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UPPER EXTREMITY SELECTIVE VOLUNTARY MOTOR CONTROL IN CHILDREN WITH UNILATERAL CEREBRAL PALSY AND ITS ASSOCIATION WITH UPPER EXTREMITY FUNCTIONS

ORIGINAL ARTICLE

ABSTRACT

Purpose: The study aimed to define the upper extremity selective voluntary motor control (SVMC) in children with unilateral Cerebral Palsy (CP). It was also aimed to investigate the relationship between upper extremity SVMC and upper extremity functions.

Methods: Twenty-four children diagnosed with unilateral CP, aged between 6 and 18, were included in the study. The Quality of Upper Extremity Skills Test (QUEST) assessed the upper extremity functions. Manual dexterity was measured using the Jebsen-Taylor Hand Function Test (JTT) timed tasks. The SVMC of the upper extremity was measured using the Selective Control of Upper Extremity Scale (SCUES) using the videotape recording method.

Results: Statistically significant decreases in SCUES scores from shoulder to fingers were recorded using the Page statistical test for trend ($p<0.001$). There was a significant positive correlation between the SCUES total score and the QUEST total score (r: 0.796; $p<0.001$). Also, score on SCUES showed a significant negative correlation with JTT (r:- 0.875; $p<0.001$).

Conclusion: In children with unilateral CP, there was a relationship between upper extremity selective voluntary control and upper extremity functions. Deficiency in selective upper extremity movements disturbed functional manual skills, indicating these impairments' significance in assessing upper extremity functions and, potentially, rehabilitation.

Keywords: Cerebral Palsy, Motor Skills, Upper Extremity

UNİLATERAL SEREBRAL PALSİLİ ÇOCUKLARDA ÜST EKSTREMİTENİN İSTEMLİ SELEKTİF MOTOR KONTROLÜ VE ÜST EKSTREMİTE FONKSİYONLARI İLE İLİŞKİSİ

ARAŞTIRMA MAKALESİ

ÖZ

Amaç: Çalışmada, unilateral Serebral Palsili (SP) çocuklarda üst ekstremite istemli selektif motor kontrolünü (SMK) tanımlamak ve SMK ile üst ekstremite fonksiyonları arasındaki ilişkiyi incelemek amaçlanmıştır.

Yöntemler: Çalışmaya yaşları 6 ile 18 arasında değişen 24 unilateral SP tanılı çocuk dahil edilmiştir. Üst ekstremite fonksiyonlarını değerlendirmek için Üst Ekstremite Beceri Kalitesi Testi (ÜEBKT) kullanıldı. El becerisi, Jebsen-Taylor El Fonksiyon Testinin (JTT) süreli görevleri kullanılarak ölçüldü. Üst ekstremitenin SMK, video kayıt yöntemi kullanılarak Üst Eksremite Selektif Kontrol Skalası (ÜESKS) ile ölçüldü.

Sonuç: Omuzdan parmaklara ÜESKS skorlarında istatistiksel olarak anlamlı düşüşler Page istatistiksel trend testi kullanılarak kaydedildi ($p<0,001$). ÜESKS toplam puanı ile ÜEBKT toplam puanı arasında anlamlı bir pozitif korelasyon vardı (r: 0,796; $p<0,001$). Ayrıca ÜESKS skoru, JTT ile anlamlı bir negatif korelasyon gösterdi (r: - 0,875; $p<0,001$).

Tartışma: Unilateral SP'li çocuklarda üst ekstremite SMK ile üst ekstremite fonksiyonları arasında ilişki bulundu. Selektif üst ekstremite hareketlerindeki eksikliğin, fonksiyonel el becerilerini etkilediği bulunmuştur. Bu nedenle üst ekstremite fonksiyonlarını değerlendirmede ve potansiyel olarak rehabilitasyonunda üst ekstremite SMK göz önünde bulundurulmalıdır.

Anahtar Kelimeler: Serebral Palsi, Motor Beceriler, Üst Ekstremite

INTRODUCTION

Cerebral palsy (CP) has been described as a group of disorders of the development of movement and posture in the developing fetal or infant brain (1). Children with CP can have many neurological deficits that interfere with motor function. These impairments include hypertonicity or hypotonicity with weakness, abnormal patterns of muscle activation, including excessive co-contractions, and absent or poor selective voluntary motor control (SVMC) (2).

