after a 4-week intervention period involving either single-task or dual-task balance exercises.

Results: Pre- and post-intervention scores were analyzed using an unpaired t-test. Group A (single-task training) showed a t-value of 13.39, while Group B (dual-task training) had a t-value of 11.42. Both values exceeded the critical value of 2.05 at the 5% significance level with 28 degrees of freedom, indicating statistically significant improvements in both groups.

Conclusion: The findings suggest that dual-task training produced a significant and positive effect on balance and gait in cerebellar ataxic patients, as demonstrated by improvements in BBS and SARA scores following the intervention.

Keywords: Cerebellar ataxia, balance training, Berg Balance Scale, coordination, single-task exercise, dual-task exercise.

INTRODUCTION

The cerebellum plays an important role for balance control and the coordination of voluntary movements. Cerebellar degeneration leads to ataxic symptoms, such as ataxic of stance, gait and limbs. Beyond that there is growing evident that the cerebellum is also involved in cognitive functions, particularly executive control including working memory and language, and possible visuospatial function. Cerebellar involvement in cognition is supported by human cerebellar lesion studies and functional brain imaging studies in healthy subjects. Cerebellar involvement in cognition is supported by human cerebellar lesion studies and functional brain imaging studies in healthy subjects. Shashank Ghai et al explored dual-task training involving two cognitive tasks unrelated to balance. Their findings highlighted the significant role of the instructional approach in dual-task training. The aim of the present study was to assess whether dual-task exercises are more effective in enhancing balance among individuals with cerebellar ataxia. Since managing two tasks at once is a common and essential part of daily life, incorporating dual-task exercises into physical therapy programs for cerebellar patients is recommended.

Neuroanatomy

The cerebellum is situated at the rear of the brain, directly beneath the occipital and temporal lobes, and rests within the posterior cranial fossa. It is separated from these lobes by the tentorium cerebelli, a sturdy membrane. Positioned at the same level as the pons and lying just behind it, the cerebellum is divided from the pons by the fourth ventricle. Structurally, it comprises two hemispheres joined at the midline by the vermis. Like other parts of the central nervous system, the cerebellum contains both grey and white matter. Its surface is highly folded, forming the cerebellar cortex.

Pathophysiology

Cerebellar ataxia categorized into motor and sensory ataxia. Motor ataxia are usually caused by disorder of the cerebellum.The sensory receptors and afferent pathway are intact but integration of the proprioceptive information is faulty. Involvement of the lateral cerebellum may lead to a motor ataxia of ipsilateral limb. Lesions affecting the midline portion of the cerebellum cause problems with axial muscles co-ordination reflected in difficulty maintain a steady upright standing or sitting posture.

Epidemiology

Ataxia is a neurological condition that affects both children and adults worldwide. Recent advancements in genetic research and neuroimaging have improved the understanding and classification of cerebellar disorders. Global epidemiological studies estimate that childhood ataxia has a prevalence of approximately **26 cases per 100,000 children**. Hereditary forms of ataxia are less common but still significant; **autosomal dominant hereditary cerebellar ataxias** have a global prevalence of about **2.7 per 100,000**, while **autosomal recessive types** are slightly more prevalent at **3.3 per 100,000**. Among hereditary ataxias, **Friedreich's ataxia** is the most common, affecting **2 to 4 individuals per 100,000** in populations of European descent. **Spinocerebellar ataxias (SCAs)** as a group have a combined prevalence ranging from **3 to 5.6 per 100,000**, with specific subtypes such as **SCA1** occurring in about **1 to 2 per 100,000**, depending on the region. The rare disorder **ataxia-telangiectasia** occurs in approximately **1 to 2.5 per 100,000** people. Regional differences are notable; for example, Portugal reports a total hereditary cerebellar ataxia prevalence of **8.9 per 100,000**, while in Korea, the total cerebellar ataxia prevalence is around **8.3 per 100,000**, with **5.0 per 100,000** being hereditary and **3.3 per 100,000** non-hereditary.

Cerebellar ataxia is a neurological condition characterized by impaired coordination, balance, and motor control due to dysfunction of the cerebellum. These deficits significantly affect a patient's ability to perform daily activities and maintain independence. Traditional rehabilitation programs for cerebellar ataxia primarily focus on single-task balance training, where patients perform exercises in isolation without additional cognitive or motor challenges. However, in real-life situations, individuals are rarely required to focus on just one task at a time. Walking while talking, navigating through crowds, or carrying items while moving are all examples of daily dual-task activities that require coordination of both cognitive and motor functions simultaneously.

