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Original Article

Motor Performance of Dominant and Non-dominant Hand in Right-handed and Left-handed Children

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Abstract
Handedness is a trait of unequal distribution of fine motor skills between the right and left hands. Earlier studies showed that the percentage of dominant hand superiority decreased with age, and the non-dominant hand motor performance improves and equalizes with the dominant hand. This is linked to the establishment of inter-hemispheric connectivity. This study explores the neuro-motor development pattern in children aged 10 to 14 years, This study evaluates and compares motor performance and hand preference in children aged 10-14 years thereby exploring the neuro-motor development pattern in this age group. 100 students (90 right-handed and 10 left-handed in accordance with the universal incidence of handedness) were the subjects. Three reliable measures of motor performance have been used in this study. Hand grip strength, finger tapping and hand steadiness were tested using dynamometer, mechanical tapper and arm-hand steadiness machine respectively. The results show that the dominant hand significantly outperforms the non-dominant hand on all three measures in the same individual. The study indicates that among children aged between 10 to 14 years, the lateral differences are still present. And suggest that the age group when the right-left differences decreases may be used as a marker for maturation of inter-hemispheric connectivity. This study also shows that the performance asymmetries between the dominant and non-dominant hand of left-handers are similar to that of right-handers. This may imply that the different patterns of lateralization (homogeneous and heterogeneous) and its extent have not been established in right- and left-handers of this age group.

Keywords: *dominant hand, non-dominant hand, hand grip strength, finger tapping, hand steadiness.*

Introduction

Handedness is an attribute of humans defined by their unequal distribution of fine motor skills between the right and left hands. Among monkeys there is an equal split (50%-50%) in handedness, right or left. In contrast humans are predominantly right-handed (90%-10%).[1,2]

Various theories have been suggested to account for handedness. The preferred hand is proposed to be a genetically determined trait. Handedness is also accounted by elementary motor asymmetry.

And handedness is also linked with language lateralization following the observation that right handedness is closely related to left hemispheric dominance for language. A learning theory has also been proposed that handedness is influenced by cultural and social pressures. Another study showed the possibility of handedness to shift in hemiplegic children.[3]

Though the two cerebral hemispheres are roughly symmetrical in appearance, there is asymmetry in their structure and more so with functions.[4]The left hemisphere is concerned with language and logical processing whereas the right hemisphere is involved in spatial recognition.[5,6] With respect to motor control in humans, a striking feature is that more than 90% of the population are right-handed, that which is controlled by the left hemisphere.[7]

Handedness and Motor Performance

The present study tries to evaluate the association between hand preference and hand performance in children aged 10 to 14 years.

It is thought that hand preference influences hand performance that is the dominant hand outperforms the non-dominant hand in the same individual.[8,9,10]. The association between handedness and hand performance has not been clearly established and has only been tentatively resolved in previous studies. Also earlier studies used only a single measure of motor performance. But since hand motor performance is a multidimensional trait and must be related to different performance tasks, this study takes into account three reliable and characteristic measures of motor performance (hand grip strength, finger tapping and hand steadiness).[11]

Hand being an essential organ for various activities of daily living, it is imperative that hand function and dexterity be assessed and investigated.[12,13] This would provide useful information in determining the severity of hand dysfunction in case of impaired hand functions due to brain lesions, peripheral neuropathies or other causes and in establishing effective rehabilitation programs.

Aim

To evaluate the association of handedness with motor performance in children.

Objectives

1. To examine whether there is difference in motor performance between the dominant hand and the non-dominant hand in the same individual.
2. If yes, to evaluate the degree to which hand preference influences motor performance in the same individual.

Materials and Methods

Source of data

- Number of school students – 100 (90 right-handed and 10 left-handed in accordance with the universal incidence of handedness).
- 50 boys and 50 girls were included.
- Students belonged to the age group of 10 to 14 years (9 right-handed and 1 left-handed in each year).

Inclusion criteria

- Healthy school going children.
- Both boys and girls.
- Age group 10-14 years.

