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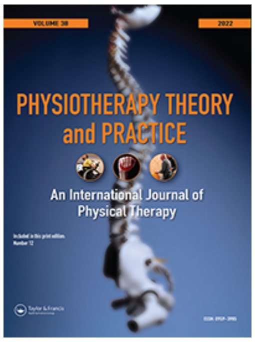

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REPORT

The effects of postural control and upper extremity functional capacity on functional Independence in preschool-age children with spastic cerebral palsy: a path model

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ABSTRACT

Purpose: To investigate the effects of postural control and upper extremity functional capacity on functional independence and identify whether quality of upper extremity skills mediates the effects of postural control on functional independence in preschool-age children with spastic cerebral palsy (CP).
Methods: 106 children with CP -mean age 43.4 ± 11.3 (24–71 months)- were included in this cross-sectional study. Postural control, upper extremity functional capacity, and functional independence in activities of daily living were evaluated using the Early Clinical Assessment of Balance (ECAB), Quality of Upper Extremity Skills Test (QUEST), and the Functional Independence Measure of Children (WeeFIM), respectively. A path model was used to evaluate the total, direct, and indirect effects.
Results: According to the path model, ECAB (direct effect; $r = 0.391$, $p < 0.01$, indirect effect; $r = 0.398$) and QUEST (direct effect; $r = 0.493$, $p < 0.01$) had an impact on WeeFIM. In addition, QUEST had mediating effects on the relationship between ECAB and WeeFIM. The path model explained 71% of the variation in functional independence of the participants.
Conclusion: In the management of CP in preschool-age children, the focus should be on improving not only upper extremity capacity but also postural control to help improve functional independence in activities of daily living.

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Cerebral palsy; capacity; function; independence; postural control; upper extremity

Introduction

Functional independence in daily living activities is one of the most desired goals within pediatric rehabilitation in children with cerebral palsy (CP) (Posłuszny et al., 2017). Functional independence enables children participate actively in activities at home, school, and community and contributes to the development of self-concept. In addition, functional independence is strongly associated with children's life satisfaction (Bogart, 2014; Fasig, 2000; Posłuszny et al., 2017). In children with spastic CP, functional independence is adversely affected due to neuromuscular factors such as spasticity, hyperactive stretch reflexes, muscle coordination problems, insufficient selective motor control, and muscle weakness (Brogren, Hadders-Algra, and Forssberg, 1998; Rosenbaum et al., 2007). Starting from young ages, most of these children may be person- or device-dependent to participate in age-appropriate activities of daily living (ADL) and may require lifelong healthcare services (Novak, 2014).

Postural control is the ability to maintain body position in space for the purpose of stability and orientation (Kiefer et al., 2021). Maintaining a stable posture during functional activities requires a complex interaction between the musculoskeletal and the nervous system. Head-trunk stabilization (i.e. axial segment stabilization) is the primary reference frame for postural control (Ivanenko and Gurfinkel, 2018). Children with spastic CP have difficulties in fine-tuning postural muscle contractions to task-specific conditions and co-regulating trunk and upper extremity movements. Therefore, they exhibit excessive antagonistic co-activation and have difficulties with subtle modulation of head and postural activity of the trunk during upper extremity functions (van der Heide and Hadders-Algra, 2005). In addition, neuromuscular disorders can also affect upper extremity functional capacity (Yildiz, Yildiz, and Elbasan, 2018).

Preschool period is a critical period in enhancing the biopsychosocial development of children (Caniato et al., 2010). From a neurodevelopmental aspect, rapid

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neuroplastic adaptation of the brain in the first years of life highly contribute to functional gains (Tooley, Bassett, and Mackey, 2021). A previous study suggested that, on average, children with CP reach 90% of their motor functional capacity potential by 6 years of age. Another study stated that children with CP who did not gain trunk control and independent sitting balance by 4 years of age had poor prognosis for functional independence in mobility (Saavedra and Woollacott, 2015). In their recent study Burgess et al. (2021) found a reverse relationship between the severity of upper extremity involvement and self-care development achieved by 5 years of age. Thus, in the field of pediatric rehabilitation, it is important to investigate the predicting factors of functional independence in preschool-age children with CP.

