IZMIR DEMOCRACY UNIVERSITY HEALTH SCIENCES JOURNAL
IDUHES
e-ISNN:2651-4575

IDUHeS, 2024; 7(3): 262-271
Doi: 10.52538/iduhes.1510201

Research Paper – Araştırma Makalesi

THE RELATIONSHIP OF UNIMANUAL AND BIMANUAL CAPACITY WITH PERCEIVED BIMANUAL PERFORMANCE IN CHILDREN WITH UNILATERAL CEREBRAL PALSY

UNİLATERAL SEREBRAL PALSİLİ ÇOCUKLARDA UNİMANUEL VE BİMANUEL KAPASİTENİN ALGILANAN BİMANUEL PERFORMANSLA İLİŞKİSİ

Hilal Başak CAN[1,2], Gönül ACAR[2], Gaye TORNA[3], Çiğdem ÇEKMECE[4], Fuat BİLGİLİ[3]

Özet

Çalışmada 6-12 yaş aralığındaki unilateral Serebral Palsi'li çocuklarda unimanuel ve bimanuel kapasitenin algılanan bimanuel performansla ilişkisini araştırmak amaçlandı. Çalışmaya yaş ortalaması 9,47±1,62 yıl olan, 15'i kız ve 19'u erkek olmak üzere toplam 34 çocuk katıldı. Her iki elin unimanuel kapasitesini ölçmek için Minnesota El Becerisi Testi'nin (MEBT) yerleştirme alt testi ve Kutu ve Blok Testi (KBT) kullanıldı. Bimanuel kapasite MEBT'in döndürme alt testi ile değerlendirildi. Ebeveynler, Çocukların El Kullanım Deneyimi Anketi (ÇEDA) ve ABILHAND-Kids aracılığıyla algılanan bimanüel performansı değerlendirdi. KBT ve yerleştirme testi ile ölçülen etkilenen elin kapasitesinin ÇEDA alt skalaları ile düşük-orta düzeyde ve ABILHAND-Kids ile düşük düzeyde anlamlı ilişkili olduğu ($p<0,05$); bimanuel kapasitenin ÇEDA alt skalaları ile düşük-orta ve ABILHAND-Kids ile düşük düzeyde anlamlı ilişkili olduğu bulundu ($p<0,05$). Kontralateral elin MEBT'nin yerleştirme alt testi ile ölçülen kapasitesinin ÇEDA'nın hissedilen rahatsızlık alt skalası ile düşük düzeyde anlamlı ilişkisi olduğu saptandı ($p<0,05$). Sonuçlar, etkilenen elin kapasitesi ve bimanuel kapasitenin algılanan bimanuel performansla ilişkili olduğunu ortaya koydu. Ancak, bu kapasiteler tarafından algılanan bimanuel performansın tahmin edilebilirliği düşüktü.

Anahtar Kelimeler: Bimanuel Kapasite, Bimanuel Performans, Unimanuel Kapasite, Unilateral Serebral Palsi

Abstract

The aim of this investigation was to examine the correlation between unimanual and bimanual capacities as well as the perceived bimanual performance among children diagnosed with unilateral cerebral palsy, aged between 6 and 12 years. A total of 34 children, consisting of 15 girls and 19 boys with a mean age of 9.47±1.62 years, participated. The placing test, which is one of the subtests of the Minnesota Manual Dexterity Test (MMDT), and the Box and Block Test (BBT) were used to quantify the unimanual capacity of both hands. Bimanual capacity was evaluated with the turning test, another subtest of the MMDT. Parents evaluated perceived bimanual performance through the Children's Hand-Use Experience Questionnaire (CHEQ) and ABILHAND-Kids. The capacity of the affected hand, quantified by the BBT and placing test, was found to be significantly correlated with the CHEQ subscales at a low to moderate level and with ABILHAND-Kids at a low level ($p<0.05$). Bimanual capacity demonstrated a significant correlation ranging from low to moderate with the CHEQ subscales, and exhibited a weak correlation with ABILHAND-Kids ($p<0.05$). It was observed that the capacity of the contralateral hand, as measured by the MMDT placing test, exhibited a low level of significant correlation with the CHEQ subscale feeling bothered ($p<0.05$). The results revealed that the capacity of the affected hand and bimanual capacity were related to perceived bimanual performance. However, the predictability of perceived bimanual performance by these capacities was low.

