Correlation between Anthropometric Measurements and Balance in Children with Hemiplegic Cerebral Palsy

Ahmed Ibrahim Ali Ibrahim[1], Gehan Hassan El Meniawy[2], Hassan Magdy El barbary[3], Walaa Abd El-Hakim Abd El-Nabie[4]
[1] Physical therapist, Senbellawein Health Administration, Dakahlia, Egypt
[2,4] Department of Physical Therapy for Pediatrics, Faculty of Physical Therapy, Cairo University, Giza, Egypt.
[3] Department of Orthopedic, Faculty of Medicine, Cairo University, Giza, Egypt.
Corresponding author: Ahmed Ibrahim Ali Ibrahim, **Email:** ptrservices2022@gmail.com, **Mobile:** 01050366830

ABSTRACT

Background: Children with cerebral palsy suffer from deficits in balance and multiple nutritional deficiencies.
Purpose: This study aimed to investigate the correlation between anthropometric measurements and balance in children with hemiplegic cerebral palsy.
Subjects and Methods: Thirty children with spastic hemiplegic cerebral palsy of both sexes with mean age of 8.48 ± 1.47 years participated in this study. Their degree of spasticity ranged from 1 to 2 according to the Modified Ashworth' Scale and they were on level I or II on the Gross Motor Function Classification System. Their mean body mass index (BMI) was 16.16 ± 2.86. Balance was assessed by the Biodex balance system, which is represented by overall stability index (OASI), the mediolateral stability index (MLSI) and the anteroposterior stability index (APSI).
Results: The results showed a moderate positive significant correlation between weight and OASI, APSI and MLSI ($r = 0.419$, $r = 0.364$, $r = 0.434$ respectively). Also, there was a moderate positive significant correlation between height and OASI and MLSI ($r = 0.378$, $r = 0.378$ respectively), while there was a moderate positive non-significant correlation with APSI ($r = 0.318$). Additionally there was a weak positive non-significant correlation between BMI with OASI, APSI and MLSI ($r = 0.180$, $r = 0.152$, $r = 0.207$, $p = 0.271$ respectively).
Conclusion: Weight, height and BMI influence the ability of children with hemiplegic cerebral palsy to maintain balance.
Keywords: Anthropometric measurements, Cerebral palsy, Hemiplegia, Balance.

INTRODUCTION

Brain trauma sustained during fetal development or soon after birth is the cause of cerebral palsy (CP), a neurodevelopmental condition. It can seriously affect a child's ability to move, resulting in diminished muscle coordination and motor function. Additionally, children with CP have poor balance, which further impairs their ability to walk and their level of physical activity **(1)**.

A type of spastic cerebral palsy known as hemiplegia affects one arm and one leg on either the left or right side of the body **(2)**. Hemiplegic CP constitutes 20–30% of all forms of CP **(3)**.

Weight bearing through the unaffected leg is a common occurrence in asymmetric alignment, which may be an attempt to compensate for muscle paresis in the hemiplegic leg. Despite its functionality, this approach might not be the best due to higher energy costs and long-term overuse injuries. This uneven weight-bearing pattern combined with innate spasticity may cause muscle atrophy, stunted growth, paretic side weakness, and impaired balance **(4)**.

Anthropometric measurements are a methodical approach that use trustworthy, legitimate, and scientifically recognized measurements for classifying and sizing the physical characteristics of the human body. Put another way, it's a method for figuring out the physical dimensions of the human body. These days, anthropometric measurements are thought to be the most significant parameter for determining body composition **(5)**. Anthropometric evaluation is a commonly employed technique to evaluate the nutritional condition of children with cerebral palsy. Instead of utilizing weight for height, it is advised to use the body mass index (BMI), which is calculated by dividing a person's weight in kilograms by the square of their height in meters **(6)**.

The fundamental element of the definition of cerebral palsy is impaired control of posture because dysfunctional regulation of posture interferes with day-to-day activities. Balance, which can be characterized as the process of preserving, reaching, or reestablishing the center of mass in relation to the base of support, requires control over posture. The intricate integration of several body systems, including the vestibular, visual, auditory, proprioceptive, and higher-order premotor systems, results in balance. One of the balance system's functional objectives is to (1) preserve a particular postural stance (standing or sitting), (2) facilitate voluntary motion, including the switching between different postures, and (3) regain balance following outside disruptions, like a push, tumble, or slip **(7)**.