The development of postural control and upper extremity skills starts in infancy and advanced fine motor control improves progressively throughout the childhood (Schneiberg et al., 2002). In preschool period, children start to gain functional independence in self-care and play activities (Khetani, Graham, and Alvord, 2013). These activities require the precise use of upper extremity skills and postural control of the head and trunk against gravity in different positions. Moreover, from a developmental perspective, head and trunk control is closely associated with the functional development of the upper limbs (Harbourne and Kamm, 2015; Rachwani, Santamaria, Saavedra, and Woollacott, 2015; van der Heide, Otten, van Eykern, and Hadders-Algra, 2003). The development of postural control and upper extremity skills in infants and the relationship between postural control and functional activity in school-aged children with spastic CP are descripted in the literature (Boxum et al., 2017; van der Heide et al., 2004). However, there is a gap in the literature about the relationship between postural control, quality of upper extremity skills, and functional independence of children with spastic CP in preschool period (Kyvelidou et al., 2018; Ryalls et al., 2016). Furthermore, the effect size of upper extremity capacity and postural control on functional independence in this period is yet unknown. The present study aims to: 1) investigate the effects of postural control and upper extremity functional capacity on functional independence in preschool-age children with spastic CP, and 2) identify whether the quality of upper extremity skills has a mediating role on the relationship between postural control and functional independence.

Methods

This cross-sectional study was carried out in the Cerebral Palsy and Pediatric Rehabilitation Unit, Faculty of Physical Therapy and Rehabilitation, Hacettepe University between August 10, 2021- February 15, 2022. The permission and approval to conduct the study were obtained from the Clinical Research Ethics Committee of Hacettepe University (project number: GO 21/1121, decision number: 2021/17-16).

Participants

The parents of children diagnosed with CP who referred to our department for routine therapy program were informed about the study and those willing to participate in the study signed consent forms. Children who were: 1) between 24–71 months of age; 2) diagnosed with spastic CP; 3) able to communicate in the Turkish language with strangers based on the Communication Function Classification System (CFCS); and 4) had mild to moderate spasticity according to the F subscale (spasticity rating section) of the Quality of Upper Extremity Skills Test (QUEST). The exclusion criteria were as follows: 1) children who had visual and hearing problems; 2) severe spasticity (i.e. affected part(s) rigid in flexion or extension); 3) history of botulinum toxin injection or surgery in the last 6 months; and 4) lack of motivation, or concentration problems.

Clinical Assessments

Classifications

Gross motor function classification system (GMFCS). The GMFCS classifies and describes the locomotor abilities of children with CP. It provides a general overview of the performance of the child at home, school, or in society. The GMFCS has 5 levels and higher levels indicate lower degrees of mobility skills (Palisano, Rosenbaum, Bartlett, and Livingston, 2008). The Intra-class Correlation Coefficient (ICC) is 0.97, the total agreement is 89%, test-retest reliability is high (ICC: 0.94–95% confidence interval), and the total agreement is 75% for test-retest reliability (El et al., 2012).

Manual ability classification system (MACS). This classification system describes the use of hands in handling objects during daily living activities in 4- to 18-year-old children with CP. It classifies hand skills based on the need for self-help or adaptation into five levels. As the level increases, manual ability decreases (Eliasson et al., 2006). The inter-rater reliability of the MACS for children aged 1–5 years was moderate, with a linear weighted kappa of 0.62 (95% confidence interval (CI) 0.49–0.76) (Plasschaert et al., 2009).

