RESEARCH ARTICLE

Frequency of mirror movements and comparison of hand function in spastic cerebral palsy children with and without mirror movements

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Abstract

Objective: To assess the frequency of mirror movements in spastic cerebral palsy children and to compare hand function and functional independence of such children with and without mirror movements.

Methods: The comparative cross-sectional study was conducted in special education schools of Lahore and Islamabad from August 2017 to January 2018, and comprised children of either gender aged 5-18 years diagnosed with spastic cerebral palsy who were able to make a gross grip. Wood and Teuber criteria for the assessment of mirror movements and Jebsen-Taylor hand function test for hand function assessment were used, while manual ability classification system was used for the assessment of functional independence. Data was analysed using SPSS 21.

Results: Of the140 subjects, 113(80.7%) were boys and 27(19.3%) were girls. The overall mean age was 11.17±3.69 years. Of the total, 51(36.4%) subjects had diplegic cerebral palsy, while 50(35.7%) were suffering from mirror movements. There was no difference in the unimanual hand function of children with and without mirror movements ($p>0.05$). However, children without mirror movements had more functional independence ($p<0.001$).

Conclusion: Mirror movement was found in one third of the sample, and there was no difference in hand function in children with and without mirror movements.

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Introduction

Cerebral palsy (CP) describes a group of permanent disorders of the development of movement and posture, causing activity limitations that are attributed to non-progressive disturbances that occurred in the developing foetal or infant brain. The motor disorders of CP are often accompanied by disturbances of sensation, perception, cognition, communication, and behaviour.[1] The brain damage is caused by cerebral injury or strange advancement of the cerebrum which happens while a child's brain is developing, before birth, during birth and immediately after birth. CP influences body developments, muscle control, muscle co-appointment, tone of muscle, reflex, balance and coordination.[2]

Signs and symptoms appear in mid-outset or pre-school years. CP causes weakened development related with strange reflexes, floppiness or unbending nature of the appendages and trunk, anomalous stance, automatic developments, temperamental strolling, or some mix of these conditions. Additionally, epilepsy, visual deficiency or deafness might be present.[3] The most widely recognised symptoms include problems with development on one side of the body, stiff muscles, exaggerated or jerky reflexes, involuntary developments or tremors, lack of coordination and adjustment, drooling, problems gulping or sucking, difficulty with discourse (dysarthria) and seizures.[4] Spastic CP(SCP) is portrayed by increased muscle tone. Hypertonia is associated with SCP.[5] Non-spastic CP will display diminished or fluctuating muscle tone.[6]

Mirror movements reflect development issue, and a condition in which deliberate developments of one side of the body are reflected by automatic developments of the opposite side. For instance, when an influenced singular makes a clench hand with the right hand, the left hand makes a comparable development.[7] The mirror developments in this issue principally include the upper limb, particularly the hands and the fingers. This example of development is available from early stages or early adolescence and typically perseveres all through life without other related signs and side-effects. Insight and life expectancy are not influenced.[8] Subsequently, development signals from 50% of the cerebrum are unusually transmitted to the two sides of the body, prompting mirror developments. The degree of the mirror developments in this issue can change even inside a similar family.[9] Much of the time, the automatic developments are recognisable but less articulated than the related deliberate developments. The degree of the developments ordinarily remain the same all through the

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lifetime of an affected person.[10] To the best of our knowledge and literature search, there is no published study from Pakistan on the frequency of mirror movements in SCP children. Also, no study could be located on comparison of unimanual hand function in children with and without mirror movement. Most of the paediatricians as well as several rehabilitation specialists in Pakistan are unaware of this movement disorder and often confuse it with associated movements. The current study was planned to assess the frequency of mirror movements in SCP children, and to compare the hand function and functional independence of such children with and without mirror movements.

Subjects and Methods

The comparative cross-sectional study was conducted at special education schools of Lahore and Islamabad, Pakistan, from August 2017 to January 2018, and comprised all types of SCP (hemiplegic, diplegic and quadriplegic) children of either gender aged 5-18 years who were able to make a gross grip. Those excluded were low-tone CP children, those not able to follow the command and children with fixed deformity making assessment difficult.

