JRSR 12 (2025) 66-72

Journal of Rehabilitation Sciences and Research

Journal Home Page: jrsr.sums.ac.ir

Original Article

The Relationship between Attention and Balance in Children with Cerebral Palsy: A Comparative Preliminary Study in Diplegia and Hemiplegia

Mahrokh Ghahari[1], MSc; Aliyeh Daryabor[2], PhD; Minoo Kalantari[1*], PhD; Ashkan Irani[1], PhD; Zahra Shafiee[1], MSc

[1]Department of Occupational Therapy, School of Rehabilitation, Shahid Beheshti University of Medical Sciences, Tehran, Iran
[2]Physiotherapy Research Center, Department of Orthotics and Prosthetics, School of Rehabilitation, Shahid Beheshti University of Medical Sciences, Tehran, Iran

ARTICLE INFO

Article History:
Received: 28/05/2023
Revised: 29/01/2024
Accepted: 29/04/2024

Keywords:
Attention
Cerebral palsy (CP)
Dynamic balance
Static balance

Please cite this article as: Ghahari M, Daryabor A, Kalantari M, Irani A, Shafiee Z. The Relationship between Attention and Balance in Children with Cerebral Palsy: A Comparative Preliminary Study in Diplegia and Hemiplegia. JRSR. 2025;12(2):66-72. doi: 10.30476/jrsr.2024.98966.1376.

ABSTRACT

Background: Attention and concentration disorders, alongside tone disorders and imbalance, are among the significant challenges faced by children with cerebral palsy (CP). This study investigated the relationship between attention and balance in children with CP.

Methods: This cross-sectional study included 15 children with hemiplegia (mean age: 8.8±2 years) and 10 children with diplegia (mean age: 8.5±1.43 years) recruited from occupational therapy clinics in Tehran, Iran. All participants were classified as level II on both the Gross Motor Function Classification System (GMFCS) and the Manual Ability Classification System (MACS). Attention and balance were assessed using the Continuous Performance Test (CPT) and the Pediatric Balance Scale (PBS). Spearman's correlation coefficient was calculated to determine the relationship between attention and balance, with a significance threshold of α=0.05.

Results: The results showed no significant correlation between dynamic and static balance with attention (P>0.05) in children with hemiplegia. However, in children with diplegia, there were significant correlations between dynamic balance and attention (P=0.04), static balance and attention (P=0.01), and total balance and attention (P=0.02).

Conclusion: This study found a significant correlation between attention and balance in children with diplegic CP but not those with hemiplegic CP. Given that children with diplegia exhibited weaker dynamic and static balance compared to those with hemiplegia, their balance deficits appear to demand more significant attentional resources. Due to the small sample size, further research is necessary to validate these findings.

Introduction

Cerebral Palsy (CP) is a permanent, non-progressive brain lesion that occurs before birth or in early life, affecting motor development [1, 2]. The average prevalence of CP is estimated to be between 1.5 and 3.0 per 1000 live births, though this rate may vary among specific patient groups due to various factors [2]. In Iran, the prevalence is reported to be around 2 to 2.6 per 1000 live births [3]. Evidence shows that low birth weight is one of the most common risk factors for predicting CP-related complications [4, 5]. The incidence of CP is 70 times higher in children born with a body weight of less than 1500 grams compared to those born with a

Corresponding author:* Minoo Kalantari, PhD; Department of Occupational Therapy, School of Rehabilitation, Shahid Beheshti University of Medical Sciences, Damavand street, Emam Hossein squre, Postal code: 1616913111, Tehran, Iran. **Tel: +98 21 77542057; **Email:** mn_kalantari@yahoo.com

body weight of over 2500 grams. The diagnosis of CP primarily relies on assessing motor function and postural disorders, which manifest in early childhood and persist throughout life [2]. From a topographical perspective, children with CP are classified into several types of motor impairments, including diplegia, hemiplegia, quadriplegia, monoplegia, and triplegia [6, 7].