Outcome measures

Early clinical assessment of balance (ECAB). Developed to evaluate postural control and balance in preschool-age children with CP, the ECAB consists of two parts: 1) Head-and-Trunk Postural Control; and 2) Sitting-and-Standing Postural Control. It combines items of two separate postural control evaluation tools in children with CP. The first part has seven items imported from the Movement Assessment of Infants: Head righting-lateral, Head righting-extension, Head righting-flexion, Rotation in trunk, Equilibrium reactions in sitting, Protective extension-sideward, Protective extension-backward. The second part has six items imported from the Pediatric Balance Scale: Sitting with back unsupported but feet supported on floor, sitting to standing, standing unsupported with eyes closed, standing unsupported with feet together, turning 360°, and placing alternate foot on the step while standing unsupported. A high score indicates better head, trunk, and postural control. Internal consistency (Cronbach's alpha = 0.92) and content and construct validity are high (r = 0.97) (McCoy et al., 2014). Interrater and test-retest reliability are strong (intraclass correlation coefficients > 0.98 vs 0.87–0.94) (Randall, Bartlett, and McCoy, 2014). Despite several clinical postural control assessments, the ECAB is the only valid and reliable assessment tool for evaluating head and trunk control, and postural control in sitting and standing in preschool-age children with CP (Pavão, Dos Santos, Woollacott, and Rocha, 2013).

Quality of upper extremity skills test (QUEST). The QUEST measures upper extremity functions and movement patterns of children with CP. It consists of four domains: 1) Dissociated movement; 2) Grasping; 3) Weight bearing; and 4) Protective extension (Haga et al., 2007). Also, the QUEST has a spasticity rating section that is not included in the summary score. In this study, the severity levels of spasticity of the children were evaluated according to this section. The QUEST can be used for 18-months to 8-year-old children and has excellent reliability and validity properties. The ICC for inter-rater and intra-rater reliability is 0.86 and 0.96, respectively (Thorley et al., 2012). The QUEST is the only test that evaluates upper extremity capacity together with the protective postural reactions and weight bearing ability in the upper limbs for this population.

Functional Independence measure for children (WeeFIM). The WeeFIM assesses disability in children aged six months to seven years. It consists of 18 items along a 7-level ordinal scale that measures a child's steady performance in essential daily functional skills. The items are scored through interviews with the parents/caregiver or by observing the child's task performance. The total score ranges from 18 (i.e. fully dependent) to 126 (i.e. independent). Three main domains (i.e. self-care, motor, and cognitive) should be treated as separate scales in children with spastic CP (Ottenbacher et al., 1996). The self-care domain includes 6 items: eating, grooming, dressing upper, dressing lower, bathing, and toileting. The motor domain includes 7 items: bladder and bowel management, changing positions from chairs, getting on and off the toilet, getting in and out of showers and bathtubs, self-mobility indoors and outdoors, and ascending and descending stairs. The cognitive domain includes 5 items: 1) comprehension; 2) expression (i.e. items 1 and 2 focusing on communication); 3) social interaction; 4) problem solving; and 5) memory (i.e. items 3, 4, and 5 focusing on social cognition). Reliability of the WeeFIM is excellent with high Cronbach's alpha and ICC values ranging between 0.91 and 0.98 (Ottenbacher et al., 1996; Tur et al., 2009).

Procedures

Demographic characteristics were collected from parents and medical files. All classifications and clinical assessments were carried out by the same twelve-year experienced physiotherapist within a maximum timeframe of 1 hour and in accordance with standardized procedures. A mat, step board, height-adjustable chair and table, and the standardized upper extremity evaluation materials (i.e. cubes, pencils, and grapes) were used for ECAB and QUEST evaluations. While evaluating the upper extremity, the children were in sitting position with their feet flat on the ground. The WeeFIM was performed by the same physiotherapist using the interviews with the caregivers, who were mostly the mothers of the children.

Statistical Analysis

The statistical analyses were carried out using the Licensed IBM SPSS Statistics for Windows software, Version 24.0. Armonk, NY: IBM Corp and AMOS Graphics 25.0. Normality analysis was performed to check normal distribution of the data. Mean, standard deviation (SD), and frequency were calculated for the demographic data and scale scores. Spearman's rank correlation coefficient was used to examine the relationships between the scale subscales. As proposed by Portney and Watkins (2009) correlation coefficients between 0 and 0.25 indicate little or no relationship, between 0.25 and 0.50 low, between 0.50 and 0.75 moderate to good, and above 0.75 may indicate a good to excellent relationship. The level of significance was set at 0.05.