Keywords: Bimanual capacity, bimanual performance, unimanual capacity, unilateral cerebral palsy

Geliş Tarihi (Received Date): 04.07.2024, Kabul Tarihi (Accepted Date): 01.09.2024, Basım Tarihi (Published Date): 31.12.2024. [1] Institute of Health Sciences, Department of Physiotherapy and Rehabilitation, Marmara University, İstanbul, Türkiye, [2] Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, Marmara University, İstanbul, Türkiye, [3] Istanbul Faculty of Medicine, Department of Orthopedics and Traumatology, İstanbul University, İstanbul, Türkiye, 4 Kocaeli Vocational School of Health Services, Department of Therapy and Rehabilitation/Occupational Therapy, Kocaeli University, Kocaeli, Türkiye. **E-mail:** hbasakcan@gmail.com **ORCID ID's:** H.B.C.; https:/orcid.org/0000-0001-8991-202X, G.A.; https:/orcid.org/0000-0002-6964-6614, G.T.; https://orcid.org/0009-0005-8118-6461, Ç.Ç.; https://orcid.org/0000-0003-2865-480X, F.B.; https://orcid.org/0000-0002-9417-2166

1. INTRODUCTION

Functional limitations of the affected arm and hand in children with unilateral cerebral palsy (CP) may inhibit them from participating in activities of daily living (Klingels et al., 2010, pp. 887-900). The severity of these limitations is in relation to brain damage features and the reorganization process of the corticospinal tract (Gordon, Bleyenheuft and Steenbergen, 2013, pp. 32-37). One of the main focuses regarding the rehabilitation of these children is the functional use of the affected upper limb in daily life. Therefore, both unimanual capacity, that is, "what the affected hand can do" when it is asked to use it, and bimanual performance, that is, "how it is used" in activities necessitating the use of both hands together, hold significant importance (Sakzewski, Ziviani and Boyd, 2010, pp. 811-816). Among the most effective treatments for improving hand function are stand constraint-induced movement therapy, which is a unimanual approach, and bimanual therapy; these two therapies have been deemed complementary to each other in those with unilateral CP. After developing unimanual actions with constraint-induced movement therapy, it has been proposed to use bimanual therapy to transform these acquired skills into bimanual performance (Hoare and Greaves, 2017, pp. 47-59). However, it has been reported that the order in which these two therapies are received does not make clinically meaningful differences (Au et al., 2023, pp. 490).

Poor bimanual performance in many daily activities is the major functional problem for children diagnosed with unilateral CP (Greaves, Imms, Dodd and Krumlinde-Sundholm, 2010, pp. 413-421). The affected hand has lower unimanual capacity, and the capacity of the contralateral hand in addition to the affected hand is below normative values (Tomhave, Van Heest, Bagley and James, 2015, pp. 900-907). Bimanual performance in early childhood improves with increasing age (Klevberg et al., 2018, pp. 490-497). Although unimanual capacity improves over time, deterioration in bimanual performance was noted after the age of 9, which may be related to sensory deficits and developmental disregard (Klingels et al., 2018, p. 2831342).

Sensibility and muscle strength, especially distal muscle strength, are determinants of affected hand capacity and bimanual performance (Klingels et al., 2012, pp. 475-484). While a robust association between the capacity of the affected hand and observed bimanual performance has been highlighted in the existing literature (Chaleat-Valayer et al., 2015, pp. 193-201), no such study has been found regarding perceived bimanual performance. Furthermore, it remains unclear whether bimanual capacity is related to bimanual performance. Hence, the aim of the present study was to investigate the relationship between unimanual/bimanual capacities and the perceived bimanual performance of children diagnosed with unilateral CP, aged between 6 and 12 years.

2. METHODS

Approval for this study, which had a cross-sectional design and was conducted in compliance with the Declaration of Helsinki criteria, was granted by the Marmara University Faculty of Health Sciences Human Ethics Committee (25.04.2024/75). Informed consent was obtained from children verbally and from parents in writing.