In hemiplegic CP, there are changes in both static and dynamic postural stability parameters. Hemiplegic toddlers and adults can walk without the need for assistance, but their gaits are irregular **(8)**.

Received: 03/04/2023
Accepted: 30/05/2023

The goal of this study was to examine the relationship between anthropometric measurements and balance in children with hemiplegic cerebral palsy, given that maintaining balance is crucial for completing activities of daily living (ADL) and that balance is impacted in hemiplegic CP.

SUBJECTS AND PROCEDURES

Study design: Cross-sectional study design that included 30 hemiplegic CP of both sexes. They were recruited from the Outpatient Clinic of the Faculty of Physical Therapy, Cairo University. This study was conducted from September 2021 to February 2023.

Inclusion criteria: Age ranged from 6 to 12 years. The degree of spasticity ranged from 1 to 2 according to Modified Ashworth' Scale (MAS) [9]. They were level I or II on the Gross Motor Function Classification System (GMFCS) [10]. BMI ranged from 0 percentile to 84th percentile [11]. Able to stand without assistive devices and follow the instructions to complete the assessments.

Exclusion criteria:

The children were excluded if they had one of the following: 1) Visual or auditory impairment, 2) Fixed deformities of the lower extremities, or 3) Botulinum toxin injections in the last 6 months.

Procedures for Evaluation:

1- Evaluation of anthropometric measurements: Weight, height and BMI for each child were evaluated to determine the anthropometric measurements.

A) Evaluation of weight and height:

Weight and height were measured using a portable stadiometer with a movable headpiece (FM -S120 China) [12]. Every parent was informed about the goals and methods of the study for their kid. Before the assessment, the evaluative methods were given to each child to ensure that they were all familiar with the equipment and the stages involved in the process. To get an accurate weight and height, each child was requested to take off their outer garments, shoes, and hair accessories. They were also instructed to stand in the center of the scale with their feet slightly apart (on the footprints, if marked), and to remain still until the weight was taken. Every youngster was instructed to stand with their heels together, legs straight, arms at their sides, and shoulders relaxed against the stadiometer. The child's headgear was brought down to touch the top of the head with sufficient pressure to compress the hair in order to achieve an accurate height measurement. The child's eyes were gazing straight ahead, and their chin was neither tucked nor extended too far back [13].

2) Evaluation of Body Mass Index:

Children's body mass index (BMI) is compared to reference values based on their age and gender. Throughout the US, the 2000 CDC 2000 charts serve as reference values [14].

- Calculate the BMI value by using this formula: Metric System Formula: weight (kg) / [height (m^2)].

-Determine the BMI percentile by Plotting the BMI number on the appropriate CDC BMI-for-age growth chart (for either girls or boys) [15].

3- Evaluation of Balance: The Biodex balance system (BBS) (Biodex, Shirley, NY) was employed to evaluate each child's balance as part of the current investigation. The Biodex balance system (BBS) demonstrated strong validity and reliability when assessing dynamic postural balance [16]. The Biodex balance system (BBS) consists of the platform is round and has 12 levels of movement control. It may move freely in the anterior-posterior and medial lateral axes at the same time. Dedicated software is used to interface with the BSS device (Biodex, Version 1.08, Biodex, Inc.) enabling the BSS to calculate the average sway score by measuring the tilt in each axis. The resistance to movement (platform stability level) is provided by eight springs that are positioned beneath the outer border of the platform. Levels of resistance vary from 8 (most stable) to 1 (least stable) [17].

The foot platform is one of the main parts and adjusting mechanisms of the Biodex system, wheels, joy-stick port, support handle, support handle release pin, printer, computer port, display module, and locking knob for the display height [18]. Before beginning the evaluation process, each kid received an explanation of the assessment's purpose. Every child was told to take off their shoes and place themselves on the foot platform. Before the evaluation process, all children received an explanation session so they could understand the various test stages. Every child was instructed to take a two-leg stance in the middle of the secured platform.

The toddler may now stare directly at the display thanks to adjustments made to it. The child's height, age in months, and platform firmness (stability level) were entered into the gadget. Every youngster underwent a 30-second exam on the stability level 5 [19].

The center of gravity (COG) of the child was positioned over the point of the vertical ground reaction force by performing centering steps. The child was then instructed to maintain the position of his or her feet until the platform stabilized, at which point the coordinates of the heels and feet were recorded from the platform. Each test run ended with the acquisition of a printed report.