Motor impairments are one of the primary symptoms of CP, but they are often associated with other disorders such as perceptual-sensory deficits, epilepsy, cognitive problems (e.g., attention deficits), and executive function disorders [2, 8, 9]. Among these, deficiencies in balance and posture represent significant challenges for individuals with CP [10-12]. Balance and postural control are essential for effective performance in fundamental life activities and rely on the interaction between the visual-vestibular systems, peripheral systems, the Central Nervous System (CNS), and neuromuscular responses [13].

For nearly 90% of children with CP who achieve the ability to walk, reduced postural dysfunction plays a crucial role in their participation in sports and physical activities [14]. Furthermore, high manual ability in children with CP has been linked to greater involvement in various areas of life [15]. However, the child's cognition is one of the critical factors influencing the acquisition of movement skills, the development of trunk control, and anti-gravity muscle strength. In typically developing children, cognition develops significantly from 1 to 1.5 years of age. Although cognition and action are closely related, no definitive evidence links postural control disorders—such as sitting balance—to attention deficits in children with CP [16].

Previously, postural control was considered an automatic process. However, recent studies have shown that postural limitations in children with CP often require conscious attention, which plays a role in the proper execution of balance-related tasks [17-19]. Since postural control in children with CP involves static and dynamic adaptations, these activities can be seen as dual-task scenarios in intervention strategies. For instance, walking while maintaining attention on posture represents a dual-task demand, highlighting the need to address attention deficits in interventions aimed at improving trunk control [20].

A child's cognition is one of the key factors influencing the acquisition of movement skills, the development of trunk control, and anti-gravity muscle strength. Attention, a fundamental component of cognition, typically develops around 18 months in children with typical development. While cognition and action are interrelated, no definitive correlation has been established between postural control disorders, such as sitting balance, and attention in children with CP [16].

Previously, postural control was believed to be an automatic process. However, recent studies indicate that postural limitations in children with CP are linked to brain abnormalities. These abnormalities may necessitate an increased focus on attention during the implementation of balance-related functions, driven by the role of cranial nerves in each hemisphere of the brain [17-19].

Given that postural control in children with CP requires static and dynamic adaptation, these activities can be conceptualized as dual tasks in interventions addressing motor and sensory control functions. It is crucial to consider both walking tasks and attention capacity as integral to improving outcomes for children with CP, particularly for those with co-occurring Attention Deficit Disorder (ADD). Furthermore, enhancing trunk control must remain a central focus for achieving meaningful progress in children with CP [20].

Although there is a recognized relationship between the severity of motor and cognitive abnormalities across all types of CP, it cannot be conclusively stated that this relationship solely depends on the fundamental parameter of attention [21, 22]. Maintaining proper balance is a critical daily task, compensating for brain abnormalities affecting attention. Experimental evidence suggests that attention is essential for integrating sensory brain functions in postural control disorders, thereby improving control performance [23-25].

Although CP is a non-progressive condition [1], secondary factors that arise over time can significantly impact the functional abilities of these children in various ways [2]. Given the challenges posed by postural control impairments in daily activities, this study examined the relationship between attention and balance. Understanding this relationship is a critical step toward designing more effective treatment plans for children with CP.

Methods

Participants

This cross-sectional study recruited children with CP aged 6 to 12 years from various occupational therapy clinics in Tehran. Using statistical data from a pilot study involving five children with hemiplegia and 5 with diplegic CP, the sample size was determined to be 15 children in each group. The calculation of the sample size was based on the correlation of data from the pilot study, applying the following mathematical model:

$$\alpha = 0.05, \beta = 0.1, \; Z_\alpha = 1.96, Z_\beta = 1.28$$

$$n = \frac{(Z_\alpha + Z_\beta)^2}{\{\frac{1}{2}\ln({}^{1+r}/_{1-r})\}^2} + 3$$

The inclusion criteria included: 1) age between 6 and 12 years, 2) Gross Motor Function Classification System (GMFCS) levels I or II, 3) Manual Ability Classification System (MACS) levels I or II, 4) ability to understand simple commands, (5) capability to distinguish simple shapes and recognize numbers 1 through 10, and 6) no uncorrected visual and hearing impairment. The exclusion criteria were lack of cooperation during the assessments or the occurrence of any issues, such as brain seizures, during the test.

