Current issue list available at AnnMedRes

Annals of Medical Research

journal page: www.annalsmedres.org

Motor imagery profiles of the children with hemiplegic cerebral palsy according to gender and affected side

Demet Gozacan Karabulut[a,*], Eylem Tutun Yumin[b]

[a] *Gaziantep Islam Science and Technology University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, Gaziantep, Türkiye*

[b] *Bolu Abant Izzet Baysal University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, Bolu, Türkiye*

ARTICLE INFO

Keywords:
Age
Cerebral palsy
Gender
Motor imagery
Screen time

Received: Jul 26, 2022
Accepted: Oct 17, 2022
Available Online: 23.12.2022

DOI:
10.5455/annalsmedres.2022.07.219

Abstract

Aim: The purpose of the present study is to examine the motor imagery profiles of children with hemiplegic cerebral palsy.

Materials and Methods: 52 Hemiplegic (29 males, 23 females) individuals with 11.35 ± 3.48 years of mean age were included in the research. Participants' implicit motor imagery abilities were analyzed with the laterality task. In addition, weekday and weekend screen times were questioned.

Results: No statistically significant difference was determined in motor imagery abilities in terms of gender and affected extremity ($p>0.05$). Additionally, a significant correlation was found between screen time and Laterality task affected side accuracy and Laterality task not affected side accuracy percentages in both females and males ($p<0.05$). A significant correlation was found between age and motor imagery skills of males and left hemiplegic individuals.

Conclusion: Excessive screen times negatively affect motor imagery abilities in Hemiplegic Cerebral Palsy. It was observed that motor imagery skills were associated with age, but not with gender and affected sides.

Introduction

Cerebral palsy (CP) is a constant disease in postural and movement development, characterized by non-progressive disturbances in the evolving infant or fetal brain, causing activity limitation. In other words, CP is a movement, posture, and motor dysfunction resulting from a lesion in the immature Central Nervous System during the perinatal, prenatal, and postnatal periods. This lesion is constant but it is not progressive [1, 2]. CP's prevalence in Turkey is 4.4/1,000 live births [3]. Hemiplegic CP (HCP), on the other hand, is the most frequent type of CP among term infants, including one half of the body [4].

People with CP have constraints in motor functions evolving from multiple disorders such as contractures, spasticity, weakness, and decreased selective motor control [5]. Recent studies indicate that motor disturbances of children with CP cannot be related to only movement performance, but also to motor planning and motor imagery impairments, which involve an important cognitive-motor process and motor control [6-9]. Motor disorders in people with CP generate disorders in prospective motor planning [10-12]; thus, it can lead to an effect on the imagination ability [11]. In recent years, difficulties due to the cognitive processes arranged before movement in CP have been emphasized, and the issue of the effect of motor imagery has been also emphasized [13]. Motor imagery refers to a mental process in which an individual mentally imagines that movement without actually revealing an active movement. Studies have shown that similar brain sides are activated during movement performance and movement imagery [14,15]. Motor imagined movements and actively performed motor movements occur in parietal and premotor areas, cerebellum, and basal ganglia [16].

Today, it has been shown in studies that children's screen time has increased too much with the increase in technology [17,18]. With the surge in online activities, especially during the COVID-19 period, in which we have gone through a very dynamic process, the time to look at the screen has increased significantly in children as well as in adults [19,20]. This situation affects the child physically,

*Corresponding author:
Email address: dg.karabulut@gmail.com (Demet Gozacan Karabulut)

behaviorally, cognitively, and psychologically. However, it is known that excessive screen time has many negative effects on the mental functions of the child [21]. This is also very important for the development of individuals with CP. It is very important to draw attention to this issue, especially in individuals with CP who are behind in motor planning compared to their peers. Studies in the literature have presented that the capacity of motor imagery and motor planning are affected in people with HCP.

When the literature is examined, it is striking that motor imagery studies have attracted attention recently. No study has been found that specifically examines the motor imagery abilities of individuals with HCP according to gender, affected side, and screen time. For these reasons, the current study was planned to analyze the motor imagery abilities of individuals with hemiplegic CP according to gender and affected side and to investigate the correlation between screen time and motor imagery abilities.

