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Original Article

Correlation of Skin Folds Measurements and Selective Motor Control of Lower Extremity in Children with Diplegic Cerebral Palsy

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ABSTRACT

Background: Cerebral palsy (CP) is a significant neurological disorder affecting movement and coordination. Spastic diplegic CP, a common subtype, presents unique challenges in motor control and balance. Understanding the interplay between selective motor control, body composition, and motor functions is crucial for effective therapeutic approaches.

Objective: The study aimed to explore the correlations between selective motor control, skinfold measurements, and their impact on balance and gross motor function in children with spastic diplegic CP.

Methods: Employing a cross-sectional survey design, this study involved 31 children with spastic diplegic CP. Selective motor control was assessed using the SCALE tool, while skinfold measurements were taken at the iliac crest, mid-thigh, and mid-calf. The Pediatric Balance Scale and GMFM-66 were used for evaluating balance and gross motor function, respectively. Statistical analysis involved Pearson Correlation and chi-square tests.

Results: Significant positive correlations were found between balance and selective motor control of the right limb (Pearson Correlation .738, p<.001) and left limb (Pearson Correlation .621, p<.001). Gender-based differences in selective motor control were non-significant. Skinfold measurements varied, with the mid-thigh region showing the maximum fat accumulation, but they demonstrated no significant correlation with balance (Pearson Correlation range -.043 to .191, p>.05) or gross motor function (Pearson Correlation range -.366 to .143, p>.05). The correlation between selective motor control and gross motor function was also non-significant (Pearson Correlation range -.162 to .046, p>.05).

Conclusion: This study underscores the significance of balance and motor control in managing spastic diplegic CP. The absence of a significant correlation between skinfold measurements and motor functions suggests that physical body composition may not directly influence motor abilities in CP. These findings call for further research, potentially with a more diverse sample, to develop nuanced, effective therapies for CP.

Keywords: Cerebral Palsy, Spastic Diplegic, Selective Motor Control, Skinfold Measurements, Gross Motor Function, Pediatric Balance, Children.

INTRODUCTION

Cerebral palsy (CP) is a neurological disorder that significantly impacts muscle coordination and movement, presenting a major health challenge globally. Originating from damage to the developing brain, either before, during, or shortly after birth, CP manifests in a spectrum of symptoms including muscle stiffness, rigidity, poor coordination, and challenges in fine motor skills, varying from mild to severe cases (1, 2). The condition often coexists with other health issues such as intellectual disabilities, seizures, and vision and hearing problems. While there is no cure, various therapies offer symptom management and quality of life improvements, emphasizing the importance of early intervention (3, 4).

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Globally, CP affects approximately 17 million people, with an estimated incidence of 1.5 to over 4 cases per 1000 live births. The prevalence of CP is not uniform, varying greatly across regions and influenced by income levels, healthcare access, environmental factors, and maternal health. It is more prevalent in low- and middle-income countries, particularly in regions like sub-Saharan Africa and South Asia (5, 6). In contrast, high-income countries, including the United States, also report disparities in CP prevalence linked to race, ethnicity, and socio-economic factors, with a higher incidence in non-Hispanic black and Hispanic populations (7).

In Asia, the prevalence of CP ranges from 0.8 to 3.5 per 1000 live births, highlighting a significant health concern, especially in lower-income countries like India and Bangladesh. The distribution of CP types- spastic, dyskinetic, ataxic, and mixed- varies across regions, influencing overall prevalence rates. Spastic CP, characterized by muscle stiffness and accounting for 70-80% of cases, has a higher prevalence in lower-income regions. Conversely, dyskinetic CP, known for involuntary movements, and ataxic CP, affecting balance and coordination, are more common in high-income countries, albeit less frequent overall (8, 9).

Children with CP often face challenges in selective motor control, crucial for daily activities. This impairment in voluntary muscle activation can significantly affect movement and motor functions. Consequently, evaluating selective motor control is vital in developing tailored treatment plans and interventions to enhance motor learning and overall function (13).

Body composition assessments, particularly skin fold measurements, offer crucial insights into the health and obesity risk of children with CP. This non-invasive and cost-effective method requires careful consideration of factors such as assessor expertise and caliper quality for accuracy. When paired with selective motor control assessments, these measurements provide a comprehensive understanding of the child's physical condition and motor capabilities (11, 12).