Including children at MACS levels I and II ensured participants could complete the attention tests. This research study was approved by the Ethics Committee at Shahid Beheshti University of Medical Sciences (Ethics Code: IR.SBMU.RETECH.REC.1401.049). The study objectives were clearly explained to the parents of the participating children, and informed consent was obtained before proceeding. Demographic information was collected from the parents, and the researcher conducted both evaluations during the summer of 2019 in Tehran clinics.

Data Collection Tools

Gross Motor Function Classification System (GMFCS)

The GMFCS is a standardized tool used to assess the gross motor function of children with CP from birth to 18 years of age. It focuses on self-initiated movement, emphasizing sitting, mobility, and locomotion. This classification system is divided into five levels representing meaningful differences in daily life activities. However, distinctions between levels at specific ages may not always be clear or well-defined.

The GMFCS was revised and expanded in 2007 by Palisano et al. [26]. In this classification, Level II includes children who can move independently inside and outside the home and climb stairs while holding onto railings. However, these children experience limitations in walking on uneven surfaces and cannot perform movements such as running and jumping, even under the most optimistic circumstances. The validity and reliability of the Persian version of the GMFCS were tested by Dehghan et al. in 2011 [27].

Manual Ability Classification System (MACS)

The MACS is a performance-based assessment tool introduced by Penta et al., developed based on the GMFCS framework. This tool evaluates hand function in children with CP, aged 4 to 18, by assessing their ability to manipulate objects during daily activities.

The MACS focuses explicitly on activities involving object manipulation within the individual's personal space or close to the body. It does not encompass tasks requiring interaction with objects out of reach. The system classifies hand function into five levels, where Level I represents the highest manual ability and Level V represents a lack of active manual function. This tool evaluates activities in contexts such as play and leisure, providing a detailed understanding of a child's functional hand use during everyday tasks [28, 29]. The validity and reliability of the Persian version of MACS for the Iranian population have been established, making it a suitable tool for clinical use in this context [30].

Continuous Performance Test (CPT)

The CPT evaluates sustained attention or vigilance in various populations while seated. During this test, 150 stimuli are presented, of which 20% are target stimuli requiring the subject's response. Each stimulus is displayed for 250 milliseconds, with a one-second interval between stimuli [31, 32]. The type of stimulus (e.g., number or shape) is selected when entering the individual's characteristics, and the target stimulus is designated on the results page. The test records the following parameters: A) Correct Detection: This refers to the number of times the client successfully responded to the target stimulus. B) Omission Errors: This indicates the number of times the target stimulus was presented, but the client failed to respond. C) Commission Errors: This counts the number of times the client responded when no target stimulus was presented. D) Reaction Times: This measures the time interval between the presentation of the stimulus and the client's response.

The test must be conducted in a quiet, well-lit environment conducive to concentration. Psychometric conditions should be observed to ensure the subject performs to the best of their ability. To achieve optimal results, the examiner is advised to create a comfortable and friendly atmosphere with informal conversation before starting the primary test [33, 34].

Pediatric Balance Scale (PBS)

The PBS measures the functional balance of children with CP aged 4 to 15 years, specifically including those with GMFCS levels I–Ш [35]. This evaluation consists of 14 items, with 7 items assessing dynamic balance and 7 items assessing static balance. The test can be completed within approximately 15 minutes. Items 1–3 and 10–13 are related to dynamic balance, while items 4–9 (with item 4 explicitly focusing on static balance) assess static balance [36].

The maximum achievable score on the test is 56. Required tools for administering the test include a stopwatch, a chair with armrests, a 15 cm step ladder, a meter, and an object like a rubber. Scoring ranges from 0 to 4, where a score of 0 represents the inability to perform the activity, and a score of 4 indicates competent and complete performance of the task.

The validity and reliability of the Persian version of the PBS for children with CP have been confirmed in previous studies. The criterion validity of the tool is reported to be less than 0.001. Furthermore, both test-retest and inter-rater reliability were found to be at a statistically significant level of 0.0001. The internal consistency of the Persian version of the PBS was found to be highly favorable, with a reliability rate of 98% [36-38].