Materials and Methods

Individuals

Fifty-two Individuals with HCP, 23 females and 29 males, aged 7-18 years, with I and II levels of GMFCS were included in the present study. Participants with HCP who had the appropriate level of cognition to follow motor imagery task's procedures, got higher points in the mini-mental state exam for children (MMC) than 24, and had an IQ>70 were chosen for the study. People with HCP who had advanced vision, attention, and hearing issues, who had taken motor imagery training in the period of last 6 months, and who had taken Botulinum toxin application or who had undergone surgery were not included. Informed consent forms were taken from all participants and their family members participating in the research. The current study was approved by the clinical research ethics committee (Gaziantep Islam Science and Technology University, Non-Invasive Clinical Research Ethics Committee. Protocol Number: 2021/38).

The individuals chosen for the study were evaluated by face-to-face interview method. First of all, information about the age, height, weight, gender, affected side, screen time on weekdays and weekends, and their parents were questioned and recorded in the evaluation form.

Since there is no research similar to the present study that we were going to do as a reference, in the power analysis made in line with the expectations and the information obtained from the literature, assuming that the effect size of the relationship to be examined could be at a medium level (r=0.4), it was determined that 80% power could be taken at the 95% confidence level when at least 44 individuals took part in the study.

Gross Motor Function Classification System (GMFCS)

The GMFCS was utilized to analyze gross motor functions of individuals with CP. This system is a five-level allocation system based on the individual's self-initiated movements based on displacement, sitting, and mobility. Individuals with CP can be classified as the least dependent at level 1, and they can be allocated as the most dependent at level 5 in motor functions [22-24].

Conners Parent Rating Scale-Revised Short (CPRS-RS)

The Conners Parent Rating Scale-Revised Short (CPRS-RS) was utilized to determine the attention levels of individuals with CP. The Conners Parent Rating Scale-Revised Short consists of 3 subscales and 27 items (Subscales: Opposition, cognitive problems-unmindfulness, hyperactivity). The questions are in the type of four-point Likert. The options range from "never true" to "very true", and the scoring of the relevant options is between 0 and 3 points. The Turkish validity of the CPRS-RS was conducted by Kaner et al. [25]. The lowest score that can be obtained from the subscale of Cognitive Problems-Unmindfulness is 0, and the highest possible score is 18. High scores reflect poor attention.

Mini-Mental State Exam for Children (MMC)

The MMC includes 15 questions created to analyze the cognitive functions. The test is comprised of orientation, attention, episodic memory, working memory, constructional praxis, and language areas. It has been emphasized that MMC can be used as a multifunctional scanning tool to assess cognitive disorders in children with hemiplegic SP [26]. Individuals with hemiplegic CP who scored more than 24 on MMC were included in the study.

Laterality task

Laterality task assesses implicit motor imagery capacity. The right-left discrimination was analyzed using the Recognize App Recognize Foot program developed and designed by the NOI group (http://www.noigroup.com/Recognize). The participants were asked to decide whether the foot images belonged to the right or left from different angles of the right and left feet displayed on the phone screen while in a comfortable sitting position. In total, 10 images were shown to each individual at 5 second intervals, response times and accuracy percentages were calculated and recorded by the program. This determined as primary outcome measurement.

Statistical analysis

Data of the study was analyzed by using SPSS 25.0 (IBM SPSS Statistics 25 software (Armonk, NY: IBM Corp.). The categorical variables were defined by number and percentage, and the continuous variables were defined by the mean ± standard deviation, median (minimum-maximum values). In the determination of normal distribution, Shapiro Wilk tests were used. Mann Whitney U test was used when the assumptions of a parametric test were not provided. Also, we utilized Spearman correlation analysis to investigate the correlations between continuous variables. A value of $p<0.05$ was determined for statistically significance.

Results

Fifty-two hemiplegic children, 29 males and 23 females, aged 7-18 years, with the levels of I and II GMFCS, were included in the study. The physical and sociodemographic characteristics of the individuals are presented in Table 1. There was no statistically significant difference in any of the variables according to gender and affected side ($p>0.05$, Table 2).

Table 1. The physical and sociodemographic characteristics.