A structural equation model (SEM) was created between ECAB, QUEST and WeeFIM, but due to multicollinearity, the path coefficients between ECAB and QUEST and similarly between QUEST and WeeFIM exceeded the [−1, +1] range. To cope with the multicollinearity problem, the subscale scores were converted to standardized values and the structural equation model was recreated using the standard values to investigate the causality between the factors, however, multicollinearity continued hampering the process. As a solution, instead of the structural equation model, a path model was created (Jöreskog and Sörbom, 1982). For this purpose, exploratory factor analysis was used to calculate subscale factor scores for each assessment tool (e.g. ECAB-head and trunk control and ECAB-sitting and standing control for the ECAB). Thereby, the obtained single factors were recorded as regression values among the available options (i.e. regression, Bartlet, and Rubin-Anderson). Factor analyzes for calculating factor scores for the ECAB, QUEST, and WeeFIM were performed in a similar way. Factor analyses results showed that factor loadings: Average Variance Extracted (AVE > 0.7); Kaiser-Meyer-Olkin Measure (KMO > 0.7); and Bartlett's Sphericity (< 0.05) values met the expected values. This confirmed that the factor scores were significant and acceptable (Shrestha, 2021) and sample size is adequate.

Subsequently, the path model was created between the three factor scores (i.e. Factor ECAB, Factor QUEST, and Factor WeeFIM) to further investigate the direct effects of Factor ECAB on Factor WeeFIM and the indirect effects of Factor ECAB -via Factor QUEST (i.e. mediator factor) on Factor WeeFIM. Within the path analysis, the best predictors of the model parameters were investigated using the Maximum Likelihood method. Then, the model observations were tested via these predictors to calculate the unpredictable parts (standard error values; "e1" and "e2") (Jöreskog and Sörbom, 1982).

Results

A total of 115 children with CP were screened for the study. Two children had severe spasticity in their upper limbs (rigid in flexion), and seven children could not complete the assessments due to lack of motivation. As a result, the study was completed with 106 participants. The mean age was 43.4 ± 11.3 months (range: 24–71 months). According to extremity involvement, most of the children had bilateral involvement. The bilateral hand use of approximately 40% of the children was classified as independent (Table 1).

The total and subscale-scores of the ECAB, QUEST, and WeeFIM according to the GMFCS, MACS, and extremity involvement can be found in the Supplement File. Lower GMFCS and MACS levels were associated with higher ECAB, QUEST, and WeeFIM scores. In terms of extremity involvement, children with hemiplegia had the highest scores of ECAB, QUEST, and WeeFIM (Supplement File).

The scatterplot graphs representing the relationships between total scores of the ECAB and QUEST, ECAB and WeeFIM, and QUEST and WeeFIM are shown in

Table 1. Clinical and functional characteristics of children with spastic CP.

n = 106	Mean ± SD	Min-max
Age (months)	43.4 ± 11.3	24–71
	n	%
Gender (girl/boy)	59/47	55.7/44.3
Extremity involvement		
Hemiparetic	21	19.8
Diparetic	38	35.8
Quadriparetic	47	44.3
GMFCS		
Level I	12	11.3
Level II	12	11.3
Level III	35	33.0
Level IV	27	25.5
Level V	20	18.9
MACS		
Level I	13	12.3
Level II	31	29.2
Level III	39	36.8
Level IV	9	8.5
Level V	14	13.2