Recent research in neurorehabilitation has shown that dual-task training can improve balance and cognitive-motor integration in individuals with various neurological conditions. However, there is limited evidence specifically addressing the benefits of dual-task training in patients with cerebellar ataxia. Understanding whether dual-task balance training is more effective than traditional single-task training could help develop more functional and efficient rehabilitation strategies tailored to the daily needs of these patients.

Therefore, this study was chosen to compare the effects of single-task and dual-task balance training in patients with cerebellar ataxia, aiming to identify which approach provides greater improvements in balance, coordination, and overall functional mobility.

MATERIALS AND METHODOLOGY

Materials

The materials required include a treatment couch, treatment chair, towel, stop clock, stethoscope, sphygmomanometer, goniometer, foot stool or stepper, wobble board, yardstick, one standard chair with armrests, one standard chair without armrests, and a stopwatch or wristwatch.

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Methodoloy

All patients underwent a neurological examination along with a postural assessment. The **Scale for the Assessment and Rating of Ataxia (SARA)** was administered to evaluate the impact of **cerebellar ataxia** on the patients' **independence in activities of daily living (ADLs)**. Additionally, the **Berg Balance Scale (BBS)** was utilized to assess and confirm impairments in both **static and dynamic balance** among the patients.

Population: Patients with age group of 40 to 65 years with cerebellar ataxia.

Inclusion and Exclusion Criteria

The inclusion criteria consisted of individuals who submitted a signed informed consent form, included both male and female participants aged between 40 and 65 years, and had balance impairments. Participants were also required to have a **Berg Balance Scale (BBS)** score below 1 and a **SARA** score above 40, and be diagnosed with **spinocerebellar ataxia**, **Friedreich's ataxia**, or **sporadic ataxias**.

The exclusion criteria included individuals who did not complete the BBS assessment or failed to sign the informed consent form, those with a history of other **neurological disorders**, those with BBS scores greater than 1 or 2, and those with SARA scores below 40.

Procedure

The study was conducted over a duration of six months, with a total sample size of 30 patients, and the data for this study were collected from the Outpatient Department of Nehru College of Physiotherapy in Coimbatore, Neuro Speciality Hospital in Erode, and Bharath Neuro Center in Erode.Subjects were selected using a convenient sampling method. A total of 30 patients who met the inclusion and exclusion criteria were then randomly assigned to two groups, with 15 participants in Group A and 15 in Group B. The study was clearly explained to all participants, and written informed consent was obtained from those who met the eligibility criteria. Following consent, participants were informed about the assessment scales, and the relevant scales were administered accordingly. Detailed project instructions were provided, including the purpose of the study, safety measures, comfort guidelines, necessary precautions, and psychological support. Prior to initiating the intervention, all vital signs were checked. During the assessment process, participants' willingness to proceed—with or without rest—was given priority. Both groups underwent a progressive balance training program over a period of four weeks. Each session began with a 5-minute child-oriented warm-up involving simple games, followed by a 45-minute balance training session, and concluded with a 5-minute child-oriented cool-down.

Group A (Single Task Exercises)

1. Static Standing Balance (Romberg Stance)

    Stand with feet together, arms at sides, near a stable support.Hold position for 30 seconds to 1 minute.Progress to eyes closed (if safe and supervised).

2. Tandem Standing

    Stand with one foot directly in front of the other (heel-to-toe).Hold for 30 seconds, repeat with other foot forward.Use a wall or parallel bars for support if needed..

3. Seated Reaching

    Sit upright in a chair with feet flat.Reach forward, sideways, and across the body to touch or pick up an object.Repeat 10–12 reps per direction.

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4. Heel-to-Toe Walking (Tandem Gait)

Walk in a straight line placing the heel of one foot directly in front of the toes of the other.Use a hallway or wall for support.Perform 5–10 steps, rest, then repeat.

5. Weight Shifting (Anterior/Posterior & Lateral)

Stand with feet shoulder-width apart.Gently shift weight forward/backward and side to side.Hold each position for 5 seconds.Repeat 10 times in each direction.

6. Stepping Practice

Step forward, backward, and to the side with one leg, then return to starting position.Alternate legs, repeat 10–15 reps per direction.