		Mean ± S.D	Median (min - max)
Age		11.35 ± 3.48	11 (7 - 18)
Height		141.56 ± 21.75	142.5 (103 - 183)
Weight		42.71 ± 20.1	38 (16 - 100)
		n	%
Gender	Male	29	55.8
	Female	23	44.2
S.D: Standard Deviation			
		n	%
Affected side	Right	37	71.2
	Left	15	28.8
Preferred hand	Right	15	28.8
	Left	37	71.2
Getting physiotherapy	Yes	52	100.0
		Mean ± S.D	Median (min - max)
Duration of physiotherapy (years)		8.37 ± 3.6	7 (2 - 17)
GMFCS		1.19 ± 0.4	1 (1 - 2)
CPRS-RS		2.13 ± 2.3	2 (0 - 9)
$MMC_{(0-37)}$		34.87 ± 2.42	35.5 (28 - 37)
Laterality task affected side (time)		2.05 ± 0.67	2.1 (0 - 3.5)
Laterality task not affected side (time)		1.8 ± 0.53	1.8 (0.1 - 3)
Laterality task affected side (accuracy percentage)		60 ± 24.41	60 (0 - 100)
Laterality task not affected side (accuracy percentage)		59.23 ± 23.42	60 (0 - 100)
Screen time weekdays (hour)		1.33 ± 0.83	1 (0 - 3)
Screen time weekends (hour)		2.5 ± 1.5	2 (1 - 7)
S.D: Standard Deviation			
		Mean ± S.D	Median (min - max)
Age of the Mother		40.77 ± 5.04	41 (30 - 53)
Age of the Father		43.6 ± 6.28	43 (32 - 70)
		n	%
Educational Level of the Mother	Primary School	39	75.0
	High School	10	19.2
	University	2	3.9
	Postgraduate	1	1.9
Educational Level of the Father	Uneducated	1	1.9
	Primary School	34	65.4
	High School	13	25.0
	University	3	5.8
	Associate Degree	1	1.9
Occupation of the Mother	Housewife	40	76.9
	Private Sector	4	7.7
	Worker	6	11.6
	Teacher	1	1.9
	Trainer	1	1.9
Occupation of the Father	Unemployed	1	1.9
	Worker	25	48.1
	Officer	9	17.3
	Pensioner	5	9.6
	Driver	3	5.8
	Police officer	1	1.9
	Private Sector	2	3.8
	Self-employment	3	5.8
	Technician	1	1.9
	Teacher	2	3.8
Income (Turkish Liras-TLs)	Less than 1000 TLs	1	1.9
	1 1000-1999 TLs	6	11.5
	6 2000-2999 TLs	24	46.2
	24 3000-4999 TLs	15	28.8
	15 5000-6999 TLs	3	5.8
	7000-9999 TLs	3	5.8

MMC: Mini-Mental State Exam for Children. S.D: Standard Deviation.

Table 2. The comparison of motor imagery abilities and screen times according to gender and affected side.

Gender	Male (n=29) Median (min – max)	Female (n=23) Median (min – max)	p
Laterality task affected side (time)	2.1 (0.2 - 3.5)	2.1 (0 - 2.6)	0.846 (z=-0.194)
Laterality task not affected side (time)	1.9 (0.1 - 2.7)	1.8 (0.9 - 3)	0.781 (z=-0.278)
Laterality task affected side (accuracy percentage)	60 (0 - 100)	60 (20 - 100)	0.112 (z=-1.587)
Laterality task not affected side (accuracy percentage)	60 (0 - 100)	60 (20 - 80)	0.108 (z=-1.605)
Screen time weekdays	1 (0 - 3)	2 (0 - 3)	0.113 (z=-1.586)
Screen time weekends	2 (1 - 7)	3 (1 - 5)	0.146 (z=-1.453)
Affected Side	**Right (n=37) Median (min - max)**	**Left (n=15) Median (min - max)**	**p**
Laterality task affected side (time)	2.1 (0 - 3.5)	2.2 (1.5 - 3)	0.887 (z=-0.142)
Laterality task not affected side (time)	1.8 (0.1 - 3)	1.8 (0.6 - 2.6)	0.863 (z=-0.173)
Laterality task affected side (accuracy percentage)	60 (0 - 100)	60 (40 - 100)	0.7 (z=-0.385)
Laterality task not affected side (accuracy percentage)	60 (0 - 100)	60 (20 - 100)	0.622 (z=-0.492)
Screen time weekdays	1 (0 - 3)	1 (0 - 3)	0.418 (z=-0.81)
Screen time weekends	2 (1 - 7)	2 (1 - 5)	0.967 (z=-0.042)

*p<0.05 statistically significant difference; z: Mann Whitney U test.

Table 3. The correlation between motor imagery abilities, screen time, age, Conners Parent Rating Scale according to gender.