The Sample size was calculated using World Health Organisation (WHO) sample size calculator[11] with anticipated population of 0.01.[12] Non-probability purposive sampling technique was used. Permission was taken from the directors of the schools concerned.

To measure mirror movements, Woods and Teuber criteria was used that consists of three tasks (fist opening and clenching, finger opposition and finger tapping) and five grades; grade 0 (no clear mirror movement), grade 1 (barely discernable repetitive movement), grade 2 (showing slight mirror movement or stronger short time), grade 3 (stronger and sustained repetitive mirror movement), and grade 4(mirror movement equal to opposite hand). Intra-class correlation coefficient (ICC) of mirror movement scoring was reported to be greater than 0.82.[13,14] Each task was done with the participant sitting comfortably with elbows and forearm supported on the table. Videotaping was done for all the children while performing tasks in order to make sure the presence or absence of mirror movements. To check the functional independence, manual ability classification system was used that is a valid tool (ICC=0.97),[15] consisting of five levels; level I (handle objects easily and successfully), level II(reduced quality and somewhat reduced speed of achievement), level III (help to prepare or modify activity), level IV(limited selection of easily managed objects in adapted situations), level V(does not hold any object).[12] To compare the hand function, Jebsen Taylor hand function test (JTHFT), a valid tool for the assessment of unimanual task performance, was used. It consists of writing, simulated page turning, feeding, stacking checkers, picking up small objects, lifting large light objects and lifting large heavy objects.[14]

About 15-20 minutes were spent on one individual for data collection. Well-trained physical therapists collected data under the supervision of the class teacher of each student in a separate place especially designed in the exercise room according to the standard requirements of different tools used in the study. Data was analysed using SPSS 21. Descriptive statistics were presented in the form of Mean±standard deviation (SD) along with frequencies and percentages. For comparison between the groups Mann Whitney U test was applied after checking the normality of the data by Kolomogorov Smirnov test ($p<0.05$). Chi Square was applied for comparisons of Manual Ability Classification System (MACS) scale between the groups.

Results

Of the140 subjects, 113(80.7%) were boys and 27(19.3%) were girls. The overall mean age was 11.17±3.69 years. Overall, 50(35.7%) children had mirror movements. The mean age of subjects with mirror movements was 12±3.70 years, while those without mirror movements had a mean age of 10.72±3.63 years. In the group with mirror movements, 43(86%) were boys and 7(14%) were girls, while in the other group the corresponding numbers were 70(77.8%) and 20(22.2%). Diplegic CP was found in 51(36.4%) subjects, followed by hemiplegic CP 50(35.7%) and quadriplegic CP 39(27.9%). Both right and left sides were affected in 89(63.6%) subjects, followed by right side 30(21.4%) and left 21(15%).

Table-1: Severity of mirror movements in spastic cerebral palsy children.

Tasks	0- No Clear Movement	1- Barely discernable repetitive movement	2- Slight Mirror Movement	3- Stronger sustained repetitive movement	4- Movement equal to opposite hand
Opening and clenching of fist	90 (64.3%)	37 (26.4%)	13 (9.3 %)	0	0
Finger opposition	126 (90%)	12 (8.6%)	2 (1.4 %)	0	0
Tapping	136 (97.1%)	3 (2.1 %)	1 (0.7 %)	0	0

Table-2: Mann whitney U test showing values of Jebsen Taylor hand function test (JTHFT) of right hand.

Components of JTHFT	Mirror movements Median(IQ)	Without mirror movements Median(IQ)	P value
Writing	18(38.5)	20(15.25)	.466
Page turning	16(13)	18(19)	.173
Small objects	17(15.75)	14(15.25)	.568
Feeding	22(12)	24(22.5)	.627
Checkers	18(19.5)	14(21)	.105
Light objects	17(10.5)	15(12.25)	.166
Heavy object	29(5.25)	19(14)	.320

IQ: Interquartile range.

Table-3: Mann whitney U test showing values of Jebsen Taylor hand function test (JTHFT) of left hand.