Included in this report were the following metrics: the anteroposterior stability index (APSI), which represents the foot platform displacement in degrees from level for motion in the sagittal plane, the mediolateral stability index (MLSI), which represents the foot platform displacement in degrees from level for motion in the frontal plane, and the overall stability index (OASI), which represents the variance of the foot platform displacement in degrees from level in all motions during the test [20].

Ethical considerations:

Ethical Committee of the Faculty of Physical Therapy, Cairo University approval was obtained before starting the study (P.T.REC/012/003333). A signed informed consent was obtained from each child' parent giving their acceptance for participation in the study and publication of the results. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Statistical analysis

Descriptive statistics was utilized in presenting the subjects demographic and collected data.

Pearson Correlation Coefficient was conducted to investigate the correlation between weight, height and BMI and balance indices. The level of significance for statistical tests was set at $p \leq 0.05$. All statistical measures were performed through the statistical package for social sciences (SPSS) version 25 for windows.

RESULTS

Subject characteristics:

Thirty children with hemiplegic cerebral palsy participated in this study group. Their mean age, weight, height and BMI were 8.48 ± 1.47 years, 26.27 ± 5.87 kg, 127.30 ± 9.58 cm and 16.16 ± 2.86 kg/m² respectively (Table 1).

Table (1): Participant characteristics

	Mean ± SD	Maximum	Minimum
Age (years)	8.48 ± 1.47	12	6
Weight (kg)	26.27 ± 5.87	42	20
Height (cm)	127.30 ± 9.58	156	113
BMI (kg/m²)	16.16 ± 2.86	26.13	11.52
	N	**%**	
	Sex distribution, n (%)		
Girls	15	50	
Boys	15	50	
	Spasticity grades, n (%)		
Grade I	20	66.7	
Grade II	10	33.3	
	GMFCS level, n (%)		
Level I	18	60	
Level II	12	40	

SD, Standard deviation

- Balance measurement of subjects: The mean value of OASI, APSI and MLSI of study group was 2.21 ± 0.96, 1.65 ± 0.70 and 1.61 ± 0.73 respectively (Table 2).

Table (2): Descriptive statistics of OASI, APSI and MLSI measurement

	Mean ± SD	Minimum	Maximum
OASI	2.21 ± 0.96	1.4	5.7
APSI	1.65 ± 0.70	1	4.4
MLSI	1.61 ± 0.73	0.8	3.9

SD: Standard deviation

Correlation between weight, height and BMI and balance indices: The correlations between weight and balance indices were moderate positive significant correlation with OASI (r = 0.419, p = 0.021), APSI (r = 0.364, p = 0.048) and MLSI (r = 0.434, p = 0.016). The correlations between height and balance indices were moderate positive significant correlation with OASI (r = 0.378, p = 0.039) and MLSI (r = 0.378, p = 0.039) while was moderate positive non-significant correlation with APSI (r = 0.318, p = 0.087). The correlations between BMI and balance indices was weak positive non-significant correlation with OASI (r = 0.180, p = 0.342), APSI (r = 0.152, p = 0.422) and MLSI (r = 0.207, p = 0.271) (Table 3).

Table (3): Correlation between weight, height and BMI and balance indices

	Weight		Height		BMI	
	r - value	**P- value**	**r - value**	**P- value**	**r - value**	**P- value**
OASI	0.419	0.021*	0.378	0.039*	0.180	0.342
APSI	0.364	0.048*	0.318	0.087	0.152	0.422
MLSI	0.434	0.016*	0.378	0.039*	0.207	0.271

r value: Pearson correlation coefficient; p value: Probability value, * significant at $p < 0.05$.

DISCUSSION

The current study's goal was to determine the relationship between anthropometric measurements & equilibrium in kids with hemiplegic cerebral palsy. Thirty youngsters, ranging in age from 6 to 12 years, were evaluated by using a portable stadiometer with a movable headpiece to assess height, weight, and the Biodex system to determine equilibrium. According to the latest findings, there was a rather substantial positive association between weight and OASI, APSI and MLSI (r = 0.419, r = 0.364, r = 0.434 respectively). Also, there was a moderate positive significant correlation between height and OASI and MLSI (r = 0.378, r = 0.378), although a moderately positive, non-significant association was found with APSI (r = 0.318). Also, a weak positive non-significant correlation between BMI with OASI, APSI and MLSI (r = 0.180, r = 0.152, r = 0.207, p = 0.271 respectively) was found.