Exclusion criteria

- Age<10years and >14years.
- No history of neurological or psychiatric diseases.
- No history head trauma or upper limb fractures or upper limb physical disabilities/deformities.
- No history of long term medication that might influence their motor performance.

Methods of collection of data

After obtaining the necessary permissions (institutional ethical committee and school board) and informed written consent from the parents, the school children and their teachers were congregated in a hall and they were told that the

test involved establishing each hand's grip strength, tapping, steadiness. All tests were illustrated and demonstrated to the children. It was further stressed that all these tests were non-invasive and safe and the cooperation of the children was sought.

Edinburgh Handedness Inventory

A laterality quotient (L.Q) of hand preference was first established through the Edinburgh Handedness Inventory for each subject. The inventory contained ten items and the preference in the use of hands for each activity by the subjects was established. To calculate the L.Q, first all the +'s for each hand was added. Then the sum for the left was subtracted from that for the right, which was divided by the sum of both and multiplied by 100. Positive value indicates right-handedness and negative value implying left-handedness. This reliable questionnaire was used to randomly select 90 right-handed and 10 left-handed school going children in accordance with the universal incidence of handedness.

Hand motor performance tests

• Hand grip strength

The hand grip strength of each hand of the subjects was recorded using the Improved Smedley's Dynamometer. First the dynamometer was set at a comfortable grip using the millimeter rule. The distance from where the subject's thumb joins his hand to the end of his fingers was measured and the dynamometer was adjusted by whirling the inner stirrup indicating one-half that distance. This would bring the second phalanx to bear against the inner stirrup. This will ordinarily prove to be the optimal adjustment; if not so it could also be modified to suit the subject's inclinations. Then the instrument was setup by means of the clutch, so that the inner stirrup could not twist while in use. Three trails for each hand was allowed, right and left alternately, but a brief pause of 60 seconds between each trial was introduced. Subject was illustrated that the lower pointer would register the grip, so that he/she need not have to continue his/her effort while the scale is read. Subjects were instructed to exert his/her maximal grip, and in each trial were encouraged to do his/her best. The grip strength of each trial was recorded in kilograms and the highest record for each hand was considered for statistical analysis.

• Finger tapping

Subjects were required to tap a mechanical tapper as fast as possible with his/her forefinger for 15 seconds while holding his/her arm firm, and the number of taps by each hand were determined. The procedure was repeated with the forefinger of the other hand.

• Arm-hand steadiness machine

Subjects were instructed to hold a stylus in a hole of the steadiness tester starting from the largest diameter hole for 10 seconds without coming in contact with the edge of the hole, if successful subject was asked to move to the subsequent holes of decreasing diameters (10mm, 9, 8, 7, 5, 4, 3.5 and 2.5mm). On touching the edge of the hole with the stylus, the steadiness machine would beep. The smallest hole in which subject could hold the stylus without touching the edge by each hand was considered for statistical analysis.

The statistical analysis was done using SPSS 20 software.

Results

Table 1: Comparison of Hand Grip Strength(kg) of dominant and non-dominant hand among Right-handers

Hand	n	Mean	Standard Deviation(S.D)	T	P
Right hand (Dominant hand)	90	15.300	5.711	6.465	<.001
Left Hand (Non-dominant hand)	90	13.544	4.780		

Table 2: Comparison of Finger Tapping (number/15 seconds) of dominant and non-dominant hand among Right-handers.

Hand	N	Mean	Standard Deviation(S.D)	t	P
Right Hand (Dominant hand)	90	69.611	8.670		
Left Hand (Non-dominant hand)	90	60.711	8.732	17.365	<.001

Table 3: Comparison of Steadiness (smallest hole in mm without touching the edges) of dominant and non-dominant hand among Right-handers.

Hand	n	Mean	Standard Deviation(S.D)	t	P
Right Hand (Dominant hand)	90	7.888	1.575	11.111	<.001
Left Hand (Non-dominant hand)	90	9.266	1.119		

Table 4: Comparison of Hand Grip Strength (kg) of dominant and non-dominant hand among Left-handers.