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

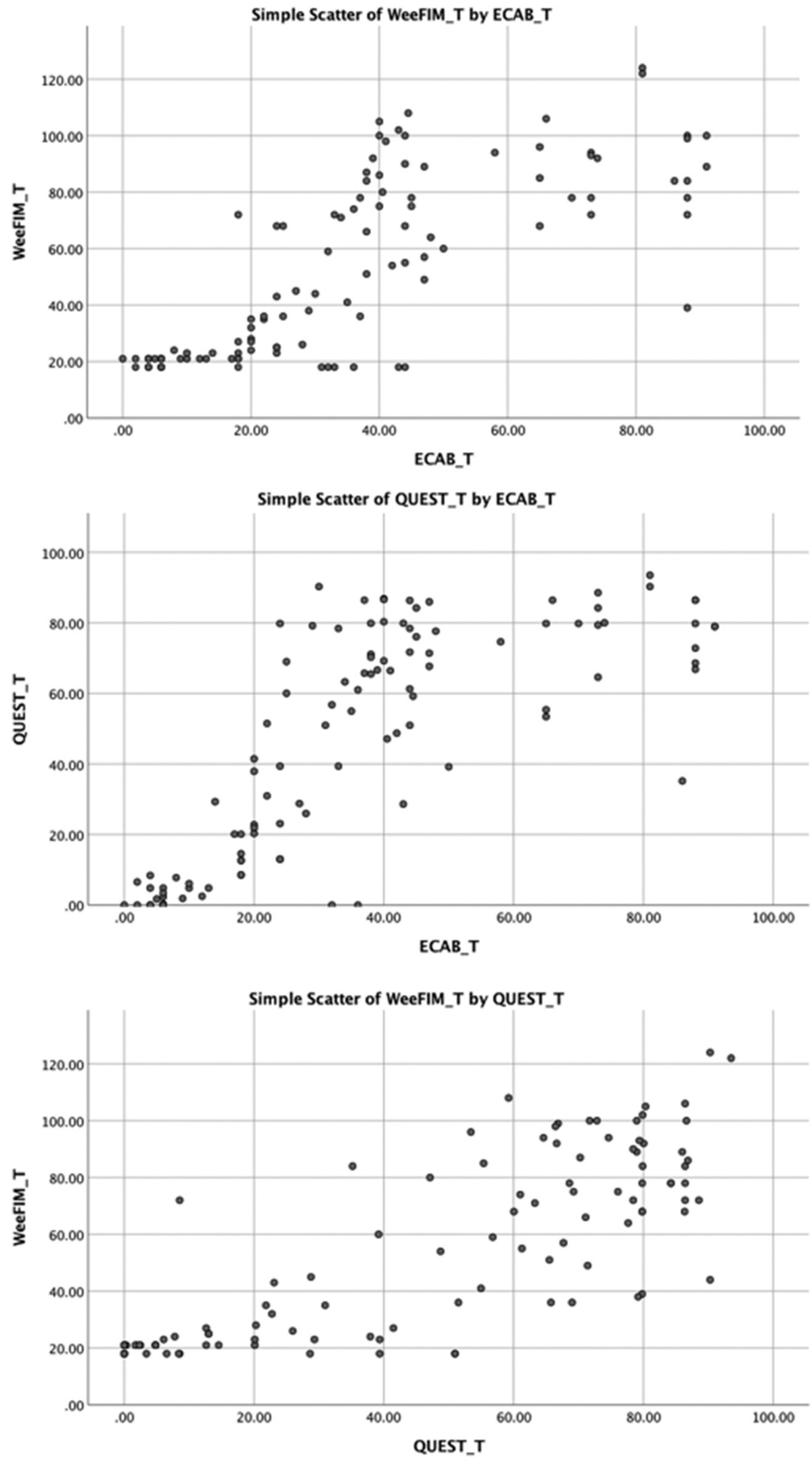

Figure 1. The relationships between total scores of ECAB, QUEST, and WeeFIM according to scatterplots.

Figure 1. According to graphs, higher ECAB scores indicated higher QUEST and WeeFIM scores, and similarly, higher QUEST scores indicated higher WeeFIM scores.

The relationships between the subscales of the ECAB, QUEST, and WeeFIM scales are shown in Table 2. There was a good-to-moderate positive relationship between subscales of the ECAB and QUEST. The highest correlation was between ECAB-head and trunk control and QUEST-protective extension reaction (rho = 0.746, $p < .001$). The lowest correlation was between ECAB-sitting and standing postural control

Table 2. Means, standard deviations, and correlations between the variables.

