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Correlation between Cognitive Abilities and Fine Motor Skills in Children with Hemiparetic Cerebral Palsy

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ABSTRACT

Background: Children with hemiparetic cerebral palsy experience fine motor ability and cognitive deficits. The development of fine motor skills is a necessary part of emotional, social, and cognitive growth.

Objective: The aim of the current work was to study the correlation between fine motor skills and cognitive abilities in children with hemiparetic cerebral palsy.

Subjects and methods: This cross-sectional study included a total of 85 children with spastic hemiplegia of both sexes and aged from 6 to 8 years, recruited from the Outpatient Clinic, Faculty of Physical Therapy, Cairo University. Fine motor abilities were assessed by Quality of Upper Extremity Skills Test (QUEST) whereas; Cognitive abilities were assessed using RehaCom system.

Results: The correlation between Fine motor skills and cognitive abilities measurements was weak positive significant correlation with reaction control ($r = 0.260$, $p = 0.016$), moderate positive significant correlation with working speed ($r = 0.351$, $p = 0.001$) and was strong positive significant correlation with working memory ($r = 0.786$, $p = 0.001$). The correlation between fine motor skills and other cognitive abilities was weak negative non-significant correlation with reaction speed ($r = -0.110$, $p = 0.316$) and with attention ($r = -0.092$, $p = 0.403$); and was weak positive non-significant correlation with neglect hemianopia ($r = 0.124$, $p = 0.259$) and with logical reasoning ($r = 0.031$, $p = 0.778$).

Conclusion: It could be concluded that there are correlations between fine motor skills and cognitive abilities in children with hemiparetic cerebral palsy.

Keywords: Cognitive abilities, Fine motor skills, Spastic hemiplegia.

INTRODUCTION

Hemiplegic cerebral palsy, which often originates from injury to the sensorimotor cortex that controls one side of the body, is the affliction of one side of the body, including the limbs, trunk, and occasionally the neck. The upper limb is significantly more afflicted than the lower limb, and ambulation frequently makes the lower limb's involvement more obvious [(1)]. Spastic hemiplegia is typical of cerebral palsy (CP), affecting 20% to 30% of all children with the condition [(2)].

Debilitating symptoms in children with hemiplegia may interfere with play, learning, and self-care. Moreover, kids with hemiplegic CP seldom ever utilize the afflicted hand for unimanual tasks. Usually, when doing a bimanual job, the afflicted hand is employed [(3)].

Little muscular actions requiring precise eye-hand synchronization are known as fine motor abilities [(4)]. The capacity to regulate movement through coordinated neural system and muscular actions, such as the motions of the fingers and hands, is known as a fine motor skill [(5)]. FMS are linked to executive function, general cognitive ability, short-term memory, and crystallized intelligence in preschoolers [(6)].

The psychological concept of cognition encompasses perception, language, intellect, learning, memory, attention, and decision-making processes. From an experimental standpoint, cognitive phenomena must be inferred from overt changes in an organism's behavior because they are basically internal psychological processes [(7)].

According to a general definition, executive functioning skills are a collection of higher order cognitive talents that are in charge of directing and controlling a person's actions and behaviors [(8)]. Children with CP are susceptible to having trouble with their EF skills [(9)]. Deficiencies in executive function (EF) or higher order cognitive abilities might affect a person's ability to participate in social situations and succeed in school [(10)].

The phrase "executive function" is used to refer to a variety of control mechanisms, including the suppression of prepotent reactions, the initiation of activity, the planning of an action, the creation of hypotheses, cognitive flexibility, judgement, and feedback management [(11)].

The prefrontal cortex and the white matter tracts that link the prefrontal and posterior areas of the brain are particularly crucial for the growth of executive functioning (EF) abilities, according to functional neuroimaging studies [(10-12)].

There is evidence from neuroimaging that general motor abilities and cognition are related. For both physical and cognitive activities, the prefrontal cortex, basal ganglia, and cerebellum are recruited [(13)].

It is typical to believe that motor and cognitive abilities are inextricably linked. While some researchers believe that motor skill development is linked to changes in cognition [(14)], others believe that motor skill development is the foundation of cognitive growth [(15)].

Although the literature shows a link between fine motor skills and cognitive ability, to the best of our knowledge, no studies have been conducted to investigate this link. The goal of this research was to look at the relationship between fine motor skills and cognitive ability in children with hemiparetic cerebral palsy.

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SUBJECTS AND METHODS

This cross-sectional study included a total of 85 children of both sexes with spastic hemiplegia, recruited from the Outpatient Clinic, Faculty of Physical Therapy, Cairo University.

Inclusion criteria: Patients diagnosed with spastic hemiplegia, aged 6 to 8 years, with gross motor function classification system -extended and revised (GMFCS-ER) [(16)], able to understand and follow instructions, and the degree of spasticity in hemiparetic children ranged from 1 to 1+ according to the Modified Ashworth scale.