Children with CP have damage to the corticospinal tract (CST) and ascending sensory tracts. With CST damage, isolated movements cannot be controlled, and SVMC is reduced (3). Reduced SVMC results in an impaired ability to isolate the activation of muscles in a selected pattern in response to the demands of a voluntary posture or movement (4). This results in decreased fluency, lack of movement, inability to change direction, reduced speed, and involuntary movement of other joints, including mirror movements (5).

Physical manifestations of reduced SVMC include mirrored movements, movement of other joints or trunk segments, mass pattern movements, and dynamic movement less than the available (passive) range of motion (4). In recent years, Selective Control of the Upper Extremity Scale (SCUES), which includes all the components of SVMC, has been developed to evaluate SVMC accurately. The SCUES allows for a more precise description of impaired selective movements (i.e., mirror movements, trunk movement, and other joints) (4).

Decreased SVMC in children with CP may prevent many daily bimanual activities that require independent control of both hands. The loss of SVMC may interfere with their overall level of functioning more so than some of the other impairments. Poor SVMC may limit the potential functional improvements in treating the other impairments (6). Therefore, SVMC evaluation is essential to determine its relationship with function to ensure possible improvement.

The literature has investigated the relationship between lower extremity SVMC and functional performance, such as gross motor function and walking, in children with CP (7-9). However, limited studies exist on the relationship between SVMC and upper extremity function. Therefore, this study aimed to describe the upper extremity SVMC in children with unilateral CP and its association with upper extremity function.

METHODS

Participants and Recruitment

This study was designed as a prospective study conducted between January 2018 and August 2018. Children with CP were evaluated in the Gazi University Faculty of Health Sciences pediatric rehabilitation unit. Each child's assessment took approximately one hour and was completed the same day. This study was approved by the Gazi University Ethical Committee (number: 77082166-302.08.01-). Volunteer approvals were received from each child and their parents to participate in the study. Inclusion criteria were: diagnosis of unilateral spastic CP, age between 6 and 18 years, and ability to follow simple instructions. The exclusion criteria were previous upper extremities surgery, botox injection of the upper extremities within the preceding six months, fixed deformities of the upper extremities, and visual or auditory problems. Twenty-four unilateral CPs who met the criteria were included in the study. One physiotherapist with expertise in the pediatric field performed the evaluations. To evaluate the child's SVMC, the review was first started with a video recording. Children's MACS level was recorded according to their daily performance. Then, the physiotherapist recorded the child's performances using JTT and QUEST.

Measurements

Selective Control of the Upper Extremity Scale (SCUES)

The scale evaluating the upper extremity selective control was developed by Wagner et al. (4). The SCUES considers movement at each joint level: the presence of mirror movements, movement of additional joints, the target or index joint, presence of trunk movement, and dynamic motion less than passive range of motion (ROM).

Upper extremity joints and trends are examined, including the shoulder (abduction/adduction), elbow (flexion/extension), forearm (supination/pronation), wrist (flexion/extension), and fingers/thumb (grasp/release). A video camera is placed in front of a participant sitting on a table. The examiner demonstrates the desired motion to the participant and then passively moves the participant's joint in the desired planes. The participant is then asked to perform the same movement—the examiner from the videotape grades this activity. The evaluation lasts less than 15 minutes. Motion at each of the five joint levels is graded on a four-point scale: no SVMC (0 points), moderately diminished SVMC (1 point), mildly reduced SVMC (2 points), and normal SVMC (3 points) (10). A third physiotherapist, blind to the child's clinical examination, scored the videos. The total score of the SCUES ranges between 0 and 15, and higher scores indicate better SVMC.

Jebsen Taylor Hand Function Test (JTT)

It is a standard test used to evaluate the general hand function of the person. Seven test subsets simulate hand function, including writing, simulated page turning, stacking checkers, simulated feeding and picking up small everyday objects, large light objects, and large, heavy objects, and in this study, eliminating the writing task and capping the maximum allowable time to complete each of the six timed items at 2 minutes modified the JTT. Thus, the whole time to complete all items was 720 seconds. A total score was calculated from the individual scores for each subtest (11).

Quality of Upper Extremity Skill Test (QUEST)

The QUEST evaluates the quality of the upper extremity in four areas: dissociated movement, grip, weight-bearing, and protective extension. A score of "yes" (1 point) or "no"(0 points) is given according to the completion of each movement or task. The four field scores are summed to achieve the total score. During evaluation, the child cannot use any device in the upper extremity. Both the right and left upper extremities of the child are scored. The total score is between 0 and 100; a child without a neurological problem can get 100 points. A higher score on the test indicates that the child has better upper extremity performance (12).