7. Wobble Board or Foam Surface Standing (Static Only)

Stand on a foam pad or wobble board for 30–60 seconds.Hold onto a stable support if necessary.Eyes open; avoid eyes closed unless advanced.

8. Wall Push-Ups

Stand facing a wall, arms shoulder-width apart.Perform push-ups against the wall slowly, 10–15 reps.Keep feet planted and core engaged.



Group B (Dual Task Exercises)

1. Walking While Counting Backward

Walk 10–15 steps in a straight line.While walking, count backward from 100 in steps of 2 or 3.Repeat 3–5 times.

2. Tandem Walking + Naming Animals

Perform heel-to-toe walking.Simultaneously name animals (or fruits, cities, etc.).Continue for 5–10 steps per trial.

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3. Standing on Foam Surface + Word Recall

Stand on a foam pad or unstable surface.While maintaining balance, recall 5–10 items from a given category (e.g., colors, tools).Hold for 30 seconds.

4. Obstacle Walking + Answering Simple Questions

Walk through a set of small obstacles or cones.While navigating, answer simple questions (e.g., "What day is it?" "What's 5 + 7?")Perform 3–5 circuits

5. Sit-to-Stand + Spelling Words Backward

Perform repeated sit-to-stand movements from a chair.While doing so, spell 3–4-letter words backward (e.g., "dog" → "g-o-d").Do 10 reps.

6. Marching in Place + Simple Math

March in place for 1 minute.Solve simple arithmetic problems aloud (e.g., 6 × 2, 14 ÷ 2).Repeat 3 rounds.

7. Ball Toss While Naming Colors

Stand or sit and toss a ball to a partner or against a wall.Each time you toss, name a color or object (not repeating).

DATA PRESENTATION AND STASTISTICAL ANALYSIS

The paired t-test was used to find out the statistical significance between pre and post t-test values of BBS and SARA before and after treatment for Group A and Group B.

Formula for paired t-test,

$$S = \frac{\Sigma d^2 - \frac{(\Sigma d)^2}{n}}{n-1}$$

$$t = \frac{\bar{d}\sqrt{n}}{s}$$

d	=	difference between the pre test V_s post test
$\bar{d}$	=	Mean difference
n	=	Total number of subjects
S	=	Standard deviation

Unpaired 'T'- Test

The unpaired t-test was used to compare the statistically significance difference of of BBS and SARA before and after treatment for Group A and Group B.

Formula for unpaired t –test,

$$S = \sqrt{\frac{(n_1-1){s_1}^2+(n_2-1){s_2}^2}{n_1+n_2-2}}$$

$$t = \frac{|\bar{x}_1-\bar{x}_2|}{s\sqrt{\frac{1}{n_1}+\frac{1}{n2}}}$$

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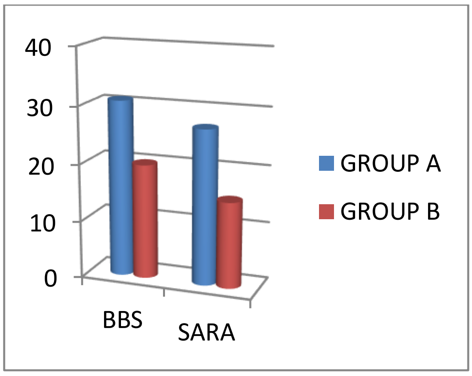
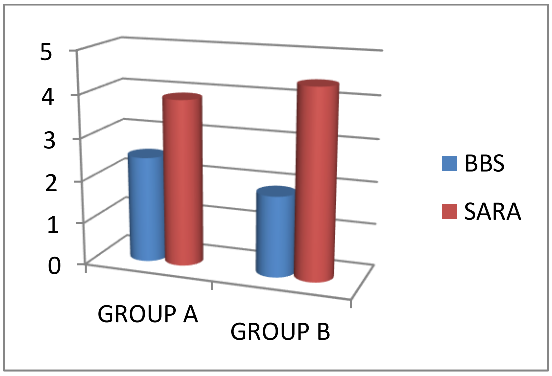
MAIN RESULTS