Procedure

Researchers conducted all evaluations in Tehran's clinics during the summer of 2019. The PBS and the CPT assessed balance and attention. The CPT was administered first, followed by the PBS for each participant.

A preliminary trial was conducted to familiarize children with the CPT. Necessary instructions were displayed on the screen, and the test commenced once the researcher ensured that the child fully understood the procedure. Three sets of 50 different shapes or numbers were repeatedly presented on a computer monitor during the test. The child was instructed to press the SPACE key to select the specific shape or number indicated by the test. Upon completion, the results displayed on the monitor included the number of errors, the number of missing figures, the number of correct detections, and the time of the test.

The CPT score was determined based on the number of correct detections. Each child completed the CPT in a quiet room with adequate lighting, was seated in a standard chair, and followed all test instructions.

After a short break, the PBS was individually administered to each child. The 14 PBS tasks were performed following the researcher's guidance. If any part of the instructions was unclear to the child, further clarification was provided to ensure comprehension. The results of the PBS, including dynamic balance scores, static balance scores, and total balance scores, were recorded in a structured database for further analysis.

Data Analysis

The normality of the data was evaluated using the Shapiro-Wilk test. Spearman's correlation was applied to determine the relationship between the two research variables (attention and balance). The significance level was set at P≤0.05, and all data were analyzed using SPSS version 20.

Results

Of the 30 participants initially recruited, five children were excluded from the study due to non-cooperation during the tests. This included behavioral issues as well as seizures during the testing process. Consequently, data from a total of 25 children with diplegic and hemiplegic CP were included in the final analysis.

Table 1 details the participants' demographic characteristics, while Table 2 summarizes the mean and standard deviation for key variables. These variables include the number of correct, incorrect, and omitted responses, response times from the CPT, dynamic and static balance scores, and total balance scores derived from the PBS.

In examining the relationship between attention and balance using the Spearman correlation coefficient, no significant correlation was observed in children with hemiplegia. Specifically, there was no significant correlation between dynamic balance and attention (P=0.742, r=0.093), static balance and attention (r=0.046, P=0.870), or total balance and attention (P=0.936, r=0.023) (Table 2).

In contrast, in children with diplegia, significant correlations were found between dynamic balance and attention (P=0.049, r=0.633), static balance and attention (P=0.014, r=0.742), and total balance and attention (P=0.021, r=0.711) (Table 3).

When comparing the two groups (Table 4), the results revealed significant differences between children with hemiplegia and those with diplegia in dynamic balance,

Table 1: Demographic Information of Children with Cerebral Palsy

Group	Hemiplegia	Diplegia
N	15	10
Age (Mean+ SD)	8.8±2	8.5±1.43
Levels	Level II(n=15)	Level II(n=10)
GMFCS levels	Level II(n=15)	Level II(n=10)
Sex	Female(n=6) Male(n=9)	Female(n=6) Male(n=4)
Educational level	Preschool(n=3) School(n=12)	Preschool(n=2) School(n=8)

GMFCS: Gross Motor Function Classification System, MACS: Manual Ability Classification System

Table 2: Test Results of Continuous Performance Test (CPT) and Pediatric Balance Scale (PBS) in Children with Diplegia and Hemiplegia

Groups	Results	Utnit	Mean	SD	Max	Min
Hemiplegia	Correct Detection	Number	139.9	4.31	147	132
	Commission errors	Number	4.4	3.7	15	1
	Omission errors	Number	5.6	3.15	11	1
	Reaction times	Minutes	638.4	97.3	859	465
	Dynamic balance test	Score	27	1.25	28	24
	Static balance test	Score	22.2	2.40	26	18
	Total balance	Score	49.2	3.26	54	43
Diplegia	Correct Detection	Number	142.6	4.27	148	137
	Commission errors	Number	4.1	2.95	9	1
	Omission errors	Number	3.3	3.05	10	0
	Reaction times	Minutes	660.6	112.8	864	501
	Dynamic balance test	Score	20.4	5.9	28	12
	Static balance test	Score	18.3	3.77	25	13
	Total balance	Score	38.7	9.499	52	28

Table 3: Distribution of Spearman's Correlation Values Between Dynamic, Static, and Total Balance Variables with the Attention Variable