Male n=29		Laterality task affected side (time)	Laterality task not affected side (time)	Laterality task affected side (accuracy percentage)	Laterality task not affected side (accuracy percentage)	Screen time weekdays	Screen time weekends
Screen time weekdays	r	-.155	-.143	-,520**	-,611**	1.000	,822**
	p	.421	.458	.004	.000		.000
Screen time weekends	r	-.235	-.181	-,707**	-,701**	,822**	1.000
	p	.221	.347	.000	.000	.000	
Age	r	-.338	.020	.162	,453*	-.100	-.090
	p	.073	.918	.401	.014	.606	.641
CPRS-RS	r	.126	-.257	-,386*	-,523**	,383*	.318
	p	.514	.178	.039	.004	.040	.092

Female n=23		Laterality task affected side (time)	Laterality task not affected side (time)	Laterality task affected side (accuracy percentage)	Laterality task not affected side (accuracy percentage)	Screen time weekdays	Screen time weekends
Screen time weekdays	r	.173	.064	-,585**	-,627**	1.000	,639**
	p	.430	.771	.003	.001		.001
Screen time weekends	r	.043	.109	-,743**	-,544**	,639**	1.000
	p	.845	.620	.000	.007	.001	
Age	r	-.077	-.110	.155	.255	-.095	-.229
	p	.727	.617	.480	.240	.666	.294
CPRS-RS	r	-.015	.209	-.271	-.159	.172	.300
	p	.946	.340	.211	.469	.432	.165

*p<0.05 statistically significant correlation; r: Spearman correlation coefficient.

There was a significant, negative, and moderate correlation between weekday screen time and laterality task affected side accuracy percentage and laterality task not affected side accuracy percentage values in both males and females ($p<0.05$). In males, there was a significant, negative, and strong correlation between weekend screen time and laterality task affected side accuracy percentage and laterality task not affected side accuracy percentage

Table 4. The correlation between motor imagery ability, screen time, age, and Conners Parent Rating Scale according to the affected side.

		Laterality task affected side (time)	Laterality task not affected side (time)	Laterality task affected side (accuracy percentage)	Laterality task not affected side (accuracy percentage)	Screen time weekdays	Screen time weekends
Right hemiplegic n=37							
Screen time weekdays	r	-.118	.081	-,588**	-,663**	1.000	,749**
	p	.488	.632	.000	.000		.000
Screen time weekends	r	-.243	-.101	-,794**	-,716**	,749**	1.000
	p	.147	.550	.000	.000	.000	
Age	r	-.305	-.193	-.092	.235	.123	.076
	p	.066	.253	.589	.162	.468	.656
CPRS-RS	r	.093	.080	-.263	-,326*	.185	.259
	p	.586	.639	.116	.049	.273	.122
Left hemiplegic n=15							
Screen time weekdays	r	.248	-.325	-,604*	-,604*	1.000	,814**
	p	.372	.237	.017	.017		.000
Screen time weekends	r	.258	.001	-,719**	-,611*	,814**	1.000
	p	.353	.997	.003	.016	.000	
Age	r	-.076	.185	,735**	,688**	-,673**	-,638*
	p	.788	.509	.002	.005	.006	.010
CPRS-RS	r	.013	-.338	-.474	-.483	.459	.397
	p	.964	.218	.074	.068	.085	.143

*p<0.05 statistically significant correlation; r: Spearman correlation coefficient.

(p<0.05). In females, there was a statistically significant, negative, and strong correlation between weekend screen time and laterality task affected side accuracy percentage, and there was a significant, negative, and moderate correlation between weekend screen time and laterality task not affected side accuracy percentage (p<0.05). In males, there was a significant, positive, and moderate correlation between age and laterality task accuracy percentage (p<0.05). Afore mentioned correlation was not present among females (p>0.05, Table 2).

In males, a significant, negative, and moderate correlation was found between the CPRS-RS and laterality task affected side accuracy percentage and laterality task not affected side accuracy percentage (p<0.05). There was a significant, positive, and moderate correlation between the CPRS-RS and weekday screen time (p<0.05). In females, there was no significant correlation between the CPRS-RS and any variable (p>0.05, Table 3).