Mean Difference and Standard Deviation of GROUP A AND GROUP B OF BBS AND SARA

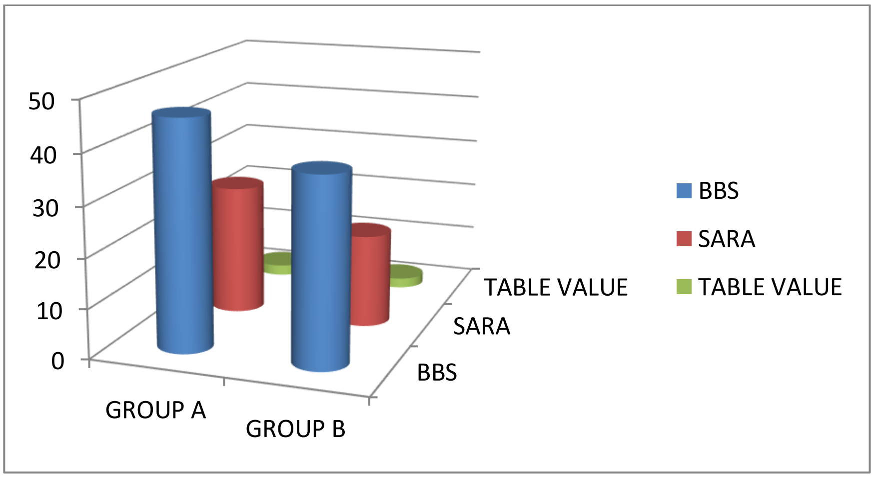
Groups	Mean Difference		Standard Deviation	
	BBS	SARA	BBS	SARA
Group A	30.73	27.00	2.49	3.9
Group B	20.00	15.00	1.89	3.1





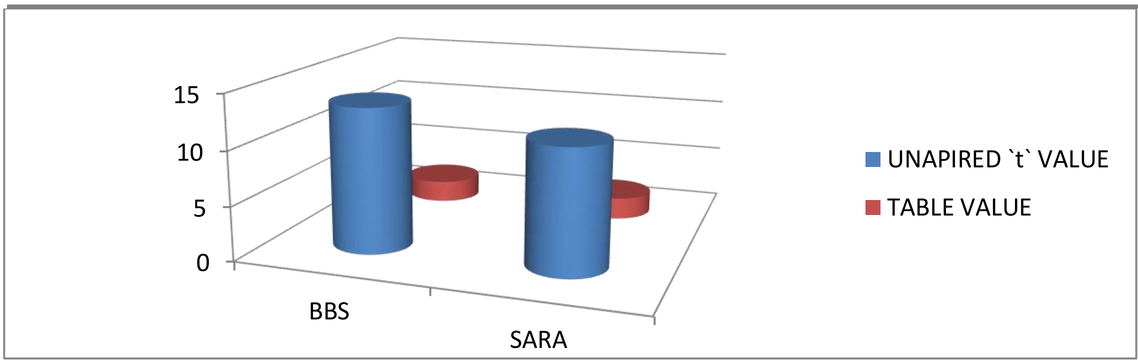
Comparison Of Paired 'T' Test And Table Value Between Bbs And Sara

Groups	Calculated t Value		Table Value	Significance
	BBS	SARA		
Group A	46.1	26.3	2.15	Significant
Group B	37.65	18.8	2.15	Significant



Comparision Of Unpaired 'T'test And Table Between Bbs And Sara

Parameters	Unpaired t Tesst Value	Table Value	Significance
BBS	13.39	2.05	Significant
SARA	11.42	2.05	Significant



RESULTS

The study included a total of 30 patients, with 15 participants assigned to Group A and 15 to Group B. The median interval between the initial and final assessments using the **Berg Balance Scale (BBS)** and the **Scale for the Assessment and Rating of Ataxia (SARA)** was four weeks. Group A received **single-task exercises**, while Group B underwent **dual-task exercises**.

In Group A, pre- and post-intervention scores were evaluated using BBS and SARA. The mean differences recorded were 30.73 and 27.00, with standard deviations of 2.49 and 3.90, respectively. The paired ‘t’ test values for BBS and SARA were 46.21 and 26.30, both exceeding the critical table value of 2.15, indicating statistically significant results at the 5% level.

For Group B, pre- and post-test assessments using BBS and SARA showed mean differences of 20.00 and 15.00, and standard deviations of 1.89 and 3.90, respectively. The paired ‘t’ test values in this group were 37.65 for BBS and 18.80 for SARA, both also surpassing the table value of 2.15 at the 5% significance level with 14 degrees of freedom.

Additionally, unpaired ‘t’ tests comparing the two groups yielded calculated values of 13.39 for BBS and 11.42 for SARA, both higher than the table value of 2.05 at a 5% level of significance with 28 degrees of freedom, indicating a statistically significant difference between the groups.