Components of JTHFT	Mirror movements Median(IQ)	Without mirror movements Median(IQ)	P value
Writing	17(30.5)	19(18)	.951
Simulated page turning	12(11.25)	18(18.25)	.127
Small objects	13(9.5)	15(13.5)	.870
Feeding	21(17.5)	23(30.5)	.666
Checkers	13(14)	14(14.5)	.479
Light objects	14(10.25)	13(12.25)	.493
Heavy objects	16(10.5)	15(10.5)	.373

IQ: Interquartile range.

Table-4: Manual Ability Classification System(MACS) level in children with and without mirror movement.

Levels	With Mirror Movements	Without Mirror Movements	P value (Chi Square Test)
I	6 (12%)	37 (41.1%)	<0.001***
II	22 (44%)	33 (36.7%)	
III	15 (30%)	6 (6.7%)	
IV	5 (10%)	8 (8.9%)	
V	2 (4.0%)	6(6.7%)	

The severity of mirror movements while performing different tasks was assessed (Table-1).

There was no significant difference in the unimanual hand function of children with or without mirror movements (p>0.05)in both hands. Children without mirror movement had better hand function regarding task completion compared to the children with mirror movement (Tables-2, 3).

MACS scale showed highest frequency was level II in 22(44%) children with mirror movements, while in the other group, highest frequency found was grade I in 37(41.1%) subjects, confirming that children without mirror movements were more functionally independent than the children with mirror movements (p<0.05) (Table-4).

Discussion

Findings showed that 50(35.7%) of the 140 CP children had mirror movements. Reitz et al. analysed how far physiologically-associated movements in normal children (which may be present up to the age of 10 years) share the same physiological mechanism with clinically apparent mirror movements. Transcranial magnetic stimulation (TMS) and kinematic movement analysis were applied in a 4-year-old child with congenital mirror movements (CMM). The results were compared with a normative database of clinically normal children. In the child with CMM, focal TMS of one motor cortex induced bilaterally symmetrical responses in distal and proximal upper extremities muscles with identical ipsilateral and contralateral latencies. Also kinematic analysis showed a precise symmetrical onset of intended and unintended contralateral movements, whereas normal children with associated movements showed a variable movement onset delay between extremities. The data suggested a different physiological mechanism underlying these two varieties of elementary associated motor activity in childhood.[16]

Although little is known about the exact pathophysiology of the mirror movements in SCP, the most possible mechanisms explained are the projection of ipsilateral corticospinal tract from the non-affected hemisphere to both upper extremities and a reduced inhibition between motor cortices of the two opposite hemispheres.[17]

Johann P. et al. did a study to assess mirror movements in children and adolescents with hemiplegic CP that had 22 participants aged 6-18 years, and, according to the results, 19(86.3%) had mirror movements. Mirroring was more prominent in the unaffected hand as well as mirror movements disturbed functional bimanual skills.[13] In the current study, mirror movements were found in 35.7% SCP children which is much less than reported earlier because in the current study only SCP children were included while in the previous study both children and adolescents were included. However, MACS was used in both previous and the current study and mirror movements mostly occurred in children with MACS score 2 and 3in almost both studies, showing mirror movements have the ability to affect the functional independence of the individuals.[12] A study on the spectrum of movement disorders in CP population with gross motor functional classification system (GMFCS) and MACS scale revealed that mirror movements were

present in 10% children and mostly occurred in children with mild to moderate motor impairment (GMFCS I-III; MACS 1-3). Although in the current study, the frequency was slightly higher than the reported study,[12] the reason might be that the latter focused on all movement disorders without focussing specifically on mirror movements. However, it still reported that among all movement disorders, mirror movements were more frequent.[12]

A study to find out the association of mirror movements with hand function in children with unilateral CP concluded that mirror movements in the non-paretic hand seemed related to hand function, while mirror movements in the paretic hand seemed related to the lesion timing as children with earlier lesion presented with more mirror movements than the children affected with lesions in later life. JTHFT was used to assess the performance of unimanual tasks while Assisting Hand Assessment (AHA) was used to evaluate bimanual tasks.[14] In the current study, JTHFT was used and similar decreased hand function was found in group presenting with mirror movement as reported in the previous study, but no comparison of paretic and non-paretic hand was made and no association with lesion timing was found due to time limitations of the current study.

