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Original Article

Delayed Finger Tapping and Cognitive Responses in Preterm-Born Male Teenagers With Mild Spastic Diplegia

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ABSTRACT

BACKGROUND: Information on fine motor and basic cognitive functions in spastic diplegia is sparse in the literature. The aim of this study was to investigate index finger's tapping speed and cognitive functions in categorization and old/new recognition of pictures in patients with mild spastic diplegia. **METHODS:** Fifteen preterm-born male teenagers with mild spastic diplegia and 15 healthy male teenagers participated in this study. Finger-tapping tests and cognitive tests were performed on all participants. Outcomes were compared between the two groups. **RESULTS:** In the finger-tapping tests, the tapping speed was significantly slower in patients than in controls. In the tests of tapping one key persistently and tapping two keys alternately, the reaction time gaps between the left and right digits were larger in patients than in controls. In the categorization tests, the accuracies and reaction times for animal/plant and girl face pictures, but not for boy face pictures, were significantly worse in patients than in controls. In the recognition tests, the accuracies for old/new, animal/plant, and boy/girl face pictures were significantly lower in patients than in controls. The reaction times for old/new, animal/plant, and new face pictures, but not for old face pictures, were significantly longer in patients compared with controls. **CONCLUSIONS:** Our results demonstrate delayed finger tapping and cognitive responses in preterm-born male teenagers with mild spastic diplegia. Our experimental paradigm is sensitive for the study of fine motor and cognitive functions between patients and healthy controls.

Keywords: mild spastic diplegia (MSD), index finger tapping, categorization, old/new recognition

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Introduction

Cerebral palsy (CP), primarily a motor disorder, is often accompanied by disturbances of sensation, cognition, communication, perception, behavior, and seizure disorders.[1] It is prevalent in the world. Spastic diplegia is a subgroup of CP found in both preterm and term infants.[2] The Gross Motor Function Classification System (GMFCS) was developed by Palisano et al.[3,4] to provide an objective classification of the patterns of gross motor disability in CP patients. According to the study of Reid et al.,[5] GMFCS level I and II was defined as mild CP. Preterm male teenagers with mild spastic diplegia (MSD) at GMFCS level I or II were included in the present study.

Finger tapping is an elementary fine motor function. The finger-tapping test is widely used to examine fine motor performance in patients with cerebral disorders.[6-9] So far, only a few studies[10,11] have investigated the finger-tapping ability on a keyboard in patients with spastic hemiplegia. In the study of Steenbergen et al.,[10] the tapping performance on a keyboard was examined in four adolescents with spastic hemiplegia. The tapping speed, tapping regularity, and tapping errors were examined within a time window. It was shown that the "good" hand outperformed the impaired hand at nearly all measures in the four fingers.

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In the study of Roon et al.,[11] the tapping ability was examined in nine adolescents with spastic hemiplegia. The impaired hand tapped slower and more irregularly and exerted less force. The deficit in the two studies was that a control group was not included for comparison. The main disorder in spastic diplegia is dysfunction in the lower limbs; so the fine motor function of the upper limb is often neglected. There is a lack of study results to accurately measure the fine finger motor function quantitatively in spastic diplegia.

Existing literature on cognitive function in CP patients is mostly limited to the assessment of discrimination and/or short-term memory toward digits,[12,13] letters of an alphabet,[14] words,[13] and simple graphs.[15,16] Among the most fundamental cognitive processes are categorization and old/new recognition.[17] However, very few studies have investigated these cognitive functions in CP patients.

Periventricular leukomalacia (PVL) is the main neuropathology in preterm-born children with spastic diplegia.[18] It was presumed that the preterm spastic diplegia–related brain damage would disrupt fine finger movement, categorization, and recognition functions. To address the hypothesis, we examined the index finger's tapping ability, categorization, and old/new recognition functions toward animal/plant and boy/girl face pictures in preterm-born male teenagers with MSD.

Methods

Participants

All participants were asked to fill in the Oldfield's Edinburgh Handedness Inventory.[19] Only right-handed participants were included in this study. There is increasing evidence for early sexual dimorphism of the brain, and recent diffusion tension imaging findings revealed sex differences in the white matter structures of the adult brain.[20] Therefore, we only chose male adolescents as our participants in this study.