DISCUSSION

In addressing balance improvement in patients with **cerebellar ataxia**, the study revealed notable and effective progress. A statistically significant difference was observed in the impact of incoordination on patients’ balance before and after undergoing single-task and dual-task balance training. The findings indicated that both **static** and **dynamic balance** performance in individuals with ataxia were adversely affected during simultaneous task execution.

Dual-task exercises, including assessments of **postural sway** and **gait**, proved to be practical—easy to administer and not time-consuming. However, results from static balance tests showed that patients experienced difficulties during **tandem walking**, particularly when performing cognitive and motor tasks concurrently.

Supporting this, **Cardien Strouwen** concluded that both consecutive and integrated dual-task training produced lasting improvements without increasing the risk of falls. **Shashank Ghai** emphasized the importance of **verbalization** in dual-task scenarios, noting its role in enhancing **cognitive-motor interference**. Furthermore, **Winfried et al.** suggested that the effects of dual-tasking in cerebellar patients are, at least in part, due to the shared involvement of the **posterolateral cerebellar regions** in both **working memory** and **complex motor functions**.

Limitations

- The study was conducted on a relatively small sample size.

- The duration of the study was limited and short-term.
- The research focused exclusively on older adults, so the findings may not be generalizable to cerebellar ataxia patients across all age groups.

RECOMMENDATIONS:

1. Future studies should be carried out with a larger sample population to enhance the reliability of the findings.
2. Comparative studies involving different types of exercise interventions could provide deeper insights.
3. Participants should be encouraged to perform balance exercises at least twice daily to reinforce improvements.

BIBILOGRAPHY

1. Zijlstra, A., & Ufkes, T. (2014, December 15). Do dual tasks have an added value over single tasks for balance assessment in fall prevention programs? A mini review.
2. Strouwen, C. (2017, April 25). Training dual tasks together or apart in Parkinson's disease: Results from the DUALITY trial.
3. Lang, C. E. (2013, November). Cerebellar damage impairs automaticity of a recently practiced movement.
4. Stoodley, C. J. (2010, August). Evidence for topographic organization in the cerebellum of motor control versus cognitive and affective processing.
5. Het Reve, E. (2006, June 13). Strength and balance supplement with computerized cognitive training to improve dual task gait and divided attention in older adults: A multicenter randomized controlled trial.
6. Pilotto, F. (2018, August 21). Epidemiology of inherited cerebellar ataxias and challenges in clinical research.
7. Jacobi, H., & Alfes, J. (2017). Dual task effect on postural control in patients with degenerative cerebellar disorders.
8. Miyai, I. (2012, June 22). Cerebellar ataxia rehabilitation trial I: Degenerative cerebellar diseases.
9. Ahn, J. S. (n.d.). The effect of balance training based on the BBS for balance function in patients with cerebellar ataxia.
10. Marsden, J. F. (2018, May 5). Cerebellar ataxia (pp. 261–281).
11. Salman, M. S. (2018, February). Epidemiology of cerebellar diseases and therapeutic approaches.
12. Molinari, M., & Filippini, V. (2008). Neuronal plasticity of interrelated cerebellar and cortical networks.
13. Schmitz-Hübsch, T. (2013, January 15). Scale for the Assessment and Rating of Ataxia (SARA): Development of a new clinical scale.
14. Ghai, S. (2017, March 23). Effect of single task and dual task training on postural stability: A systematic review and meta-analysis.
15. Winser, S. J. (2018, June). Clinical assessment of balance using BBS and SARA in cerebellar ataxia: Synthesis of findings from a psychometric property analysis.
16. Taowu, & Liu, J. (2002, March). Cerebellar damage impairs automaticity of a recently practiced movement.
17. Kung, U. M. (2009). Postural instability in cerebellar ataxia: Correlations of knee, arm, and trunk movements to center of mass velocity.
18. Ilg, W., & Christensen, A. (2013). Effect of cerebellar lesions on working memory interacting with tasks of different complexities.
19. Ilg, W., & Brötz, D. (2010, October 15). Long-term effects of coordinative training in degenerative cerebellar disease.
20. Winser, S. P., & Pang, M. Y. C. (2019, May). Does integrated cognitive and balance (dual task) training improve balance and reduce fall risk in individuals with cerebellar ataxia? Journal of NeuroRehabilitation, 126, 149–253.