2.1. Participants

Children diagnosed with unilateral CP between 6 and 12 years who had 1, 2, and 3 of the Manual Ability Classification System (MACS) and 4 and above scores of the House Functional Classification System (HFCS) were included in the study. In addition, the children were required to be capable of comprehending and completing the test procedures, and to have no uncorrected hearing or vision problems, or attention deficit. Children who had undergone any orthopaedic surgery and/or performed injections of botulinum toxin A in the upper-limbs in previous six months were excluded from the study. In a power analysis conducted using G*Power 3.1.9.7, the sample size required to achieve 80% power was calculated to be at least 29 (effect size: 0.5, $\alpha = 0.05$) (Faul, Erdfelder, Lang and Buchner, 2007, pp. 175-191).

2.2. Instruments

The Box and Block Test (BBT) assesses how many 2.5-cm cubes individuals can transfer as fast as possible between compartments of the box in one minute. A greater number of cubes indicates better unimanual capacity (Liang, Chen, Shieh and Wang, 2021, p. 20955; Mathiowetz, Federman and Wiemer, 1985, pp. 241-245). The Minnesota Manual Dexterity Test (MMDT) employs 60 discs, painted one side red and the other black, and a foldable board with 4 rows of 15 holes in each row, for a total of 60 holes. The test comprises two subtests. It is desirable to complete both tests as quickly as possible in accordance with predetermined patterns. In the placing test, children are instructed to place the discs in the holes by evaluated hand. In the turning test, it is required to place the discs in the holes by taking them with one hand and turning them while passing them to the other hand (Wang, Wickstrom, Yen, Kapellusch and Grogan, 2018, pp. 339-347). The unimanual capacity of the affected and contralateral hand was evaluated using the BBT and MMDT placing test, while the bimanual capacity was evaluated using the MMDT turning test.

The Children's Hand-Use Experience Questionnaire (CHEQ) is a tool that can be used to assess the experience of children with unilateral CP in utilizing their affected hand during various bimanual tasks (Amer, Eliasson, Peny-Dahlstrand and Hermansson, 2016, pp. 743-749; Sköld, Hermansson, Krumlinde-Sundholm and Eliasson, 2011, pp. 436-442). This allows evaluating the utilization of the affected hand in bimanual tasks, comparing the time required to complete these tasks with that of peers, and assessing feelings of discomfort experienced during the tasks (Amer et al., 2016, pp. 743-749; Eren, Ekici and Alkan, 2022, pp. 34-45; Sköld et al., 2011, pp. 436-442). The instrument is available at no cost via https://www.cheq.se, and the results of the Rasch analysis can be accessed from the report obtained from the website. ABILHAND-Kids is a questionnaire that evaluates the perceived ease and difficulty of performing 21 activities, the majority of which are bimanual, in children with CP (Arnould, Penta, Renders and Thonnard, 2004, pp. 1045-1052). The website https://www.rehab-scales.org/scale/abilhand-kids provides access to the questionnaire and allows for the retrieval of Rasch analysis results. The parents were asked to complete the Turkish versions of CHEQ and ABILHAND-Kids, which are found valid and reliable (Eren et al., 2022, pp. 34-45; Şahin et al., 2020, pp. 444-451).

2.3. Statistical analyses

The SPSS 11.5 program was employed to analyse the data, and the significance level was accepted as 0.05. Depending on the Shapiro-Wilk test, it was determined whether there was a relationship between capacity and performance with either Pearson's correlation test or Spearman's rank order correlation test. Among the correlation coefficients obtained as a result of the study, those ranging from 0.3 to 0.5 were interpreted as low, and those ranging from 0.5

to 0.7 were interpreted as moderate (Mukaka, 2012, pp. 69-71). Bimanual performance variables were considered dependent variables, and simple linear regression was performed for those variables exhibiting a significant relationship.