		ECAB			QUEST					WeeFIM			
		Head and trunk control	Sitting and standing control	ECAB total	Dissociated movement	Grasp	Weight Bearing	Pro. Ext. Reaction	QUEST total	Self-care	Motor	Cognitive	WeeFIM total
ECAB	Head and trunk control	1											
	Sitting and standing control	0.677**	1										
	ECAB total	0.833**	0.937**	1									
QUEST	Dissociated movement	0.737**	0.716**	0.795**	1								
	Grasp	0.704**	0.712**	0.759**	0.891**	1							
	Weight Bearing	0.703**	0.698**	0.777**	0.887**	0.854**	1						
	Pro. Ext. Reaction	0.746**	0.653**	0.747**	0.850**	0.811**	0.913**	1					
	QUEST total	0.748**	0.712**	0.795**	0.952**	0.923**	0.960**	0.941**	1				
WeeFIM	Self-care	0.721**	0.719**	0.779**	0.786**	0.746**	0.776**	0.773**	0.811**	1			
	Motor	0.729**	0.803**	0.832**	0.796**	0.766**	0.747**	0.746**	0.794**	0.852	1		
	Cognitive	0.692**	0.566**	0.681**	0.696**	0.659**	0.689**	0.682**	0.716**	0.869**	0.795**	1	
	WeeFIM total	0.727**	0.685**	0.780**	0.781**	0.726**	0.760**	0.765**	0.799**	0.949**	0.902**	0.945**	1

Spearman Correlation, **; p < 0.001, ECAB; Early Clinical Assessment of Balance, QUEST; Quality of Upper Extremity Skills Test, WeeFIM; Functional Independence Measure for children

and QUEST-protective extension reaction (rho = 0.653, p < .001). There was a moderate-to-excellent positive relationship between subscales of the ECAB and WeeFIM. The highest correlation was between ECAB-sitting standing postural control and WeeFIM-motor (rho = 0.803, p < .001) (Table 2). The lowest correlation was between ECAB-sitting and standing postural control and WeeFIM-cognitive (rho = 0.566, p < .001) (Table 2). There was a moderate-to-excellent positive relationship between subscales of the QUEST and WeeFIM. The highest correlation was between QUEST-dissociated movements and WeeFIM-motor (rho = 0.796, p < .001). The lowest correlation was between QUEST-grasp and WeeFIM-cognitive (rho = 0.659, p < .001) (Table 2).

According to the path coefficients of the proposed model, ECAB was significantly positively correlated with both QUEST and WeeFIM. In addition, there was also a significant positive correlation between QUEST and WeeFIM (Table 3). The path model results showed: 1) A direct effect of Factor ECAB on Factor WeeFIM, with a path coefficient of 0.391; 2) an indirect effect of Factor ECAB on Factor WeeFIM via Factor QUEST, with a path coefficient of 0.808*0.493; and 3) a total effect of 0.391 + (0.808*0.493) = 0.789. The explanatory power of ECAB on QUEST was 65%, and the explanatory power of ECAB and QUEST on WeeFIM was 71% (Table 4). Therefore, ECAB had a strong effect (correlation ~0.8) on WeeFIM both directly and indirectly through QUEST, which had

Table 3. Path coefficients of the proposed model.

Path	β	standard error	critical ratio (t statistic)	p
Factor ECAB→ Factor QUEST	.808	.058	14.041	<0.001
Factor QUEST→ Factor WeeFIM	.493	.090	5.494	<0.001
Factor ECAB→ Factor WeeFIM	.391	.090	4.359	<0.001

β; standardized regression co-efficients, ECAB; Early Clinical Assessment of Balance, QUEST; Quality of Upper Extremity Skills Test, WeeFIM; Functional Independence Measure for children

Table 4. Standardized total, direct and indirect effects.

predictor variables	independent variables	total effect	p	direct effect	p	indirect effect	p	R^2
ECAB	QUEST	0.808	<0.001	0.808	<0.001			0.652*
	WeeFIM	0.789	<0.001	0.391	<0.001	0.398	<0.001	0.707**
QUEST	WeeFIM	0.493	<0.001	0.493	<0.001			

ECAB; Early Clinical Assessment of Balance, QUEST; Quality of Upper Extremity Skills Test, WeeFIM; Functional Independence Measure for children, *; R^2 for QUEST, **; R^2 for WeeFIM,