A prospective follow-up study assessed functional outcome in children with hemiplegic CP. The hand function assessment protocol consisted of video-recorded procedures: one to assess grip, and the other to assess the extent of spontaneous use of the affected hand. It concluded that to evaluate the real disability of the affected hand in children with hemiplegia, grip assessment was insufficient and that an instrument assessing spontaneous hand use in bilateral manipulation was required.[18] In the current study, unimanual hand function was checked through JTHFT that has some items that require the formation of grip, and to check mirror movements, video recording was done while opening and closing the fist, finger opposition and tapping, but no grip testing by specific instrument was performed. A study on mirror movement asymmetries in congenital hemiparesis concluded that mirror movements were seen in normal children in the first decade. The movements persisted after age 10 in the patients. At first, mirror movements were more prominent in the good hand (when the impaired hand attempted a unimanual task), but after age 10, mirroring diminished in the good hand, and these movements were equally prominent in the good and the impaired hands.[19] In the current study, CP children aged 5-18 years were included and it was observed that the mean age of mirror movement was 11 years, and mirror movements were more common in the unaffected site as most of the patients were of age about 10 years.

A study on mirror movements in unilateral SCP to check specific negative impact on bimanual activities of daily living concluded that mirror movements indeed had a specific negative impact on bimanual performance.[20] In the current study no significant difference was found between the groups, but the group with mirror movement showed more affected hand function than the group without mirror movement. There are several treatment options that can be incorporated in the rehabilitation of the SCP children presenting with mirror movements, and Action Observation Training (AOT) is one of them. AOT works on visuomotor mirror neurons and causes activation of specific brain areas in motor cortex while at the same time preventing the development of abnormal cortical reorganisation.[21] Mirror visual feedback (MVF) is another option that also targets mirror motor neurons and thus alters the activity of both the injured and the uninjured motor cortex.[22] Intense activity-based, goal-directed interventions like Constraint-Induced Movement Therapy (CIMT) and bimanual treatment protocols like Hand-Arm Bimanual Intensive Training (HABIT) can also be used for improving the function of the affected hand in addition to botulinum toxin injection.[23,24]

The current study had marked limitations like unequal gender distribution, small study duration, assessment of unilateral hand function and no comparison of paretic and non-paretic hand function as well as the sample size calculation.

There is a need for specific diagnosis of mirror movements along with its treatment as they not only affect the function of the hand but also the confidence of the child. Future studies should be conducted with different study designs as these mirror movements require some form of treatment to improve the function of individual in performing activities of daily living. Bilateral hand function should be compared between the groups with and without mirror movements. Mirror movements should be evaluated more specifically with different types of spastic cerebral palsy as well as with other types.

Conclusion

Mirror movements in spastic cerebral palsy were found in more than one-third of the sample. There was no statistically significant difference in unimanual hand function in SCP children who presented with or without mirror movements. However, functional independence was more in those CP children who presented without

mirror movements than those with mirror movements.