Manual Ability Classification System (MACS)

The MACS is a five-level system with a practical observation-based classification system for manual ability in children with CP. Level I represents the best manual ability, and level V indicates that the child does not use their hands for functional activity. It describes the children's handling of objects in daily activities (13).

Statistical analysis

Sample size for correlation analysis was determined using G*POWER statistical software. It was stated that the appropriate sample size for the current research was N = 24 (effect size = 0.5; β=0.2; α=0.05). Statistical analyses were performed using SPSS (IBM SPSS Statistics 22.0, IBM Ehningen, Germany). The variables were investigated using visual (histograms, probability plots) and analytical methods (Kolmogorov-Simirnov/Shapiro-Wilk's test) to determine whether or not they are typically distributed. Individual joint SCUES scores were compared using nonparametric repeated measures methods (Friedman procedure). Wilcoxon test with a Bonferroni correction was used to detect the significant differences within each limb. The corresponding test for trend was computed to analyze the relation among joints from shoulder to fingers. Spearman correlation coefficient (r) was used to describe associations between selective movement control and measures of upper extremity functions. Statistical significance was set at $p<0.05$.

RESULTS

The mean age of the children participating in the study was 12.4 ± 3.4 years. The demographic characteristics and MACS levels of the participants are shown in Table 1.

Mean SCUES scores showed more significant SVMC impairment in distal than proximal joints bilaterally (Fig 1). A statistically significant decrease in SCUES scores from shoulder to fingers

Table 1. Demographic Features of the Participants

	Age (years)	
	Mean ± SD	**Range**
Child	12.40 ± 3.42	6-18
	n	**%**
Sex		
Male	11	45.80
Female	13	54.20
MACS Level		
Level 1	12	50
Level 2	6	25
Level 3	6	25

MACS: Manual Ability Classification System

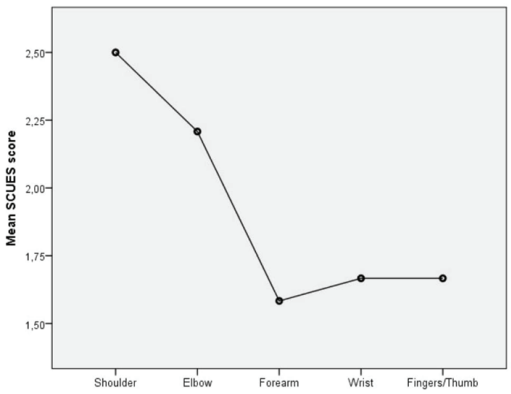

Figure 1. Mean Selective Control of the Upper Extremity Scale Scores by Joint for Affected Extremity

was found using the trend analysis (p<0.001). There was a substantial difference between all pairwise SCUES score comparisons involving shoulder and elbow joints. Comparisons between scores for fingers versus wrist, fingers versus forearm, and wrist versus forearm showed no difference. Table 2 presents p values for all pairwise comparisons using the Friedman test.

The median and IQR range of all variables are listed in Table 3. Correlations showed that all the variables of upper extremity function were associated with SCUES (Table 4). SCUES was negatively correlated with both the JTT and the MACS. Also, there was a positive correlation between QUEST and SCUES.

Table 2. Comparison between SCUES Scores for Five Joints

Joint Comparison	**p**
Shoulder vs Elbow	0.020
Shoulder vs Forearm	0.001
Shoulder vs. Wrist	0.001
Shoulder vs. Fingers/Thumb	0.001
Elbow vs. Forearm	0.001
Elbow vs. Wrist	0.002
Elbow vs. Fingers/Thumb	0.002
Forearm vs. Wrist	0.527
Forearm vs. Fingers/Thumb	0.527
Wrist vs. Fingers/Thumb	1.00

Significant at p<0.001, Individual p Values (Friedman Test) and Overall Trend

Table 3. Upper Extremity Function Results of the Participants

	Unilateral CP *n = 24*	
	Median	**IQR range**
SCUES		
Total Score	10.50	7 – 14
JTT		
Total Score	229.72	106.80 – 509.90
QUEST		
Dissociated Movement	96.80	82 – 99.65
Grasp	87.91	76.30 – 100
Weight Bearing	100	93 – 100
Protective Extension	100	91.60 – 100
Total Score	96.20	86.30 – 99.50

SCUES: Selective Control of the Upper Extremity Scale, JTT: Jebsen Taylor Hand Function Test, QUEST: Quality of Upper Extremity Skill Test

Table 4. Correlation between Upper Extremity Functions and Selective Motor Control