3. RESULTS

The study was conducted on 34 children, aged minimum 6 and maximum 12 years (mean age 9.47±1.62 years). 55.9% of the children were male, 67.6% were right-sided, 55.9% were level I according to MACS, and half scored 5 on the HFCS (Table-1). The children's unimanual and bimanual capacities, along with their bimanual performances, were as presented in Table-2.

Table 1: Demographics and functional levels of participants

Characteristic	Frequency	
	N	%
Gender		
Male	19	55.9
Female	15	44.1
Affected side		
Right	23	67.6
Left	11	32.4
MACS		
1	19	55.9
2	8	23.5
3	7	20.6
HFCS		
5	17	50
6	6	17.6
7	6	17.6
8	5	14.7

MACS: Manual Ability Classification System; HFCS: House Functional Classification System; n: number of participants.

Table 2: Results of BBT, MMDT, CHEQ, and ABILHAND-Kids

Assessment	Mean±SD (min-max)
BBT	
Contralateral side	45.82 ± 8.75 (23-62)
Affected side	31.5 ± 11.87 (10-54)
MMDT	
Placing test	
Contralateral side	101.76 ± 22.21 (80-192)
Affected side	187.41 ± 83.16 (84-387)
Turning test	185.35 ± 93.84 (76-486)
CHEQ	
Grasp efficacy	48.74 ± 17.18 (9-83)
Time consumption	53.53 ± 14.49 (29-82)
Feeling bothered	54.91 ± 15.92 (30-91)
ABILHAND-Kids	2.37 ± 1.24 (0.17-4.35)

BBT: Box and Block Test; MMDT: Minnesota Manual Dexterity Test; CHEQ: Children's Hand-Use Experience Questionnaire; SD: Standard Deviation; min: Minimum; max: Maximum.

Analyses revealed that only the MMDT placing test result of the contralateral hand had a low-level negative correlation with CHEQ feeling bothered (r: -0.407, p: 0.017), which is one of the indicators of bimanual performance. A moderate-level positive correlation was observed between the affected hand's capacity, assessed by BBT, and the CHEQ grasp efficacy (r: 0.529, p: 0.001), while a low-level positive correlation was found with other CHEQ subscales (r: 0.407, p: 0.017 for time consumption; r: 0.393, p: 0.022 for feeling bothered) and ABILHAND-Kids (r: 0.362, p: 0.035). The affected hand's capacity, as evaluated by the MMDT placing test, exhibited a negative moderate correlation with all subscales of the CHEQ (r: -0.627, p: <0.001 for grasp efficacy; r: -0.565, p: <0.001 for time consumption; r: -0.512, p: 0.002 for feeling bothered) and a negative low correlation with ABILHAND-Kids (r: -0.443, p: 0.009). A negative moderate level relationship was determined between bimanual capacity and CHEQ grasp efficacy (r: -0.578, p: <0.001) and time consumption (r: -0.515, p: 0.002) subscales, and a negative low-level relationship with CHEQ feeling bothered (r: -0.492, p: 0.003) and ABILHAND-Kids (r: -0.373, p: 0.030) (Table-3).

Table 3: The Correlation Findings of Unimanual and Bimanual Capacity with Bimanual Performance

		BBT		MMDT		
				Placing test		
		Contralateral side	Affected side	Contralateral side	Affected side	Turning test
CHEQ	Grasp efficacy	r: 0.016 p: 0.930 [a]	r: 0.529 p: 0.001 [a*]	r: -0.203 p: 0.250 [b]	r: -0.627 p: <0.001 [b*]	r: -0.578 p: <0.001 [b*]
	Time consumption	r: -0.027 p: 0.880 [a]	r: 0.407 p: 0.017 [a*]	r: -0.339 p: 0.050 [b]	r: -0.565 p: <0.001 [b*]	r: -0.515 p: 0.002 [b*]
	Feeling bothered	r: -0.031 p: 0.864 [a]	r: 0.393 p: 0.022 [a*]	r: -0.407 p: 0.017 [b*]	r: -0.512 p: 0.002 [b*]	r: -0.492 p: 0.003 [b*]
ABILHAND-Kids		r: -0.026 p: 0.884 [b]	r: 0.362 p: 0.035 [b*]	r: -0.297 p: 0.088 [b]	r: -0.443 p: 0.009 [b*]	r: -0.373 p: 0.030 [b*]

BBT: Box and Block Test (unimanual capacity); MMDT: Minnesota Manual Dexterity Test (unimanual and bimanual capacity); CHEQ: Children's Hand-Use Experience Questionnaire (bimanual performance); r: Correlation coefficient; a: Pearson's correlation test; b: Spearman's rank order correlation test.