Hand	n	Mean	Standard Deviation(S.D)	t	P
Right Hand (Non-dominant hand)	10	15.900	5.258	5.041	.001
Left Hand (Dominant hand)	10	18.300	6.236		

Table 5: Comparison of Finger Tapping (number/15 seconds) of dominant and non-dominant hand among Left-handers.

Hand	n	Mean	Standard Deviation(S.D)	t	P
Right Hand (Non-dominant hand)	10	64.000	9.763	5.526	<.001
Left Hand (Dominant hand)	10	67.300	9.978		

Table 6: Comparison of Steadiness (smallest hole in mm without touching the edges) of dominant and non-dominant hand among Left-handers.

Hand	n	Mean	Standard Deviation(S.D)	t	P
Right Hand (Non-dominant hand)	10	8.500	1.715	3.207	.011
Left Hand (Dominant hand)	10	7.700	1.702		

The Paired-Samples t-test shows that the difference between the dominant and non-dominant hand among right-handers on all three measures to be very highly significant. The Paired-Samples t-test shows that the difference between the dominant and non-dominant hand grip strength among left-handers is very highly significant on measures of grip strength and tapping and significant on the measure of steadiness.

Discussion

The association between handedness and motor performance was assessed in 100 healthy school going children aged 10 to 14 years.

The results suggest hand preference and asymmetries in motor performance are strongly related that is, the dominant hand significantly outperforms the non-dominant in the same individual. These results are in conjuncture that this study includes children between 10 and 14 years.

A study by Cornwell et al[14] showed that toddlers demonstrated an increasingly lateralized hand preference in that more children at age 2 years showed consistent hand preference for activities like reaching and manipulation of toys than those at 9 and 13 years of age. Barnea-Goraly et al[15] and Denckla[16] showed that after 5 years of age, although hand preference persist, these lateral

differences diminish and they attributed this to the rapid development and myelination of the corpus callosum that allows for more efficient communication from the dominant to non-dominant motor cortex. The increased use of the preferred hand is high so as to induce an asymmetry in all three measure of motor performance (grip strength, tapping and steadiness) among this age group.[17,18,19] An additional aspect of dominance is that non-dominant hand motor performance also improves and may ultimately equalize with that of the dominant hand. This is likely due to connectivity between hemispheres or different rates of cortical maturation. But our study shows that the lateral differences are still present in the children of this study aged 10 to 14 years. Thus our study reflects that the myelination and maturation of inter-hemispheric cortical brain systems supporting motor skill, as well as rapid myelination of the corpus callosum has not been fully developed in these age groups. The age at which the reduction in right left motor performance differences may be used as a marker for maturation of neural pathways linking basic motor control with higher order executive control.

Future studies can include children with psychopathology, reading disorders, ADHD, etc. Although the motor findings of this study is attributed to maturation of certain cortical structures and corpus callosum, future studies can directly link the motor findings to imaging studies which will furnish important insight into typical and atypical development of neuromotor function in children. Upcoming studies should employ other age groups such as teens and older subjects in whom the neuromotor development pattern can be studied.

Conclusion

1) In this study on children aged 10 to 14 years, there is a significant difference between the Hand Grip Strength, Tapping and Steadiness of the dominant and non-dominant hand among both Right- and Left-handers. The preferred hand (dominant hand) outperforms the non-preferred (non-dominant) hand in all the three aspects of motor performance.
2) The increased use of the dominant hand induces motor performance asymmetries. This also is linked to the increased learning rate and skill performance of the preferred hand.
3) This may reflect that the maturation of cortical brain systems that support motor skill and myelination of corpus callosum are not fully developed in this age group. If completely developed, these would have allowed more efficient communication between the dominant and the non-dominant motor cortex reducing the lateral differences. Also, these findings can be considered as a marker for maturation of neural pathways linking basic motor control with higher order executive control.
4) Since left-handers also show motor performance asymmetries on all measures similar to right-handers, it may also imply that the dissimilar lateralization patterns (homogeneous and heterogeneous) and its strength in right- and left-handers are not completely established in this age group of 10 to 14 years.

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