There was a significant, negative, and moderate correlation between weekday screen time and laterality task affected side accuracy percentage and laterality task not affected side accuracy percentage on both the right and left sides (p<0.05). In the right hemiplegics, there was a significant, negative, and strong correlation between weekend screen time and laterality task affected side accuracy percentage and laterality task not affected side accuracy percentage (p<0.05). In the left hemiplegics, there was a significant, negative, and strong correlation between weekend screen time and laterality task affected side accuracy percentage, and a significant, negative, and moderate correlation between weekend screen time and laterality task not affected side accuracy percentage was observed (p<0.05, Table 4).

In the left hemiplegics, there was a significant, positive, and strong correlation between age and laterality task affected side accuracy percentage, and a significant, positive, and moderate correlation was found between age and laterality task not affected side accuracy percentage (p< 0.05). In the right hemiplegics, no significant correlation was found between age and any other variable (p>0.05). In addition, there was a significant, negative, and moderate correlation between age and weekday and weekend screen times (p<0.05).

In the right hemiplegics, there was a statistically significant, negative, and moderate correlation between the CPRS-RS and laterality task not affected side accuracy percentage (p<0.05). In the left hemiplegics, there was no statistically significant correlation between the CPRS-RS and any other variable (p>0.05, Table 4).

Discussion

As a result of the study, no difference was found between motor imagery abilities according to gender and the affected side in HCP. In addition, it was observed that the long duration of screen time negatively affected the motor imagery skills of individuals with HCP, and age was associated with motor imagery abilities.

In the current literature, it is stated that the motor deficits encountered in CP are not only related to the disturbances in motor movements but also the problems in motor planning [8,27]. Recent studies focus on the effects of motor imagery in CP due to the difficulties evolving from the processes of cognition determined before the movement [10,11,13]. It has been stated that motor imagery skills in HCP are disturbed compared to those of typically enhancing controls [28]. Motor imagery ability is expressed as the quality and formatting of the created image. Evaluation of motor imagery skills is considered as a measure of the type of imagery used by the individual and the success achieved in motor imagery approaches [29].

According to the studies carried out to determine the age at which the motor imagery ability in children is fully developed, it has been seen that a 5-year-old child cannot engage in the motor imagery process, about half of the 5-6-year-old children can do motor imagery, but it was also stated that the effective participation of children younger than 7 years in motor imagery training can be controversial [30,31]. In the study of Molina et al., it has been stated that the motor imagery ability in children develops at the age of 7 [31]. In the light of the literature, motor imagery abilities were evaluated by including children aged 7 years and older with HCP in the present study. In the literature, there is no clear and definite age for motor imagery among children with CP. More studies on this subject are needed. In the present study, age was found to be associated with motor imagery abilities of males and left hemiplegic individuals; however, it can be stated that there is a need for studies in the literature on this subject.

Opinions on motor imagery in CP are divided into two. Some studies have argued that motor imagery capacity is more affected in individuals with left hemisphere damage [10,32-34]. In some other sources, it has been emphasized the performance of motor imagery in HCP is not dependent on the affected side [35,36]. According to a study of individuals with HCP that examined brain activations in the follow-up of motor imagery tasks with functional Magnetic Resonance Imaging (fMRI), in those with right-brain extremity, bilateral frontoparietal network activation was activated during the motor imagery task as described in those with typical development. Conversely, those with left-brain lesions had less brain activation following motor imagery tasks than those with right-brain lesions [34]. In the present study, when motor imagery abilities were examined according to the affected sides, no difference was found between individuals with HCP in the right and left extremities. According to this result, we can say that the motor imagery abilities of individuals with HCP who have right or left extremities are affected at the same rate in both. However, we emphasize the necessity of examining motor imagery abilities of individuals with CP with more detailed and objective data in the literature, since motor imager abilities were not objectively evaluated with fMRI, and the present study has methodological differences from literature studies.

When the effect of gender differences on motor imagery abilities was examined, it was stated that gender did not make any difference on motor imagery abilities [37,38]. Similarly, we can emphasize that there was no difference between the genders in terms of motor imagery ability in the present study. In terms of gender differences, we can state that motor imagery studies are limited in the literature, and more studies are needed on this subject in the CP population.

It has been reported that the risk of physical, behavioral, and mental problems increases with the increase in the screen time of children [21,39]. It is thought that the increase in screen time in HCP also affects motor imagery abilities due to the fact that it causes such problems. In the current study, it was observed that motor imagery abilities were negatively affected by the increase in the screen time of both males and females. We think that it would be important to consider how the exposure to screen time affects motor imagery skills in more detailed studies with larger sample groups. Moreover, this study's relatively small sample size can be considered as one of the limitations.