Regression analysis demonstrated that the affected hand's capacity accounted for 28-35% of the grasp efficacy of the affected hand, 17-21% of the time consumption, and 15-20% of the feeling bothered. It was determined that it explained 16-17% of the perceived bimanual performance evaluated with ABILHAND-Kids. The results indicated that bimanual capacity explained 33%, 15%, 17%, and 13% of the variance in CHEQ grasp efficacy, CHEQ time consumption, CHEQ feeling bothered, and ABILHAND-Kids, respectively (Table-4).

Table 4: Predictive Level of Unimanual and Bimanual Capacity on Bimanual Performance

Dependent variable	Independent variable	R	R^2	F	B	SE	Beta	t	P
CHEQ-Grasp efficacy	BBT-affected side	0.529	0.280	12,461	0.766	0.217	0.529	3.530	0.001
	MMDT-Placing test-Affected side	0.592	0.351	17.283	-0.122	0.029	-0.592	-4.157	<0.001
	MMDT-Turning test	0.578	0.334	16.072	-0.106	0.026	-0.578	-4.009	<0.001
CHEQ- Time consumption	BBT-affected side	0.407	0.166	6.351	0.497	0.197	0.407	2.520	0.017

	MMDT-Placing test-Affected side	0.459	0.210	8.528	-0.080	0.027	-0.459	-2.920	0.006
	MMDT-Turning test	0.393	0.154	5.833	-0.061	0.025	-0.393	-2.415	0.022
CHEQ-Feeling bothered	BBT-affected side	0.393	0.154	5.834	0.527	0.218	0.393	2.415	0.022
	MMDT-Placing test-Contralateral side	0.167	0.028	0.923	-0.120	0.125	-0.167	-0.961	0.344
	MMDT-Placing test-Affected side	0.446	0.199	7.926	-0.085	0.030	-0.446	-2.815	0.008
	MMDT-Turning test	0.416	0.173	6.706	-0.071	0.027	-0.416	-2.590	0.014
ABILHAND-Kids	BBT-affected side	0.398	0.158	6.018	0.042	0.017	0.398	2.453	0.020
	MMDT-Placing test-Affected side	0.411	0.169	6.508	-0.006	0.002	-0.411	-2.551	0.016
	MMDT-Turning test	0.365	0.133	4.911	-0.005	0.002	-0.365	-2.216	0.034

BBT: Box and Block Test (unimanual capacity); MMDT: Minnesota Manual Dexterity Test (unimanual and bimanual capacity); CHEQ: Children's Hand-Use Experience Questionnaire (bimanual performance); R: Correlation Coefficient; R^2: R-Squared; F: F-Statistic; B: Unstandardized Coefficient; SE: Standard Error; Beta: Standardized Coefficient; t: t-Statistic. Simple linear regression.

4. DISCUSSION

This study investigated whether the perceived bimanual performance of the children aged 6–12 with unilateral CP was related to their unimanual capacity of the affected and contralateral hand and bimanual capacity. The primary result of this study is affected hand's capacity and bimanual capacity were revealed to be related to bimanual performance. Secondly, the results indicated that the capacity of the contralateral hand was only related to feeling bothered during bimanual performance.