Given that people with hemiplegic CP typically have smaller muscles on the affected side of their body than the unaffected side, the current finding regarding the link between weight and balance may be the result of an asymmetry in muscle size between the two lower limbs. This is consistent with **Sees *et al.*** [(21)] where they found that, with the exception of the gracilis muscle, all muscles on the affected side of children with hemiplegic CP have a smaller volume when compared to the uninvolved side. These muscles range from the iliopsoas muscle to the plantar and dorsiflexors of the lower extremities.

The larger the size, the better the strength capacity, so this difference in muscle size and strength capacity leads to uneven balance and an uneven distribution of weight on both lower limbs. This is consistent with **Styer-Acevedo** [(22)] where he stated that the majority of the body weight is placed on the lower leg that is not injured, making it harder for the damaged side to bear weight. The results of the present study agree with **Ibrahim *et al.*** [(23)] who noted that while bearing weight on the injured leg decreases postural stability, the child usually underloads the affected limb during the stance phase. Postural malalignments occur when a child who is hemiplegic prefers to bear his weight on the lower limb that is not affected. The aforementioned misalignments impede his capacity to shift weight to the impacted lower extremity.

The positive correlations between height and balance indices could also be due to greater postural sway. This comes in agreement with **Ojie *et al.*** [(24)] who said that a person with a higher centre of mass would produce a greater postural sway, which leads to postural malalignments leading to impaired balance that suppresses gait ability and physical activity.

The weak positive non-significant correlation between BMI and balance indices could be due to increased postural instability with increased body mass which comes in agreement with **Greve *et al.*** [(25)] who found that being overweight and not exercising enough led to more postural instability. A twenty percent increase in body mass causes postural instability and decreases one's capacity to adapt to outside perturbations to the orthostatic position. There is solid biomechanical data demonstrating that when body mass, as measured by BMI, increases, postural balance will deteriorate. The study of **Benetti *et al.*** [(26)] found variations in the center of pressure in the anterior-posterior or medial-lateral directions that were not significantly different in static standing following a substantial weight loss, suggesting that BMI may not be the primary determinant of static balance. It would be challenging for people with higher BMIs to maintain a larger body mass volume within their supported base. This is supported by **Do Nascimento *et al.*** [(27)] who found that young people' BMI had a greater effect on their balance and also increased their risk of falling when moving.

CONCLUSION

Based on the current study's findings, children with hemiplegic cerebral palsy have difficulty maintaining balance whether they are taller, heavier, or have a higher body mass index.

LIMITATIONS

The current study was limited because of smaller sample size so the result cannot be generalized. Also, it was limited to one type of CP (children with hemiplegic CP aged from 8-12 years).

- **Recommendation:** Further studies are recommended on other age group and other types of CP.

- **Availability of data and material:** Upon reasonable request, the corresponding author will make the datasets used in the current work public.
- **Competing interests:** No conflicting agendas.

- **Acknowledgments:** The authors would like to thank all children and their parents who participated in this study.