Type of cerebral palsy	Variables	Correlation coefficient	P value
Hemiplegia	Dynamic balance and attention	0.093	0.742
	Static balance and attention	0.046	0.870
	Total balance and attention	0.023	0.936
Diplegia	Dynamic balance and attention	0.633	0.049
	Static balance and attention	0.742	0.014
	Total balance and attention	0.711	0.021

Table 4: Comparison Between Diplegia and Hemiplegia Groups on Balance and Attention Variables

	Variables	F	P value
Comparison between two groups (hemiplegia and diplegia)	Dynamic balance	25.722	0.007*
	Static balance	3.938	0.011*
	Total balance	15.518	0.007*
	Correct response	0.220	0.144
	Omit response	0.401	0.076
	Error response	0.019	0.825
	time response	0.169	0.617

*P<0.05

static balance, and total balance (P<0.05). However, no significant difference was found in attention variables between the two groups (P>0.05).

Discussion

This study aimed to explore the relationship between attention and balance in children with hemiplegia and diplegia who have CP aged 6 to 12. The results demonstrated a significant relationship between attention and balance in children with diplegia, as measured by the CPT and the PBT.

The findings indicated no significant correlation between attention and dynamic or static balance in children with hemiplegia. In contrast, a significant relationship was observed between attention and dynamic and static balance in children with diplegia. These findings are somewhat in line with previous studies; for example, Abuin-Porras et al. found a significant relationship between visual attention and balance in children aged 4–5 years [39]. Reilly et al. also highlighted a significant relationship between executive attention capacity and postural control interference during dual-task conditions in children with CP [17]. However, to our knowledge, no direct comparison has been made between different types of CP concerning attention and balance.

When comparing the balance abilities between the two groups, the data revealed significant differences in static and dynamic balance between children with hemiplegia and those with diplegia. In this study, all children with hemiplegia achieved a full score in the sitting without the static balance test support item. Additionally, the average dynamic balance score for children with hemiplegia was 27 out of 28. This favorable score could be attributed to the presence of specific items, such as the sit-to-stand task, which may have allowed the children to control the movement better using their unaffected legs [40, 41]. This could explain the lack of a significant relationship between attention and balance in the hemiplegia group.

Each child responded to the CPT test while seated on a regular chair, which was adjusted to the patient's height so that both feet were flat on the floor. This seating arrangement allowed the child to allocate more attentional resources to the task, avoiding the demands of a dual-task condition. This setup might explain the two groups' lack of significant attention differences. However, it's important to note that during the test, the children leaned forward slightly rather than fully leaning back against the chair, making trunk balance a vital consideration.

Impaired postural control can increase the attentional demands associated with balance in patients with neurologic conditions [42]. When comparing the balance between the two groups, it was found that children with hemiplegia had significantly different static and dynamic balance abilities compared to those with diplegia. This suggests that children with hemiplegia might require more attentional resources in dual-task conditions. Roostaei et al. explored how children with CP respond to dual tasks, emphasizing that impairments significantly influence their neuromuscular responses in neurotransmitter functioning [43].

However, the role of cognitive tasks in postural control can vary depending on the age group [44]. For example, in a wide-stance single-task condition, children with spastic CP aged 10–14 years did not show a significant difference in postural stability compared to typically developing children aged 7–12 years [17]. This highlights the importance of considering the patient's age during evaluations and interventions, as it helps to set more realistic expectations for the patient's progress in physical therapy.

In this study, all participants were at level II regarding manual ability according to the MACS. Children in level II can control most objects with their hands but perform related activities more slowly and with lower quality. Although both groups were at the same MACS level, children with hemiplegia used their unaffected hands to perform the CPT. Despite this, the study found no significant difference in attention scores between the two groups. Wist et al. suggested that children with CP often adopt a "posture second" strategy during dual tasks, such as alternating standing while naming fruits and animals. This strategy allowed them to maintain their cognitive performance without significantly impacting their balance [45]. It's possible that the children in this study employed a similar approach, meaning both hemiplegic and diplegic children allocated most of their attention to the cognitive task during the sitting position.