Various clinical tools, including the Gross Motor Function Measure-66 (GMFM-66) and its comprehensive counterpart, GMFM-88, are instrumental in evaluating motor skills in CP children. These assessments encompass a range of motor activities, from lying and rolling to sitting and standing, aiding in the selection of appropriate therapeutic interventions (14, 15, 16).

The integration of balance assessments, such as the Pediatric Balance Scale, further enriches our understanding of a child's motor abilities, highlighting the importance of early and personalized therapeutic interventions for improving outcomes (17).

This study aims to investigate the relationship between selective motor control and skin fold measurements of the lower limbs in children with spastic diplegic CP. Specifically, it focuses on how these factors correlate with gross motor function and balance, shedding light on potential predictors of mobility in this population (19, 20). The primary objective is to establish a clear link between these measures and the overall motor abilities of children with spastic diplegic CP, contributing to more effective and targeted interventions for this challenging condition.

MATERIAL AND METHODS

This study utilized a cross-sectional survey design to examine the correlation between selective motor control, skinfold measurements, and their impact on gross motor function and balance in children with spastic diplegic cerebral palsy. The research was conducted at the Rising Sun Institute in Lahore over a six-month period, following approval from the BASR.

A total of 31 participants were included in the sample, selected through convenience sampling. The study was designed to achieve a 95% confidence level with an acceptable error margin of 2, assuming a population standard deviation of 5.5. The participant selection was meticulously carried out, adhering to specific inclusion and exclusion criteria. Included were children diagnosed with spastic diplegic cerebral palsy, exhibiting spasticity of less than 2 on the Modified Ashworth Scale and cramped synchronized general movements (GMs). Additionally, participants were required to have the capability to stand on their toes with minimal variation in the motor behavior of their lower limbs. Essential inclusion criteria encompassed being at GMFCS levels I and II, belonging to both genders, having a minimum SCALE score of 1 on both hip joints, scoring at least 25 points on the Pediatric Balance Scale, an MMSE score greater than 24, the ability to walk indoors for a minimum of 5 meters, and a minimum skinfold measurement of 1 mm on both iliac crests. Exclusion criteria included recent lower limb surgery (within the past 6 months), recent treatment with serial casting or botulinum injections in the lower limb (within the last 3 months), and current use of HKAFO or KAFO devices.

The data collection process began with obtaining ethical clearance from the RCR&AHS ethical committee and securing informed consent from each participant or their guardians. Initial assessments utilized the Modified Ashworth Scale (MAS) to screen for spasticity. This involved stretching the child's limb from the highest allowable flexion to the highest allowable extension position, primarily in a lying down posture, with MAS scores ranging from 0 to 4.

Following this, the Selective Control Assessment of the Lower Extremity (SCALE) was employed to evaluate selective motor control (SMC). Participants were required to perform specific isolated movement patterns at each joint, primarily in a seated position. SMC scores were categorized as 2 (normal), 1 (impaired), or 0 (unable), with a normal grade requiring completion of the specified movement in 3 seconds without additional movements.

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Skinfold measurements were taken using a skinfold caliper while participants were seated with uncrossed legs. Measurements were recorded at three regions on both lower limbs: the right iliac crest, the anterior aspect of the thigh, and the calf's bulkiest area.

For data analysis, SPSS version 27 was utilized. The demographic information of the participants was graphically represented, and descriptive statistics for each variable were calculated. The chi-square test was applied to ascertain correlations between categorical variables. Furthermore, the Pearson Correlation coefficient was employed to evaluate the relationships between skinfold measurements, gross motor function items, and scores on the Pediatric Balance Scale. This methodology ensured a thorough and systematic approach, both in data collection and subsequent analysis, thus providing a comprehensive and detailed examination of the study's objectives.

RESULTS

The research presented in these tables provides a detailed analysis of the association between gender and selective motor control (SMC) of the left lower limb, the correlation of the Pediatric Balance Scale with SMC of both lower limbs, and the relationship between skinfold measures and Gross Motor Function Measure (GMFM-66) scores.