It was observed that as the capacity of the affected hand and bimanual capacity increased, the utilization of the affected hand in bimanual tasks increased, also the time to complete bimanual tasks was comparable with peers. Moreover, feelings of being bothered during bimanual tasks and perceived difficulty in most bimanual tasks decreased. The strength of these correlations was low to moderate. Chaleat-Valayer et al. demonstrated a high correlation between the capacity of the affected hand as well as bimanual performance in children with hemiplegic CP and that the capacity explains 70% of the performance (Chaleat-Valayer et al., 2015, pp. 193-201). Similarly, in children with congenital hemiplegia, there has been evidence of a robust correlation, and furthermore, 75% of the variability in bimanual performance was accounted for by unimanual capacity together with stereognosis collectively (Sakzewski et al., 2010, pp. 811-816). It is worth noting that this current study differs from the two previously published studies in terms of the methodology employed. In contrast to this study, the previously published studies used the Melbourne Test (MUUL) to assess unimanual capacity and the Assisting Hand Assessment (AHA) to evaluate bimanual performance (Chaleat-Valayer et al., 2015, pp. 193-201; Sakzewski et al., 2010, pp. 811-816). AHA, which

was used in the mentioned studies, and CHEQ, which we used as an outcome measure for bimanual performance, are instruments that assess different yet interrelated aspects of bimanual performance. While CHEQ evaluates the perceived performance, AHA measures the observed performance. The CHEQ subscales account for only a small proportion, between 8 and 25%, of the observed variance in the AHA (Ryll, Bastiaenen and Eliasson, 2017, pp. 199-209).

Another difference from previous studies was the instruments used to evaluate unimanual capacity. MUUL is focused on unilateral upper-limb movement quality (Randall, Carlin, Chondros and Reddihough, 2001, pp. 761-767), while BBT and MMDT are concerned with speed and dexterity (Mathiowetz et al., 1985, pp. 241-245; Wang et al., 2018, pp. 339-347). The discrepancy between the relationship levels detected in the present study and those previously researches may be attributed to the differing tools employed for assessment. Future studies should aim to reveal whether this discrepancy is related to the evaluation instruments. In general terms, the present study corroborates the findings of previous studies, which have demonstrated that there was a relationship unimanual capacity and bimanual performance. The research to date has not considered the impact of bimanual capacity on bimanual performance. Another potential area for future investigation may be the results of the current study related to these two.

The distinction between capacity, the function of the hand in a standard environment at the highest level, and performance, the perceived or observed function of the hand in daily life, is an essential one. It should be noted that the capacity to use the hand for a task does not necessarily imply that that person actually uses their hand for the relevant task in real life (Krumlinde-Sundholm and Wagner, 2020, pp. 1569-1597; Lemmens, Timmermans, Janssen-Potten, Smeets and Seelen, 2012, p. 21). The moderate correlation between the affected hand's capacity and performance in bimanual tasks, along with the fact that it can only account for 28–35% of performance in bimanual tasks, indicates that the affected hand's capacity only reflects its perceived use in daily life to a limited extent. Conversely, the observation that the capacity of the contralateral hand is only weakly related to the experience of bothering during bimanual tasks and is insufficient to account for the observed change in feeling bothered suggests that the capacity of the affected hand may have played a more decisive role in the perception of bimanual performance.

The regression analyses indicate that the capacity of the affected hand accounts for 15–35% of the CHEQ subscales and 16–17% of the ABILHAND-Kids; bimanual capacity explains 15–33% of the CHEQ subscales and 13% of the ABILHAND-Kids. The results indicated that the perceived using of the affected hand during bimanual tasks had low predictability based on its capacity and bimanual capacity. This suggests the existence of other potential factors that can significantly explain the change in perceived bimanual performance. Klingels et al. demonstrated that 46% of ABILHAND-Kids was explained by wrist strength and stereognosis from body structure measurements (Klingels et al., 2012, pp. 475-484). Furthermore, when the predictability of the bimanual performance of the affected hand capacities evaluated by BBT and MMDT was examined, it was observed that MMDT was better. Whereas in BBT, the cubes are taken from one compartment of the box and left in any order in the other compartment of the box, regardless of the order, in MMDT, the discs must be placed in the holes of the folding board in a specific order. This implies that MMDT demands greater hand-eye coordination and precision. The evidence that MMDT is superior at elucidating variance suggests that hand-eye coordination and sensitivity may be additional contributing factors that can explain perceived performance.

The study's limited sample size of 34 children precludes the ability to generalize the observed results. However, the findings from the current study can inform future studies utilizing larger samples.