Several limitations were identified in this study, including the impact of the Coronavirus pandemic, which affected clinic operations and resulted in fewer participants. Additionally, the sample size was relatively small, which could limit the generalizability of the findings. A larger sample size would provide more robust data and lead to more valid conclusions regarding the relationship between attention and balance in children with CP. Future studies should also consider examining different age ranges in children with CP, especially extending to adults. Moreover, various tools, such as force plates, could provide further insights into the balance-performance correlation.

Conclusion

The findings of this study suggest a significant correlation between attention and balance in children with diplegic CP but not in those with hemiplegia. Given that diplegic children exhibit weaker dynamic and static balance compared to their hemiplegic peers, attention resources may be more heavily allocated to maintaining balance. However, due to the small sample size, further research is needed to confirm these results and enhance the understanding of the relationship between attention and balance in CP.

Acknowledgment

I sincerely thank all the patients and their parents who participated in this study. I would also like to thank Dr. Hossain Islambalchi for his valuable guidance in revising the manuscript.

Key Highlights

There is no significant correlation between attention and dynamic or static balance in children with hemiplegic cerebral palsy (CP).

A significant correlation exists between attention and dynamic and static balance in children with diplegic CP.

The position evaluation parameter strongly influences the relationship between attention and balance.

Plain Language Summary

Based on the research results focused on children with cerebral palsy, the correlation between attention and balance depends on the position evaluation parameter. Additionally, children with hemiplegic CP had a better ability to maintain their balance in a sitting position.

Funding

No funding was received for this submission.

Conflict of Interest: None declared.