Fifteen teenager patients (Table) with MSD (mean age, 14 years 7 months; standard deviation, 3 years; aged from 10 years 1 month to 19 years 9 months) participated in this study. Patients were diagnosed with spastic diplegia by two independent and experienced pediatricians. All patients were prematurely born (gestational age at birth ranged from 30 to 34 weeks) with low birth weight (birth weight $\leq$3000 g). They all participated in mainstream educational institution and were able to understand and perform the tests well. They had normal or corrected normal vision acuity and hardly any strabismus and nystagmus. The muscle tones in their upper limbs were normal or mildly increased (grade 0 to 1 according to the Modified Ashworth Scale[21]), and the muscle tones were similar in bilateral upper limbs. The functions of forearm pronation-supination and finger flexion-extension were close to normal. Independent finger movements can be achieved in each patient. Their hand functions were at level I or II according to Manual Ability Classification System,[22] and their gross motor functions were at level I or II according to GMFCS (i.e., they could walk independently, in spite of reduced balance, speed, and coordination). Some brain magnetic resonance imaging data were displayed in Fig 1, and the pathology of imaging conformed to PVL. Patients were recruited from the Department of Orthopedics at the Beijing Dongzhimen Hospital. Exclusion criteria of patients were as follows: (1) severe mental retardation; (2) severe vision or hearing impairment; and (3) epilepsy history.

All 15 healthy teenagers (mean age, 14 years 6 months; standard deviation, 2 years 8 months; aged from 10 years 1 month to 19 years 6 months) were recruited from a local primary and middle school as the control group. The patient group and the control group did not differ significantly with respect to age ($P = 0.923$). Written informed consent was given by all participants and their parents according to the Helsinki declaration. Ethical approval was obtained from local Medical Ethic Committee.

TABLE.
Demographic and Clinical Data of the Patient Group

Patient	Age	GA	BW	Handedness	MACS	GMFCS
1	232	31	2250	Right	I	I
2	154	30	2900	Right	I	I
3	133	34	2950	Right	II	I
4	237	30	2200	Right	I	I
5	163	34	2700	Right	II	I
6	207	32	1500	Right	I	I
7	162	34	3000	Right	I	I
8	155	32	1600	Right	I	I
9	216	34	1650	Right	II	I
10	121	32	2300	Right	II	I
11	192	30	2000	Right	II	II
12	191	34	2500	Right	I	II
13	141	30	2250	Right	II	II
14	160	30	1800	Right	II	II
15	158	32	1900	Right	II	II
Mean	175 (174*)	32 (>37*)	2233 (>3000)	Right	—	—

Abbreviations:
BW = Birth weight (g)
GA = Gestational age at birth (weeks)
GMFCS = Gross Motor Function Classification System
MACS = Manual Ability Classification System
* Healthy control data.

Experimental paradigm

Finger-tapping tests have often been studied in neurological diseases.[23] The index finger is most often used in manipulating a computer keyboard. In the present study, only index finger's tapping ability was examined. Participants were asked to tap one key persistently and the left and right keys alternately with his right and left index fingers (four kinds of tests) as fast as possible within a period of time (i.e., 30 seconds). Output data were recorded automatically.

In the cognitive tests, there were two sets (A and B) of monochrome pictures. The first set (A) presented animal/plant pictures, and the second set (B) presented neutral-expression of boy/girl face pictures. Each set of pictures consisted of two groups (A1 and A2 and B1 and B2).

The first group A1 in the first set consisted of 10 animal and 10 plant pictures and was used to test the categorization function in the mixture of animal/plant pictures. The second group A2 in the first set consisted of 10 old pictures that were already displayed in the first group A1 and 10 new pictures that were not present in the first group A1 and was used to test the old/new recognition memory function (Fig 2B).

Similarly, the second set (B) employed the boy/girl face pictures to test the cognitive functions (Fig 2C). Of the pictures in the second set, the first group B1 consisted of 10 boy and 10 girl face pictures and was used to test the gender categorization function in the mixture of boy/girl face pictures. The second group B2 in the second set consisted of 10 old pictures that were already displayed in the first group B1 and 10 new pictures that were not present in the first group B1 and was used to test the old/new recognition memory function.

The pictures were presented in a pseudo-randomized order on the screen one by one, with no more than three consecutive the same kind of pictures. The presenting time of each picture was 3 seconds, and the interval between two pictures was 2 seconds. The accuracy and reaction time (RT) were recorded automatically by our customized program written by one of our authors (X.M.). Participants had been instructed that a correct response was more important than short RT. If the RT was >3seconds, it was identified as an invalid time-out. Similar categorization and old/new recognition memory tests have been reported in previous literature.[24,25]

Experimental procedure

Finger-tapping tests

First, participants were asked to tap the right keyboard key persistently with the right index finger. Second, participants were