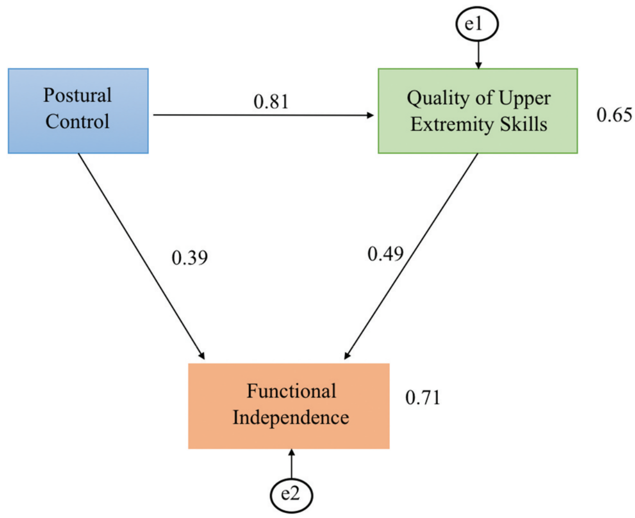

Figure 2. Path model of the study, e1 and e2; measurement errors.

a partial mediation role between ECAB and WeeFIM (Figure 2).

Discussion

This study investigated the effects of postural control and quality of upper extremity skills on functional independence in ADL in preschool children with CP. Our results revealed direct and indirect (via upper extremity functional capacity) effects of postural control on functional independence. The current study highlighted that upper extremity functional capacity partially mediated the effect of postural control on functional independence. Better postural control as well as better upper extremity functional capacity can lead to greater functional independence in activities of daily living.

The trunk is the central key point for postural stabilization, connecting the head and extremities. Decreased segmental trunk control worsens mobility and increases the necessity for segmental trunk support in children with spastic CP (Saavedra and Woollacott, 2015). Van Balen et al. (2015) found that children with CP had abnormal direction-specific postural adjustment in the sitting position and trunk control influenced reaching skills in the first two years of life. Hadders-Algra, van der Fits, Stremmelaar, and Touwen (1999) showed that a distinct direction-specific recruitment of the trunk muscles was present from fifteen months of age onwards. This study demonstrated that head-trunk control and sitting-standing postural control in children aged two to six years were positively associated with both the quality of their upper extremity skills and functional independence. This finding emphasized that in children with spastic CP, head and trunk control impairments in sitting and standing positions should be addressed at the earliest age to enhance the development of complex upper extremity skills in functional daily living activities. Goal-oriented, activity-based approaches including head-trunk control exercises are recommended to be included in the treatment programs of the preschool children with CP (Novak et al., 2020). In order to increase the functionality of children in daily life, child-specific, age-appropriate, motivating unilateral and bilateral upper extremity skills should be trained as a whole-task practice in different positions such as prone, supine, standing, and walking (Chiarello et al., 2019; Jackman et al., 2022). In addition, families should be trained on how to enhance their children's active participation in the target activities in different settings such as home, kindergarten, and community (Palisano et al., 2012).

As a core biomechanical element, postural stabilization is important in maintaining eye-hand coordination, hand manipulation, and writing skills. Furthermore, the acquisition of upper trunk and lumbar control is critical in achieving independent sitting and standing position (Rachwani, Santamaria, Saavedra, and Woollacott, 2015). Previous studies indicated that trunk support equipment may limit the compensatory trunk movements, facilitate postural stabilization, and stimulate selective upper extremity movements, and they may also assist improvement in self-care and playing skills in children with moderate to severe CP (Angsupaisal, Maathuis, and Hadders-Algra, 2015; Santamaria, Rachwani, Saavedra, and Woollacott, 2016). Yildiz, Yildiz, and Elbasan (2018) showed that static and dynamic trunk control in sitting position was positively and moderately correlated with upper extremity functional capacity in children with spastic CP. Pierret, Caudron, Paysant, and Beyaert (2021) reported that insufficient trunk control in sitting position was associated with inadequate postural control in standing position. The current study showed that better sitting and standing postural control were associated with better upper extremity selective movements, grasping, weight bearing, protective reactions, mobility, self-care, and communication functions in children with spastic CP. Therefore, it is recommended that therapists pay work on the development of postural control in sitting and standing positions, as well as upper extremity skills, in order to improve functional independence in pediatric rehabilitation practices of children with CP aged two to six years. Furthermore, supporting upper extremity skills not only in sitting but also in different upright positions may be beneficial for gaining functional independence in this period.