References

1. Piitulainen H, Kulmala J-P, Mäenpää H, Rantalainen T. The gait is less stable in children with cerebral palsy in normal and dual-task gait compared to typically developed peers. Journal of biomechanics. 2021;117:110244.
2. Sadowska M, Sarecka-Hujar B, Kopyta I. Cerebral palsy: current opinions on definition, epidemiology, risk factors, classification and treatment options. Neuropsychiatric disease and treatment. 2020:1505-18.
3. Amiri A, Akbarfahimi N, Hosseini SA. The Correlation Between Leisure Participation and Parental Life Balance in Children and Adolescents With Cerebral Palsy and Their Typically Developing Peers. Iranian Rehabilitation Journal. 2022;20(2):139-48.
4. Jahan I, Muhit M, Hardianto D, Laryea F, Chhetri AB, Smithers-Sheedy H, et al. Epidemiology of cerebral palsy in low-and middle-income countries: preliminary findings from an international multi-centre cerebral palsy register. Developmental Medicine & Child Neurology. 2021;63(11):1327-36.
5. Khandaker G, Muhit M, Karim T, Smithers-Sheedy H, Novak I, Jones C, et al. Epidemiology of cerebral palsy in Bangladesh: a population-based surveillance study. Developmental Medicine & Child Neurology. 2019;61(5):601-9.
6. Rojas VG, Rebolledo GM, Muñoz EG, Cortés NI, Gaete CB, Delgado CM. Differences in standing balance between patients with diplegic and hemiplegic cerebral palsy. Neural regeneration research. 2013;8(26):2478.
7. Soleimani F, Vameghi R, Rassafiani M, AKBAR FN, Nobakht Z. Cerebral palsy: motor types, gross motor function and associated disorders. 2011.
8. Mak C, Whittingham K, Cunnington R, Boyd RN. Effect of mindfulness yoga programme MiYoga on attention, behaviour, and physical outcomes in cerebral palsy: a randomized controlled trial. Developmental Medicine & Child Neurology. 2018;60(9):922-32.
9. Pashmdarfard M, Amini M, NAMAZI NG, RASSAFIANI M. Does parent report gross motor function level of cerebral palsy children impact on the quality of life in these children? Iranian journal of child neurology. 2017;11(4):52.
10. Schmit J, Riley M, Cummins-Sebree S, Schmitt L, Shockley K. Children with cerebral palsy effectively modulate postural control to perform a supra-postural task. Gait & posture. 2015;42(1):49-53.
11. Gabis LV, Tsubary NM, Leon O, Ashkenasi A, Shefer S. Assessment of abilities and comorbidities in children with cerebral palsy. Journal of child neurology. 2015;30(12):1640-5.
12. Bonnechère B, Omelina L, Jansen B, Van Sint Jan S. Balance improvement after physical therapy training using specially developed serious games for cerebral palsy children: preliminary results. Disability and rehabilitation. 2017;39(4):403-6.
13. de AC Duarte N, Grecco LAC, Franco RC, Zanon N, Oliveira CS. Correlation between Pediatric Balance Scale and functional test in children with cerebral palsy. Journal of physical therapy science. 2014;26(6):849-53.
14. Lazzari RD, Politti F, Belina SF, Collange Grecco LA, Santos CA, Dumont AJL, et al. Effect of transcranial direct current stimulation combined with virtual reality training on balance in children with cerebral palsy: a randomized, controlled, double-blind, clinical trial. Journal of motor behavior. 2017;49(3):329-36.
15. Pashmdarfard M, Badv RS. The impact of manual ability level on participation of children with cerebral palsy in life areas: a cross-sectional study. Iranian Journal of Child Neurology. 2019;13(3):83.
16. Surkar SM, Edelbrock C, Stergiou N, Berger S, Harbourne R. Sitting postural control affects the development of focused attention in children with cerebral palsy. Pediatric Physical Therapy. 2015;27(1):16-22.
17. Reilly DS, Woollacott MH, van Donkelaar P, Saavedra S. The interaction between executive attention and postural control in dual-task conditions: children with cerebral palsy. Archives of physical medicine and rehabilitation. 2008;89(5):834-42.
18. Reilly DS, van Donkelaar P, Saavedra S, Woollacott MH. Interaction between the development of postural control and the executive function of attention. Journal of motor behavior. 2008;40(2):90-102.
19. Brauer S, Broome A, Stone C, Clewett S, Herzig P. Simplest tasks have greatest dual task interference with balance in brain injured adults. Human movement science. 2004;23(3-4):489-502.
20. Cherriere C, Martel M, Sarrasin A, Ballaz L, Tallet J, Lemay M. Benefits of a dance intervention on balance in adolescents with cerebral palsy. Physical & occupational therapy in pediatrics. 2020;40(5):518-33.
21. Bøttcher L, Stadskleiv K, Berntsen T, Christensen K, Korsfelt Å, Kihlgren M, et al. Systematic cognitive monitoring of children with cerebral palsy□the development of an assessment and follow-up protocol. Scandinavian Journal of Disability Research. 2016;18(4):304-15.
22. Pashmdarfard M, Richards LG, Amini M. Factors affecting participation of children with cerebral palsy in meaningful activities: systematic review. Occupational Therapy in Health Care. 2021;35(4):442-79.
23. Huxhold O, Li S-C, Schmiedek F, Lindenberger U. Dual-tasking postural control: aging and the effects of cognitive demand in conjunction with focus of attention. Brain research bulletin. 2006;69(3):294-305.
24. Teasdale N, Simoneau M. Attentional demands for postural control: the effects of aging and sensory reintegration. Gait & posture. 2001;14(3):203-10.
25. Palluel E, Chauvel G, Bourg V, Commare M-C, Prado C, Farigoule V, et al. Effects of dual tasking on postural and gait performances in children with cerebral palsy and healthy children. International Journal of Developmental Neuroscience. 2019;79:54-64.
26. Palisano RJ, Rosenbaum P, Bartlett D, Livingston MH. Content validity of the expanded and revised Gross Motor Function Classification System. Developmental Medicine & Child