Exclusion criteria: Patients had any of the following conditions: (1) significant mental or behavioral disorders, (2) significant visual or auditory problems as determined by medical reports (audio-vestibular and ophthalmic examination), or (3) significant upper limb contractures or orthopedic problems. (4) had a botulinum toxin injection in the upper limbs within the previous six months. (5) undergone any surgical treatment in hands such as tenotomy.

Procedures

Each child's fine motor skills and cognitive abilities were assessed individually.

Assessment of fine motor skills

Quality of Upper Extremity Skills Test (QUEST), a criterion-referenced measuring instrument created to evaluate upper extremity quality of movement in children with CP aged 18 months to 8 years, was used to assess fine motor abilities. The Quality of Upper Extremity Skills Test (QUEST) was created to address the shortcomings of existing assessments of hand function. This measure assesses the quality of upper extremity function in four domains: dissociated movement, grip, protective extension, and weight bearing, however only two domains (dissociated movement and grasp) were tested in the current investigation.

Assessment of cognitive abilities

Specific aspects of cognitive abilities (Selective attention, Logical reasoning, Spatial number search, working memory) were measured by RehaCom system, which is a computer-assisted treatment system based on software. It's made up of a unique input panel, a computer keyboard, a mouse, and a central processing unit (CPU). RehaCom is a computer-based platform for managing the cognitive training process. The system operates locally or as a part of a local network, can also be used online. The difficulty of the training tasks may adapt depending on the user's performance. The user communicates with the system via a dedicated panel, standard peripheral devices (mouse, keyboard), or alternatively eye tracking technology which makes it possible to offer rehabilitation to patients with motor dysfunctions. RehaCom provides several Screening Modules to diagnose deficits and propose appropriate cognitive training modules. Frequent screening can also aid in demonstrating progression and providing thorough information.

Ethics consent:

The Faculty of Physical Therapy at Cairo University in Egypt's Ethics Committee gave its approval for this study (P.T.REC/012/003859). The nature and goal of this study were explained to all the parents of the enrolled youngsters. A documented consent form allowing the kids to participate was signed by all the parents. The study protocol conformed to the Helsinki Declaration, the ethical norm of the World Medical Association for human testing.

Statistical analysis

The statistical analyses were carried out using the statistical program for social sciences (SPSS) version 25 for Windows (IBM SPSS, Chicago, IL, USA). Descriptive statistics in the forms of mean± standard deviation, minimum, maximum, and frequency were used to report the measured variables. The Pearson Correlation Coefficient was used to investigate the relationship between fine motor abilities and cognitive capacity. The significance level for all statistical tests is set at p 0.05.

RESULTS

Eighty-five children with hemiparetic cerebral palsy participated in this study.
Their mean ± SD age was 7.32 ± 0.71 years. Participant characteristics are presented in table (1).

Table (1): Participant characteristics.

	Mean ± SD	Maximum	Minimum
Age (years)	7.32 ± 0.71	8	6
	N	**%**	
Sex distribution			
Girls	48	56.5	
Boys	37	43.5	
Affected side distribution			
Right	44	52	
Left	41	48	

SD, Standard deviation.

Fine motor skills and cognitive abilities in children with hemiparetic cerebral palsy:

The mean value ± SD fine motor skills of study group was 65.56 ± 4.68. The mean value ± SD reaction speed and reaction control was -0.63 ± 1.24 and -2.07 ± 1.65 respectively. The mean value ± SD working speed, attention and neglect hemianopia was -4.90 ± 0.40, -0.33 ± 3.23 and -2.07 ± 2.18 respectively. The mean value ± SD logical reasoning and working memory was -2.26 ± 0.92 and -2.07 ± 1.21 respectively. (Table 2).

Table (2): Descriptive statistics of fine motor skills and cognitive abilities in children with hemiparetic cerebral palsy:

	Mean ± SD	Minimum	Maximum
Fine motor skills	65.56 ± 4.68	57	78
Reaction speed	-0.63 ± 1.24	-3.37	3.68
Reaction control	-2.07 ± 1.65	-5	0.93
Working speed	-4.90 ± 0.40	-5	-2.34
Attention	-0.33 ± 3.23	-5	5
Neglect hemianopia	-2.07 ± 2.18	-5	1.47
Logical reasoning	-2.26 ± 0.92	-3.97	0.32
Working memory	-2.07 ± 1.21	-4.42	1.78

SD, Standard deviation

Correlation between fine motor skills and cognitive abilities:

The correlation between fine motor skills and cognitive abilities was weak positive significant correlation with reaction control (r = 0.260, p = 0.016), moderate positive significant correlation with working speed (r = 0.351, p = 0.001) and was strong positive significant correlation with working memory (r = 0.786, p = 0.001) (Table 3).