REFERENCES

1. **McIlvain G, Tracy B, Chaze A *et al.* (2020):** Brain stiffness relates to dynamic balance reactions in children with cerebral palsy. Journal of child neurology, 35 (7): 463-471.
2. **Galli M, Cimolin V, Rigoldi C *et al.* (2010):** Gait patterns in hemiplegic children with cerebral palsy: comparison of right and left hemiplegia. Research in developmental disabilities, 31 (6): 1340-1345.
3. **Rana M, Upadhyay J, Rana A *et al.* (2017):** A Systematic Review on Etiology, Epidemiology, and Treatment of Cerebral Palsy. International Journal Of Nutrition, Pharmacology, Neurological Diseases, 7 (4): 76-81.
4. **Jelsma J, Pronk M, Ferguson G *et al.* (2013):** The effect of the Nintendo Wii Fit on balance control and gross motor function of children with spastic hemiplegic cerebral palsy. Developmental neurorehabilitation, 16 (1): 27-37.
5. **El Ashmawy A, El-Maksoud G, Mohamed S *et al.* (2019):** Anthropometric measurement in relation to gait parameters in children with Down syndrome. IOSR JNHS., 8: 1-6.
6. **Cole J (1979):** A method for assessing age-standardized weight-for-height in children seen cross-sectionally. Annals of Human Biology, 6 (3): 249-268.
7. **Saether R, Helbostad L, Riphagen I *et al.* (2013):** Clinical tools to assess balance in children and adults with cerebral palsy: a systematic review. Developmental Medicine & Child Neurology, 55 (11): 988-999.
8. **Kenis-Coskun O, Giray E, Eren B *et al.* (2016):** Evaluation of postural stability in children with hemiplegic cerebral palsy. Journal of physical therapy science, 28 (5): 1398-1402.
9. **Mutlu A, Livanelioglu A, Gunel K (2008):** Reliability of Ashworth and Modified Ashworth scales in children with spastic cerebral palsy. BMC musculoskeletal disorders, 9 (1): 1-8.
10. **Gatobu C (2015):** Pattern of foot and ankle deformities in children with spastic cerebral palsy. Indian journal of orthopaedics, 11: 18-21.
11. **CDC (Centers for Disease Control and Prevention) (2015):** Adapted from the Centers for Disease Control website September 2015(About Child & Teen BMI | Healthy Weight, Nutrition, and Physical Activity | CDC). https://en..org/wiki/Centers_for_Disease_Control _ and_Prevention
12. **Minocha P, Sitaraman S, Choudhary A *et al.* (2018):** Subjective global nutritional assessment: a reliable screening tool for nutritional assessment in cerebral palsy children. The Indian Journal of Pediatrics, 85 (1): 15-19.
13. **World Health Organization (2008):** WHO child growth standards: training course on child growth assessment. https://iris.who.int/bitstream/handle/10665/43601/ 9789241595070 _B_eng.pdf
14. **Ogden L, Flegal M (2010):** Changes in terminology for childhood overweight and obesity. Age, 12 (12): 410-419.
15. **Wilfley E, Stein I, Saelens E *et al.* (2007).** Efficacy of maintenance treatment approaches for childhood overweight: a randomized controlled trial. Jama., 298 (14): 1661-1673.
16. **Baldwin L, VanArnam W, Ploutz-Snyder L (2004):** Reliability of dynamic bilateral postural stability on the Biodex Stability System in older adults. Medicine and Science in Sports and Exercise, 36 (5): 30-39.
17. **Parraca A, Olivares Sánchez-Toledo R, Carbonell Baeza A *et al.* (2011):** Test-Retest reliability of Biodex Balance SD on physically active old people, https://rua.ua.es /dspace/handle/10045/17843
18. **Bullock-Saxton E (1994):** Local sensation changes and altered hip muscle function following severe ankle sprain. Physical therapy, 74 (1): 17-28.
19. **Aydoğ E, Bal A, Aydoğ T *et al.* (2006):** Evaluation of dynamic postural balance using the Biodex Stability System in rheumatoid arthritis patients. Clinical rheumatology, 25 (4): 462-467.
20. **Emara A (2015):** Effect of a new physical therapy concept on dynamic balance in children with spastic diplegic cerebral palsy. Egyptian Journal of Medical Human Genetics, 16 (1): 77-83.
21. **Sees P, Miller F:** Hemiplegic CP: Effects in the uninvolved limb. http://lermagazine.com/article/hemiplegic-cp-effects-in-the-uninvolved-limb
22. **Styer-Acevedo J (2002):** Physiotherapy para crianças com paralisia cerebral. In: Tecklin JS, editor. Fisioterapia pediátrica. 3a ed. Porto Alegre: Artmed.
23. **Ibrahim M Abbass E (2022):** Weight distribution asymmetry in relation to walking speed in children with spastic cerebral palsy. African Health Sciences, 22 (2): 565-572.
24. **Ojie D, Saatchi R, Saatchi M (2020):** Demonstration of the effect of centre of mass height on postural sway using accelerometry for balance analysis. Technologies, 8 (2): 20-35.
25. **Greve J, Alonso A, Bordini P *et al.* (2007):** Correlation between body mass index and postural balance. Clinics, 62: 717-720.
26. **Benetti A, Bacha L, Junior G *et al.* (2016):** Analyses of balance and flexibility of obese patients undergoing bariatric surgery. Clinics, 71: 78–81.
27. **Do Nascimento A, Silva C, Dos Santos H *et al.* (2017):** A preliminary study of static and dynamic balance in sedentary obese young adults: the relationship between BMI, posture and postural balance. Clinical obesity, 7 (6): 377-383.