5. CONCLUSION

The study found that the perceived bimanual performance of the children aged 6–12 with unilateral CP was weakly to moderately related to their affected hand's capacity and bimanual capacity. The predictability of perceived bimanual performance by these capacities was low. The aim of upper-limb interventions in these children is to enhance bimanual performance. The study's findings suggest that improvements in perceived bimanual performance can be achieved through therapeutic interventions that will increase unimanual and bimanual capacity.

6. REFERENCES

Amer, A., Eliasson, A. C., Peny-Dahlstrand, M., Hermansson, L. (2016). Validity and test-retest reliability of Children's Hand-use Experience Questionnaire in children with unilateral cerebral palsy. *Dev Med Child Neurol, 58*(7), 743-749. doi:10.1111/dmcn.12991

Arnould, C., Penta, M., Renders, A., Thonnard, J. L. (2004). ABILHAND-Kids: a measure of manual ability in children with cerebral palsy. *Neurology, 63*(6), 1045-1052. doi:10.1212/01.wnl.0000138423.77640.37

Au, K. L. K., Knitter, J. L., Morrow-McGinty, S., Campos, T. C., Carmel, J. B., Friel, K. M. (2023). Combining Unimanual and Bimanual Therapies for Children with Hemiparesis: Is There an Optimal Delivery Schedule? *Behav Sci (Basel), 13*(6), 490. doi:10.3390/bs13060490

Chaleat-Valayer, E., Bard-Pondarre, R., Ganne, C., Roumenoff, F., Combey, A., Bernard, J. C. (2015). Relation between unimanual capacities and bimanual performance in hemiplegic cerebral-palsied children: impact of synkinesis. *Eur J Paediatr Neurol, 19*(2), 193-201. doi:10.1016/j.ejpn.2014.12.002

Eren, M., Ekici, G., Alkan, H. (2022). Reliability and validity of turkish version of children's hand use experience questionnaire for children with hemiparetic cerebral palsy. *International Journal of Health Administration and Education Congress (Sanitas Magisterium), 8*(1), 34-45. Retrieved from https://dergipark.org.tr/tr/pub/ijhadec/issue/65894/1027949

Faul F, Erdfelder E, Lang A-G, Buchner A. (2007). G* Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior research methods*, *39*(2), 175-191. doi: 10.3758/bf03193146.

Gordon, A. M., Bleyenheuft, Y., Steenbergen, B. (2013). Pathophysiology of impaired hand function in children with unilateral cerebral palsy. *Dev Med Child Neurol, 55 Suppl 4*, 32-37. doi:10.1111/dmcn.12304

Greaves, S., Imms, C., Dodd, K., Krumlinde-Sundholm, L. (2010). Assessing bimanual performance in young children with hemiplegic cerebral palsy: a systematic review. *Dev Med Child Neurol, 52*(5), 413-421. doi:10.1111/j.1469-8749.2009.03561.x

Hoare, B., Greaves, S. (2017). Unimanual versus bimanual therapy in children with unilateral cerebral palsy: Same, same, but different. *J Pediatr Rehabil Med, 10*(1), 47-59. doi:10.3233/prm-170410

Klevberg, G. L., Elvrum, A. G., Zucknick, M., Elkjaer, S., Østensjø, S., Krumlinde-Sundholm, L., Kjeken, I., Jahnsen, R. (2018). Development of bimanual performance in young children with cerebral palsy. *Dev Med Child Neurol, 60*(5), 490-497. doi:10.1111/dmcn.13680

Klingels, K., Demeyere, I., Jaspers, E., De Cock, P., Molenaers, G., Boyd, R., Feys, H. (2012). Upper limb impairments and their impact on activity measures in children with unilateral cerebral palsy. *Eur J Paediatr Neurol, 16*(5), 475-484. doi:10.1016/j.ejpn.2011.12.008

Klingels, K., Jaspers, E., Van de Winckel, A., De Cock, P., Molenaers, G., Feys, H. (2010). A systematic review of arm activity measures for children with hemiplegic cerebral palsy. *Clin Rehabil, 24*(10), 887-900. doi:10.1177/0269215510367994