The correlation between fine motor skills and cognitive abilities was weak negative non-significant correlation with reaction speed (r = -0.110, p = 0.316) and with attention (r = -0.092, p = 0.403); and was weak positive non-significant correlation with neglect hemianopia (r = 0.124, p = 0.259) and with logical reasoning (r = 0.031, p = 0.778) (Table 3).

Table (3): Correlation between fine motor skills and cognitive abilities:

	Fine motor skills	
	r - value	P-value
Reaction speed	-0.110	0.316
Reaction control	0.260	0.016*
Working speed	0.351	0.001*
Attention	-0.092	0.403
Neglect hemianopia	0.124	0.259
Logical reasoning	0.031	0.778
Working memory	0.786	0.001*

r value: Pearson correlation coefficient; p value: Probability value, * significant at $p < 0.05$.

DISCUSSION

One of the main causes of motor impairment in children is cerebral palsy (CP). One-third of these CP youngsters have hemiplegic cerebral palsy (HCP, unilateral CP), a kind of CP that is brought on by a single injury to the developing brain and is defined by a single motor deficit. The paretic hand's limited range of motion makes it much less useful for daily tasks [17].

Recent research has shown that the challenges that hemiplegic cerebral palsy (HCP) youngsters face on a daily basis stem not only from motor execution issues on the afflicted side but also from motor planning issues on both sides. According to the definition of motor planning, it is a cognitive process in which a patient plans and carries out a series of suitable movements in the direction of an object while keeping in mind both the forward internal model and the information that is now accessible. The development of one's motor abilities and experience with movement both influence one's capacity to create internal representations of a physical act [17-18].

According to certain theories, motor imagery—or imagined motions—contributes significantly to the process of planning movements and is a requirement for motor planning. Similar brain activation patterns during actual movements and imagined motions have been shown in an increasing number of investigations utilizing functional magnetic resonance imaging [19].

Since the biomechanical limitations that effect actual motions also affect the imagined task, it is suggested that using motor imagery as a method is appropriate. The increase in response times caused by the presentation of hand figures in awkward anatomical postures is known as the impact of biomechanical limitations [20].

Many research validated the study's findings, **Chinier *et al.* [21], Souto *et al.* [22], Williams *et al.* [23] and Kim *et al.* [24].**

It has been studied for many years how to measure upper limb mobility and function in children with cerebral palsy (CP). The Quality of Upper Extremity Skills Test was one of the first evaluation tools used (QUEST). The QUEST's domains and items are based on the neurodevelopmental hypothesis that was thought to underlie the function and movement of the upper limbs [25].

A rising number of research and reviews have examined EF in kids with CP, and the results point to challenges in a variety of EF areas. In a sample of 33 kids with spastic unilateral and bilateral CP, **Bottcher *et al.* [26]** describe challenges across all areas of the Behavior Rating Inventory of Executive Function (BRIEF). Regardless of the side of hemiplegia, **Bodimeade *et al.* [27]** observed that children with unilateral CP performed considerably worse than normally developing peers on major EF measures. **Stadskleiv *et al.* [28]** looked at EF in a group of kids with spastic CP and speech/motor disability, which is contrary to these findings.

Hoare *et al.* [29] extensive investigation, which looked at how cognition influences bimanual performance in kids with unilateral cerebral palsy, provides support for our position. First, it is expected that bimanual performance and cognition would have distinct correlations (executive function). Second, it is believed that there will be a shared neuropathology at the root of the links between bimanual performance and cognition. The results may influence the creation of novel methods to improve both cognitive and motor results in kids with unilateral cerebral palsy and heighten the specificity of existing upper limb therapy by presenting more targeted therapies.

The current results were consistent with functional neuroimaging research by Fontes *et al.* and **Steenbergen *et al.* [31]** that demonstrated working memory networks were activated during motor imagery tasks. These findings imply that children's capacity to hold and modify information in working memory may be a factor in their ability to do well on motor imagery tasks. In order to conduct motor imaging, patients are really taught to recall the Kinesthetic movement sensations stored in working memory in order to select the best motor approach.

CONCLUSION

It could be concluded that there are correlations between fine motor skills and cognitive abilities in children with hemiparetic cerebral palsy.

Cognitive tests should be made available to children with cerebral palsy (CP), who are more likely to experience cognitive issues. An emerging and complex topic in the field of disability and rehabilitation is the cognitive evaluation of children with cerebral palsy. Contradictory research suggests that children with cerebral palsy have motor planning problems, with variations seen depending on the variable and the hand evaluated. Several theories are put forth for this diversity, including the potential role of cognitive and complex motor planning processes.

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