Due to the role of mental processes in motor imagery abilities, motor imagery abilities are negatively affected by the increase in screen time. In the light of these results, we believe that it is very important to limit the screen time of children with HCP and to provide counseling and information to the parents about screen time.

Conclusion

The number of studies examining motor imagery abilities in the CP population is quite limited. When the literature on this topic was examined, no study was encountered to examine the correlation between motor imagery abilities and screen time. In the present study, it was found that the screen time of children with HCP was related to their motor imagery abilities. In addition, it was observed that excessive screen time could negatively affect motor imagery abilities.

Ethics approval

Ethical approval for this study was obtained from Gaziantep Islam Science and Technology University Non-Interventional Clinical Research Ethics Committee (Protocol Number: 2021/38).

References

1. Jones MW, Morgan E, Shelton JE, Thorogood C. Cerebral palsy: introduction and diagnosis (part I). J Pediatr Health Care 2007;21(3):146-52.
2. Viehweger E, Robitail S, Rohon MA, et al. Measuring quality of life in cerebral palsy children. Ann Readapt Med Phys 2008;51(2):119-37.
3. Serdaroğlu A, Cansu A, Özkan S, Tezcan S. Prevalence of cerebral palsy in Turkish children between the ages of 2 and 16 years. Dev Med Child Neurol 2006;48(6):413–416.
4. Cans C. Surveillance of cerebral palsy in Europe: a collaboration of cerebral palsy surveys and registers. Dev Med Child Neurol 2000;42(12):816–824.