	SCUES	
	r	**p**
JTT Total Score	- 0.87	<0.001
QUEST		
Dissociated Movement	0.81	<0.001
Grasp	0.78	<0.001
Weight Bearing	0.67	<0.001
Protective Extension	0.68	<0.001
Total score	0.79	<0.001
MACS	-0.83	<0.001

SCUES: Selective Control of the Upper Extremity Scale, JTT: Jebsen Taylor Hand Function Test, QUEST: Quality of Upper Extremity Skill Test, MACS: Manual Ability Classification System, Spearman's Correlation Coefficients

DISCUSSION

This study aims to investigate the relationship between SVMC and upper extremity function in children with unilateral spastic CP; few studies examine this relationship between SVMC and upper extremity function in children with CP. This study found that the severity of SVMC impairment increased from proximal to distal joints. Also, in this study, we could demonstrate a relationship between upper extremity SVMC and upper extremity functions.

The upper extremity function impairment in children with unilateral CP is mainly associated with controlling the distal movement component of the affected side rather than the proximal one (14). Tedroff et al. evaluated the temporal sequence of muscle recruitment during maximal voluntary contractions in children with CP. They reported that inappropriate antagonist activation before agonists was more prevalent in the distal than the proximal muscular system in children with CP (15). These results are consistent with our findings of decreased ability to perform isolated joint motion in distal parts. In line with the study's results, the distribution of selective motor control impairment from proximal to distal in motor function development in young children with CP may be valuable for both treatment planning and prognosis evaluation.

Children with CP demonstrate mirror movements with uncontrolled simultaneous associated movements at contralateral joints. Mirror movements are simultaneous involuntary movements that accompany the voluntary movements of the muscles on the opposite side of the body (16). Mirror movements in the upper limbs and their

relationship with upper limb function have been studied in children with unilateral CP (16-18). Kuhtz-Buschbeck et al. found significant correlations between the number of mirror movements and the scores of bimanual function (16). Adler et al. concluded that mirror movements had a significant negative impact on the time to perform the bimanual activities and a negative effect on mirror movements on the bimanual hand function (18). The results show that mirror activity is associated with poor hand coordination, in line with our findings.

Although some studies have explored the relationship between mirror movements and bimanual performance while controlling for the capacity of the affected hand (17, 18), the relationship between total SVMC and upper extremity functions has never been studied directly. Also, these studies used only a subjective, ordinal rating scale for assessing mirror movements (17, 18). Further analysis using reliable and valid upper limb assessments is required better to understand the impact of SVMC on upper limb function. For this reason, SCUES, which was recently reported to have developed validity and reliability, has been used in this study (4). SCUES is a clinical tool designed to assess SVMC of the entire upper extremity by summing the scores for five joints (shoulder, elbow, forearm, wrist, and fingers/thumb). Thus, the mirror movements, other joints' movements, trunk direction, and available ROM motion were evaluated.

Hand motor skills involve both the activation of appropriate motor sequences and the prevention of involuntary, extraneous movements (16). The mirror movements during grasping can lead to inadequate grip force. Adler et al. found that children with unilateral CP could not adjust their grip forces due to mirror movements during bimanual activities (18). Kuhtz-Buschbeck et al. showed that, during a grip-lift task, hemiparetic children with mirror movement used a high grip force. This study had a relationship between SVMC and grasping skills (15). In another recent study, it was reported that there was a positive relationship between selective motor control and upper extremity function and hand grip strength in children with hemiparesis (19). Uncoordinated hand, finger, and arm movements make manipulating and grasping objects difficult. This study found a relationship between upper extremity SVMC and upper extremity functions, in line with the literature.

The small sample size limited the current study. Additionally, bimanual tasks have yet to be evaluated separately. A comprehensive evaluation of a larger sample size is recommended for future studies.

The present study aimed to define the upper extremity SVMC and found an increase in the severity of impairment from proximal to distal joints. Also, this study concludes that SVMC is generally associated with upper extremity impairments. Therefore, focusing on SVMC in physiotherapy and rehabilitation applications is essential to improve upper extremity performance.

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Conflict of Interest: Authors declare that there is no conflict of interest.

Author Contributions: Concept – AY and BE; Design - AY; Supervision – BE; Resources and Financial Support – BE and RY; Materials – RY and BE; Data Collection and Processing - RY, and AY; Analysis and Interpretation - AY; Literature Research - RY, and AY; Writing Manuscript - RY, and AY; Critical Review – BE.

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