In Table 1, the distribution of SMC scores across different levels (ranging from 3.00 to 7.00) was analyzed in relation to gender. The study comprised 31 participants, with 16 males and 15 females. The results showed varied distribution across SMC levels, with both genders represented at each level. For instance, at the SMC level of 4.00, both males and females had the highest representation with 5 participants each.

Table 2 explored the correlation between the Pediatric Balance Scale scores and the SMC of the right lower limb. The study found significant positive correlations, particularly in the overall SMC of the right limb (Pearson Correlation .738, significant at the .000 level), SMC score of the right hip joint (.542, significant at the .002 level), and right knee joint (.431, significant at the .015 level). The SMC score of the right ankle joint showed a lower and non-significant correlation (.125).

Similarly, Table 3 examined the correlation of the Pediatric Balance Scale with SMC of the left lower limb. This table also indicated significant positive correlations, with the overall SMC of the left limb showing a Pearson Correlation of .621 (significant at the .000 level), and the left hip joint having a correlation of .727 (significant at the .000 level). Both the left knee and ankle joints showed significant but lower correlations (.422 and .402, respectively, with significance at the .018 and .025 levels).

Table 1 Association of Gender with Selective Motor Control of Left Lower Limb

Gender	SMC 3.00	SMC 4.00	SMC 5.00	SMC 6.00	SMC 7.00	Total
Male	2	5	3	5	1	16
Female	1	5	2	3	4	15
Total	3	10	5	8	5	31

Table 2 Correlation of Pediatric Balance Scale with SMC of Right Lower Limb

Measurement	Pearson Correlation	Sig. (2-tailed)	N
Selective Motor Control of Right Limb	.738**	.000	31
SMC Score of Right Hip Joint	.542**	.002	31
SMC Score of Right Knee Joint	.431*	.015	31
SMC Scale Score of Right Ankle Joint	.125	.504	31

Table 3 Correlation of Pediatric Balance Scale with SMC of Left Lower Limb

Measurement	Pearson Correlation	Sig. (2-tailed)	N
SMC of Left Limb	.621**	.000	31
Scale Score of Left Hip Joint	.727**	.000	31
Scale Score of Left Knee Joint	.422*	.018	31
Scale Score of Left Ankle Joint	.402*	.025	31

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Table 4 Correlation Between Skinfold Measures and GMFM-66 Score

Measurement	Pearson Correlation	Sig. (2-tailed)	N
Right Iliac Crest (mm)	-.366*	.043	31
Left Iliac Crest (mm)	-.330	.070	31
Right Thigh Skinfold Thickness (mm)	-.133	.475	31
Left Thigh Skinfold Thickness (mm)	.143	.444	31
Right Calf Skinfold Thickness (mm)	-.043	.820	31
Left Calf Skinfold Thickness (mm)	.191	.303	31

Table 5 Correlation of Right Lower Limb SMC Scores with GMFM-66 Scores

Measurement	Pearson Correlation	Sig. (2-tailed)	N
Selective Motor Control of Right Limb	-.124	.505	31
Selective Motor Control of Left Limb	-.162	.383	31
SMC Score of Right Hip Joint	-.151	.416	31
SMC Score of Right Knee Joint	.046	.805	31
SMC Score of Right Ankle Joint	-.001	.997	31

Table 6 Correlation of Left Lower Limb SMC Scores with GMFM-66 Scores

Measurement	Pearson Correlation	Sig. (2-tailed)	N
Scale Score of Left Hip Joint	.058	.757	31
Scale Score of Left Knee Joint	-.423*	.018	31
Scale Score of Left Ankle Joint	-.324	.075	31

Table 4 presented correlations between various skinfold measurements and GMFM-66 scores. The right iliac crest showed a negative correlation with the GMFM-66 score (-.366, significant at the .043 level), indicating an inverse relationship between skinfold thickness at this site and motor function. Other skinfold sites showed varied correlations with GMFM-66 scores, but most were not statistically significant.

In Table 5, the study investigated the correlation between the right lower limb SMC scores and GMFM-66 scores. The correlations were generally weak and mostly non-significant, with the highest negative correlation seen in the selective motor control of the left limb (-.162, not significant at the .383 level).