5. Rosenbaum P, Paneth N, Leviton A, et al. A report: the definition and classification of cerebral palsy. Dev Med Child Neurol Suppl 2007;109:8-14.
6. Gordon AM, Charles J, Steenbergen B. Fingertip force planning during grasp is disrupted by impaired sensorimotor integration in children with hemiplegic cerebral palsy. Pediatr Res 2006;60(5):587-91.
7. Steenbergen B, Gordon AM. Activity limitation in hemiplegic cerebral palsy: evidence for disorders in motor planning. Dev Med Child Neurol 2006;48(9):780-783.
8. Steenbergen B, Verrel J, Gordon AM. Motor planning in congenital hemiplegia. Disabil Rehabil 2007;29(1):13-23.
9. Munzert J, Lorey B, Zentgraf K. Cognitive motor processes: the role of motor imagery in the study of motor representations. Brain Res Rev 2009;60(2):306–326.
10. Craje C, Van-Elk M, Beeren M, Van-Schie HT, Bekkering H, Steenbergen B. Compromised motor planning and motor imagery in right hemiparetic cerebral palsy. Res Dev Disabil 2010;31(6):1313–1322.
11. Mutsaarts M, Steenbergen B, Bekkering H. Anticipatory planning deficits and task context effects in hemiparetic cerebral palsy. Exp Brain Res 2006;172(2):151–162.
12. Mutsaarts M, Steenbergen B, Meulenbroek R. A detailed analysis of the planning and execution of prehension movements by three adolescents with spastic hemiparesis due to cerebral palsy. Exp Brain Res 2004;156(3):293–304.
13. Steenbergen B, Jongbloed-Pereboom M, Spruijt S. Impaired motor planning and motor imagery in children with unilateral spastic cerebral palsy: challenges for the future of pediatric rehabilitation. Dev Med Child Neurol 2013;55(4):43–46.
14. Dechent P, Merboldt KD, Frahm J. Is the human primary motor cortex involved in motor imagery? Brain Res Cogn Brain Res 2004;19(12):138–144.
15. Taube W, Mouthon M, Leukel C, Hoogewoud HM, Annoni JM, Keller M. Brain activity during observation and motor imagery of different balance tasks: an fMRI study. Cortex 2015;64:102–114.
16. Buccino G, Solodkin A, Small SL. Functions of the mirror neuron system: implications for neurorehabilitation. Cogn Behav Neurol 2006;19(1):55–63.
17. Chassiakos YR, Radesky J, Christakis D, Moreno MA. Children and adolescents and digital media. Pediatrics 2016;138(5):e20162593.
18. Madigan S, Browne D, Racine N, Mori C, Tough S. Association between screen time and children's performance on a developmental screening test. JAMA Pediatr 2019;173(3):244-250.
19. Vanderloo LM, Carsley S, Aglipay M, Cost KT, Maguire J, Birken CS. Applying harm reduction principles to address screen time in young children amidst the COVID-19 Pandemic. J Dev Behav Pediatr 2020;41(5):335–336.
20. Ozturk Eyimaya A, Yalçin Irmak A. Relationship between parenting practices and children's screen time during the COVID-19 pandemic in Turkey. J Pediatr Nurs 2021;56:24–29.
21. Poitras VJ, Gray CE, Janssen X, et al. Systematic review of the relationships between sedentary behaviour and health indicators in the early years (0–4 years). BMC Public Health 2017;17(suppl 5):868.
22. El Ö, Baydar M, Berk H, Peker Ö, Koşay C, Demiral Y. Interobserver reliability of the Turkish version of the expanded and revised gross motor function classification system. Disabil Rehabil 2012;34(12):1030–1033.
23. Wood E, Rosenbaum P. The gross motor function classification system for cerebral palsy: a study of reliability and stability over time. Dev Med Child Neurol 2000;42(5):292–296.
24. Palisano R, Rosenbaum P, Walter S, Russell D, Wood E, Galuppi B. Development and reliability of a system to classify gross motor function in children with cerebral palsy. Dev Med Child Neurol 1997;39(4):214–223.
25. Kaner S, Büyüköztürk S, Iseri E. Conners Anababa Dereceleme Ölçegi-Yenilenmis Kisa: Türkiye stardardizasyon çalısması/Conners Parent Rating Scale-Revised Short: Turkish standardization study. Noro-Psikyatri Ars 2013;50(2):100.
26. Moura R, Andrade PMO, Fontes PLB, et al. Mini-mental state exam for children (MMC) in children with hemiplegic cerebral palsy. Dement Neuropsychol 2017;11(3):287–296.
27. Gordon AM, Charles J, Steenbergen B. Fingertip force planning during grasp is disrupted by impaired sensorimotor integration in children with hemiplegic cerebral palsy. Pediatr Res 2006;60(5):587-591.
28. Gözaçan Karabulut D, Tütün Yümin E, Öztürk Y. The effect of motor imagery training on individuals with unilateral cerebral palsy on motor imagery ability, functional mobility and muscle activity. Somatosens Mot Res 2022;39(1):62-69.
29. Martini R, Carter MJ, Yoxon E, Cumming J, Ste Marie DM. Development and validation of the Movement Imagery Questionnaire for Children (MIQ-C). Psychol Sport Exerc 2016;22:190–201.
30. Funk M, Brugger P, Wilkening F. Motor processes in children's imagery: The case of mental rotation of hands. Dev Sci 2005;8(5):402–408.
31. Molina M, Tijus C, Jouen F. The emergence of motor imagery in children. J Exp Child Psychol 2008;99(3):196–209.
32. Molina M, Kudlinski C, Guilbert J, Spruijt S, Steenbergen B, Jouen F. Motor imagery for walking: a comparison between cerebral palsy adolescents with hemiplegia and diplegia. Res Dev Disabil 2015;37:95–101.
33. Mutsaarts M, Steenbergen B, Bekkering H. Impaired motor imagery in right hemiparetic cerebral palsy. Neuropsychologia 2007;45(4):853–859.
34. Chinier E, N'Guyen S, Lignon G, Ter Minassian A, Richard I, Dinomais M. Effect of motor imagery in children with unilateral cerebral palsy: fMRI study. PloS One 2014;9(4):e9337.
35. Williams J, Anderson V, Reid SM, Reddihough DS. Motor imagery of the unaffected hand in children with spastic hemiplegia. Dev Neuropsychol 2012;37(1):84–97.
36. Williams J, Reid SM, Reddihough DS, Anderson V. Motor imagery ability in children with congenital hemiplegia: effect of lesion side and functional level. Res Dev Disabil 2011;32(2):740–748.
37. Campos A. Gender differences in imagery, Personal. Individ Differ 2014;59:107–111.
38. Subirats L, Allalib G, Briansouleta M, Salle JY, Perrochon A. Age and gender differences in motor imagery. J Neurol Sci 2018;391:114-117.
39. Stiglic N, Viner RM. Effects of screentime on the health and well-being of children and adolescents: a systematic review of reviews. BMJ Open 2019;9(1):e023191.