Maintaining postural control throughout a functional activity requires goal-directed selective motor control of all body parts. Keller et al. (2021) used the self-care subscale of WeeFIM excluding bladder and bowel control items to investigate the effect of upper extremity disorders and trunk control impairment on self-care activities in children with upper motor neuron lesions at school age. The authors reported that a major part of the change in self-care (43.2% out of 81%) was explained by trunk control, whereas selective upper extremity motor control explained 23.1% out of the 81%. In our study almost 70% of the change in functional independence in all ADL inclusive of self-care was directly and indirectly explained by postural control. Postural control is an overarching mechanism including control of the head, trunk, and extremities. Upper extremity functional capacity includes dissociated selective motor movements as well as upper extremity skills such as weight bearing, postural reactions, and grasp-and-release. Therefore, the upper limb functional capacity seems to have a significant effect on the postural control mechanism when performing complex functional activities.

Functional task performance involves complex cognitive processes. Similarly, cognition plays a great role in communication and social functioning (Stadskleiv, 2020). In this study, cognitive function was found to be associated with upper extremity skills of preschool-age children who were able to communicate with strangers. Higher cognitive levels can have a positive impact on how to use the hands together to successfully perform an upper extremity task.

The strengths of this study can be listed as following: 1) It can assist early pediatric neurorehabilitation studies in preschool children with spastic CP; 2) The sample size is adequate; and 3) and the evaluation scales have high validity and reliability for the study population. The study has some limitations that need to be addressed. Initially, it was aimed to create a structural equation model to examine the effects between the subscales of the assessment tools in detail. However, the structural equation model could not be created due to multicollinearity. In causality analyzes, when two or more explanatory factors are highly correlated, it is difficult to predict the relationships of each factor separately due to their collective contribution known as multi-collinearity (Olivoto et al., 2017). In our study, the high correlation between ECAB and QUEST and similarly between QUEST and WeeFIM led to a multicollinearity effect. Therefore, we were unable to establish a detailed structural equation model containing the subscales of the scales. As a solution, instead of the structural equation model, a path model was created. The second limitation concerns the muscle tone of the participants. Although children with muscle contracture and joint limitations were excluded, the tone of the upper limb muscles was not evaluated and recorded separately.

Suggestions for Future Research

Future studies are recommended to examine the effects of head-body control and other functional parameters (such as lower extremity functional capacity, cognitive level, muscle tone, somatosensory aspects) on upper extremity skills, participation in ADL, play, and age-appropriate social roles in preschool children with CP with different clinical subtypes. It would be relevant to investigate whether the quality of lower extremity movements and visual and hearing functions have a mediating role in the relationship between functional independence and postural control.

The study population was heterogeneous in terms of their levels of GMFCS, MACS and extremity involvement. As stated by Günel, Mutlu, Tarsuslu, and Livanelioglu (2009), less severely affected children (in terms of GMFCS, MACS, and extremity involvement) are more independent in functional activities. Our findings suggest that better postural control and advanced upper extremity skills can have a positive impact on functional independence. It is recommended that future studies with larger sample sizes investigate the effects of functional classifications and limb involvement on the three relationships as proposed in the present study namely: 1) relationship between postural control and quality of upper limb skills; 2) relationship between postural control and functional independence; and 3) relationship between the quality of upper limb skills and functional independence).

Conclusion

Postural control and upper extremity functional capacity may positively influence the functional independence of children in ADL. In addition, upper extremity skills seem to mediate the effect of postural control on functional independence. In the rehabilitation of preschool children with spastic CP, focusing on postural control as well as upper extremity capacity may be beneficial for more functional gains and independence.

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