Neurology. 2008;50(10):744-50.
27. Dehghan L, Abdolvahab M, Bagheri H, Dalvand H, Faghih Zade S. Inter rater reliability of Persian version of Gross Motor Function Classification System Expanded and Revised in patients with cerebral palsy. Daneshvar Medicine. 2020;18(6):37-44.
28. Eliasson A-C, Krumlinde-Sundholm L, Rösblad B, Beckung E, Arner M, Öhrvall A-M, et al. The Manual Ability Classification System (MACS) for children with cerebral palsy: scale development and evidence of validity and reliability. Developmental medicine and child neurology. 2006;48(7):549-54.
29. Eliasson AC, Ullenhag A, Wahlström U, Krumlinde-Sundholm L. Mini-MACS: development of the Manual Ability Classification System for children younger than 4 years of age with signs of cerebral palsy. Developmental Medicine & Child Neurology. 2017;59(1):72-8.
30. Riyahi A, Akbarfahimi N, Sarlak N, Abdolrazaghi H, Nobakht Z. Validating the Reliability and Validity of the Persian Version of the Mini-Manual Ability Classification System. Journal of Rehabilitation Sciences & Research. 2023;10(4):203-8.
31. Miranda MC, Sinnes EG, Pompéia S, Francisco Amodeo Bueno O. A comparative study of performance in the Conners' Continuous Performance Test between Brazilian and North American children. Journal of Attention Disorders. 2008;11(5):588-98.
32. Borgaro S, Pogge DL, DeLuca VA, Bilginer L, Stokes J, Harvey PD. Convergence of different versions of the continuous performance test: Clinical and scientific implications. Journal of clinical and experimental neuropsychology. 2003;25(2):283-92.
33. Roebuck H, Freigang C, Barry JG. Continuous performance tasks: Not just about sustaining attention. Journal of speech, language, and hearing research. 2016;59(3):501-10.
34. Conners CK, Epstein JN, Angold A, Klaric J. Continuous performance test performance in a normative epidemiological sample. Journal of abnormal child psychology. 2003;31:555-62.
35. Franjoine MR, Darr N, Held SL, Kott K, Young BL. The performance of children developing typically on the pediatric balance scale. Pediatric physical therapy. 2010;22(4):350-9.
36. Alimi E, Kalantari M, Nazeri A-R, Baghban AA. Test-retest & Inter-rater Reliability of Persian Version of Pediatric Balance Scale in Children with Spastic Cerebral Palsy. Iranian journal of child neurology. 2019;13(4):163.
37. Kalantari M, Alimi E, Irani A, Nazeri A, Akbarzade Baghban A. Content and face validity of Pediatric Balance Scale in children with spastic cerebral palsy. The Scientific Journal of Rehabilitation Medicine. 2016;5(3):104-10.
38. Franjoine MR, Darr N, Young B, McCoy SW, LaForme Fiss A. Examination of the effects of age, sex, and motor ability level on balance capabilities in children with cerebral palsy GMFCS levels I, II, III and typical development using the Pediatric Balance Scale. Developmental Neurorehabilitation. 2022;25(2):115-24.
39. Abuin-Porras V, Villafañe JH, Jiménez-Antona C, Palacios A, Martínez-Pascual B, Rodríguez-Costa I. Relationship between attention and balance: a dual-task condition study in children. Journal of exercise rehabilitation. 2018;14(3):349.
40. Brunt D, Greenberg B, Wankadia S, Trimble MA, Shechtman O. The effect of foot placement on sit to stand in healthy young subjects and patients with hemiplegia. Archives of physical medicine and rehabilitation. 2002;83(7):924-9.
41. Galli M, Cimolin V, Crivellini M, Campanini I. Quantitative analysis of sit to stand movement: experimental set-up definition and application to healthy and hemiplegic adults. Gait & Posture. 2008;28(1):80-5.
42. Shumway-Cook A, Woollacott MH. Motor control: translating research into clinical practice: Lippincott Williams & Wilkins; 2007.
43. Roostaei M, Raji P, Morone G, Razi B, Khademi-Kalantari K. The effect of dual-task conditions on gait and balance performance in children with cerebral palsy: A systematic review and meta-analysis of observational studies. Journal of bodywork and movement therapies. 2021;26:448-62.
44. Akbar Fahimi N, Hosseini SA, Rassafiani M, Farzad M, Haghgoo HA. The reactive postural control in spastic cerebral palsy children. Iranian Rehabilitation Journal. 2012;10(2):66-74.
45. Wist S, Carcreff L, Bruijn SM, Allali G, Newman CJ, Fluss J, et al. Gait stability in ambulant children with cerebral palsy during dual tasks. Plos one. 2022;17(6):e0270145.