Klingels, K., Meyer, S., Mailleux, L., Simon-Martinez, C., Hoskens, J., Monbaliu, E., Verheyden, G., Verbeke, G., Molenaers, G., Ortibus, E., Feys, H. (2018). Time Course of Upper Limb Function in Children with Unilateral Cerebral Palsy: A Five-Year Follow-Up Study. *Neural Plast, 2018*, 2831342. doi:10.1155/2018/2831342

Krumlinde-Sundholm, L., Wagner, L. V. (2020). Upper Extremity Assessment and Outcome Evaluation in Cerebral Palsy. In F. Miller, S. Bachrach, N. Lennon, M. E. O'Neil (Eds.), *Cerebral Palsy* (pp. 1569-1597). Cham: Springer International Publishing.

Lemmens, R. J., Timmermans, A. A., Janssen-Potten, Y. J., Smeets, R. J., Seelen, H. A. (2012). Valid and reliable instruments for arm-hand assessment at ICF activity level in persons with hemiplegia: a systematic review. *BMC Neurol, 12*, 21. doi:10.1186/1471-2377-12-21

Liang, K. J., Chen, H. L., Shieh, J. Y., Wang, T. N. (2021). Measurement properties of the box and block test in children with unilateral cerebral palsy. *Sci Rep, 11*(1), 20955. doi:10.1038/s41598-021-00379-3

Mathiowetz, V., Federman, S., Wiemer, D. (1985). Box and Block Test of Manual Dexterity: Norms for 6–19 Year Olds. *Canadian Journal of Occupational Therapy, 52*(5), 241-245. doi:10.1177/000841748505200505

Mukaka, M. M. (2012). Statistics corner: A guide to appropriate use of correlation coefficient in medical research. *Malawi Med J, 24*(3), 69-71.

Randall, M., Carlin, J. B., Chondros, P., Reddihough, D. (2001). Reliability of the Melbourne assessment of unilateral upper limb function. *Dev Med Child Neurol, 43*(11), 761-767. doi:10.1017/s0012162201001396

Ryll, U. C., Bastiaenen, C. H., Eliasson, A. C. (2017). Assisting Hand Assessment and Children's Hand-Use Experience Questionnaire -Observed Versus Perceived Bimanual Performance in Children with Unilateral Cerebral Palsy. *Phys Occup Ther Pediatr, 37*(2), 199-209. doi:10.1080/01942638.2016.1185498

Sakzewski, L., Ziviani, J., Boyd, R. (2010). The relationship between unimanual capacity and bimanual performance in children with congenital hemiplegia. *Dev Med Child Neurol, 52*(9), 811-816. doi:10.1111/j.1469-8749.2009.03588.x

Sköld, A., Hermansson, L. N., Krumlinde-Sundholm, L., Eliasson, A. C. (2011). Development and evidence of validity for the Children's Hand-use Experience Questionnaire (CHEQ). *Dev Med Child Neurol, 53*(5), 436-442. doi:10.1111/j.1469-8749.2010.03896.x

Şahin, E., Dilek, B., Karakaş, A., Engin, O., Gülbahar, S., Faruk Dadaş, Ö., Peker, M. Ö., El, Ö. (2020). Reliability and Validity of the Turkish Version of the ABILHAND-Kids Survey in Children with Cerebral Palsy. *Turk J Phys Med Rehabil, 66*(4), 444-451. doi:10.5606/tftrd.2020.4091

Tomhave, W. A., Van Heest, A. E., Bagley, A., James, M. A. (2015). Affected and contralateral hand strength and dexterity measures in children with hemiplegic cerebral palsy. *J Hand Surg Am, 40*(5), 900-907. doi:10.1016/j.jhsa.2014.12.039

Wang, Y. C., Wickstrom, R., Yen, S. C., Kapellusch, J., Grogan, K. A. (2018). Assessing manual dexterity: Comparing the WorkAbility Rate of Manipulation Test with the Minnesota Manual Dexterity Test. *J Hand Ther, 31*(3), 339-347. doi:10.1016/j.jht.2017.03.009