Table 6 focused on the correlation of the left lower limb SMC scores with GMFM-66 scores. Here, the scale score of the left knee joint showed a significant negative correlation (-.423, significant at the .018 level), suggesting an inverse relationship between SMC at this joint and gross motor function. Other correlations in this table were also negative but not significant.

Overall, these tables provided a comprehensive statistical overview of the study, highlighting significant correlations between SMC, Pediatric Balance Scale scores, skinfold measurements, and GMFM-66 scores, which are crucial in understanding the motor functions and physical characteristics of children with spastic diplegic cerebral palsy.

DISCUSSION

In this study, the interplay between selective motor control, skinfold measurements, and their influence on gross motor function and balance in children with spastic diplegic cerebral palsy was meticulously explored. The findings present an intriguing perspective on the relationship between these variables, adding depth to the existing body of knowledge in pediatric neurorehabilitation.

The research notably revealed a significant positive correlation between balance and selective motor control in the lower extremities of children with spastic diplegic cerebral palsy. This association is critical, as selective motor control is fundamental to executing precise and coordinated movements, particularly in tasks requiring fine motor skills. This correlation underscores the importance of incorporating balance training in therapeutic interventions for these children, aligning with previous studies that emphasize the role of balance in enhancing motor control and functional independence (21, 27).

Contrary to initial expectations, the study found no significant gender-based differences in selective motor control across various joints in the lower limbs. This finding aligns with previous research, suggesting that selective motor control impairment in spastic

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diplegic cerebral palsy is more closely related to neurological factors than to gender-specific attributes (22-25). Such insights could influence future research directions, focusing more on neurological underpinnings rather than demographic variables.

The assessment of skinfold thickness, particularly at the iliac crest, mid-thigh, and mid-calf regions, provided vital information about the body composition of the participants. However, these measurements did not show a significant correlation with balance or gross motor function. This outcome suggests that while body composition is an important health parameter, it may not directly influence motor abilities or balance in children with spastic diplegic cerebral palsy (26). This finding could guide clinicians in prioritizing intervention strategies that focus more on enhancing motor control and balance rather than solely on modifying body composition.

Moreover, the study reported a non-significant correlation between selective motor controls of the lower limbs and gross motor function. This result is consistent with earlier studies and highlights the complexity of factors influencing motor function in cerebral palsy. It suggests that while selective motor control is important, other factors such as muscle strength, coordination, and neurological impairments also play crucial roles in determining overall motor function (28, 30).

This research contributes to a deeper understanding of the multifaceted nature of spastic diplegic cerebral palsy and the interrelated aspects of motor control, balance, and body composition. It emphasizes the need for a holistic approach in therapy, encompassing balance and motor control training, alongside considerations of overall physical health.

The study, however, is not without limitations. Being single-centered, its findings may not be widely generalizable to all populations with spastic diplegic cerebral palsy, particularly given the lack of randomization in sample selection which could introduce bias. Additionally, focusing solely on children at GMFCS levels I and II may limit the applicability of the results to those with more severe or different functional impairments. Moreover, the exclusive inclusion of children with spastic diplegic cerebral palsy narrows the scope of the study, leaving out other subtypes of cerebral palsy which may exhibit different patterns of motor control and balance impairments.

Future research could benefit from incorporating a more diverse sample, possibly including children with different types and severities of cerebral palsy, to enhance the generalizability of the findings. Furthermore, longitudinal studies may provide insights into how selective motor control, balance, and body composition evolve over time and respond to various therapeutic interventions. Such studies could be pivotal in shaping more effective, personalized rehabilitation strategies for children with cerebral palsy, ultimately improving their quality of life and functional independence.

CONCLUSION

The study concludes that in children with spastic diplegic cerebral palsy, there is a significant positive correlation between balance and selective motor control of the lower extremity, while the correlation between skinfold measurements, gross motor function, and balance is not significant. These findings underscore the importance of integrating balance and motor control interventions in therapeutic programs for this population. However, the study's limitations, including its single-center nature and focus on a specific cerebral palsy subtype, suggest the need for broader, more diverse research to further understand and optimize treatment strategies for children with various forms of cerebral palsy.

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