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References

1. Rosenbaum P, Paneth N, Leviton A, Goldstein M, Bax M, Damiano D, et al. A report: the definition and classification of cerebral palsy April 2006. Dev Med Child Neurol Suppl. 2007; 109:8-14.
2. Martin Bax, Murray Goldstein, Peter Rosenbaum, Alan Leviton, Nigel Paneth, Bernard Dan, et al. Proposed definition and classification of cerebral palsy, April 2005. Dev Med Child Neurol. 2005; 47:571-6.
3. Krigger KW. Cerebral palsy: an overview. Am Fam Physician. 2006; 73:91-100.
4. Morris C. Definition and classification of cerebral palsy: a historical perspective. Dev Med Child Neurol Suppl. 2007; 109:3-7.
5. Steenbergen B, Gordon AM. Activity limitation in hemiplegic cerebral palsy: evidence for disorders in motor planning. Dev Med Child Neurol. 2006; 48:780-3.
6. Nelson KB, Ellenberg JH. Antecedents of cerebral palsy. N Engl J Med. 1986; 315:81-6.
7. Deon LL, Gaebler-Spira D. Assessment and treatment of movement disorders in children with cerebral palsy. Orthop Clin North Am. 2010; 41:507-17.
8. O'Shea TM. Diagnosis, treatment, and prevention of cerebral palsy in near-term/term infants. Clin Obstet Gynecol. 2008; 51:829-39.
9. Chang JJ, Wu TI, Wu WL, Su FC. Kinematical measure for spastic reaching in children with cerebral palsy. Clin Biomech (Bristol, Avon). 2005; 20:381-8.
10. Charles J, Gordon AM. Development of hand–arm bimanual intensive training (HABIT) for improving bimanual coordination in children with hemiplegic cerebral palsy. Dev Med Child Neurol. 2006; 48:931-6.
11. KCLun PYWC, Chuah Aaron. Sample size determination in health studies. [Online] [Cited 2017 March 15]. Available from: URL: https://www.who.int/
12. RICE J, BAKER F, RUSSO R. The spectrum of movement disorders in a cerebral palsy population. Dev Med Child Neurol. 2016; 58:40-7.
13. Kuhtz-Buschbeck JP, Sundholm LK, Eliasson AC, Forssberg H. Quantitative assessment of mirror movements in children and adolescents with hemiplegic cerebral palsy. Dev Med Child Neurol. 2005; 47:571-6.
14. Klingels K, Jaspers E, Staudt M, Guzzetta A, Mailleux L, Ortibus E, et al. Do mirror movements relate to hand function and timing of the brain lesion in children with unilateral cerebral palsy? Dev Med Child Neurol. 2016; 58:735-42.
15. Eliasson AC1, Krumlinde-Sundholm L, Rösblad B, Beckung E, Arner M, Ohrvall AM, et al. The Manual Ability Classification System (MACS) for children with cerebral palsy: scale development and evidence of validity and reliability. Dev Med Child Neurol. 2006; 48:549-54.
16. Reitz M, Müller K. Differences betweencongenital mirror movements' andassociated movements' in normal children: a neurophysiological case study. Neurosci Lett. 1998; 256:69-72.
17. Kuo H, Friel K, Gordon A. Neurophysiological mechanisms and functional impact of mirror movements in children with unilateral spastic cerebral palsy. Dev Med Child Neurol. 2018; 60:155-61.
18. Fedrizzi E, Pagliano E, Andreucci E. Hand function in children with hemiplegic cerebral palsy: prospective follow-up and functional outcome in adolescence. Dev Med Child Neurol. 2003; 45:85-91.
19. Nass R. Mirror movement asymmetries in congenita1 hemiparesis The inhibition hypothesis revisited. Neurology. 1985; 35:1059-62.
20. Adler C, Berweck S, Lidzba K, Becher T, Staudt M. Mirror movements in unilateral spastic cerebral palsy: Specific negative impact on bimanual activities of daily living. Eur J Paediatr Neurol. 2015; 19:504-9.
21. Sarasso E, Gemma M, Agosta F, Filippi M, Gatti R. Action observation training to improve motor function recovery: a systematic review. Arch Physiother. 2015; 5:14.
22. Deconinck FJ, Smorenburg AR, Benham A, Ledebt A, Feltham MG, Savelsbergh GJ. Reflections on mirror therapy: a systematic review of the effect of mirror visual feedback on the brain. Neurorehabil Neural Repair. 2015; 29:349-61.
23. Zhu YL, Zhang B, Li F. A potential new indication for Botulinum toxin injection: a case study of spasticity with mirror movements. Chin Med J (Engl). 2016; 129:2514-5.
24. Sakzewski L, Ziviani J, Boyd RN. Efficacy of upper limb therapies for unilateral cerebral palsy: a meta-analysis. Pediatrics. 2014; 133:e175-204.