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Relationship between Grasp and Lateral Pinch Strengthin Response to Vestibular Stimulation in Children with Hemiparetic Cerebral Palsy

Samah Attia El Shemy[1],Hanaa Mohsen Abd El-Fattah[2]

[1]Department of Physical Therapy for Growth and Developmental Disorder in Children and Its Surgery, Faculty of Physical Therapy, Cairo University, Cairo , Egypt
[2]Faculty of Physical Therapy, Badr University, Egypt.

Abstract : Interactions with the external environment require a skilled and proficient functioning hand that can perform complex actions, such as grasping. Adequate finger strength and coordination are crucial in hand functions. To investigate the relationship between grasp and lateral pinch strength after vestibular stimulation in children with hemiparetic cerebral palsy. Grasping skills and lateral pinch strength evaluated in sixty hemiparetic cerebral palsied children (40 boys, 20 girls; ranged in age from 4 to 6) using Peabody Developmental Motor Scale and Jamar hydraulic pinch gauge respectively. Children randomly assigned into three groups of equal number; control group (A), study group (B) and study group (C). The three groups received the same conventional physical therapy program. Children in the control group received especially designed occupational therapy program from sitting position. Children in study groups received the same occupational therapy program given to the control group during vestibular stimulation from prone position on especially designed wedges. All measured variables assessed before and after six months of treatment. There was a non-significant weak direct correlation between grasp and lateral pinch strength in group A. Moreover, in group B there was a significant strong direct correlation while, there was a significant moderate direct correlation in group C. This study provides evidence that grasp and lateral pinch strength have significantly direct correlation as a result of vestibular stimulation.
Key words : Hemiparesis; Vestibular Stimulation; Grasp Skills; Lateral Pinch Strength.

Introduction

Cerebral Palsy (CP) is a non-progressive neurodevelopmental disorder that includes a wide range of disorders identified with the early onset of posture and motor impairment[1].Cerebral palsy is a heterogenous group of neurological disorders mainly observed in infants. It comes about because of a static brain lesion at the time of pregnancy or early life[2].

Children with hemiplegic CP have an upper limb impairment which can influence the capacity to perform and participate in activities of daily living (ADLs).The impairment results from spasticity, impaired sensation, and reduced strength. Consequently, the functional utility of the upper limb often compromised[3].Unilateral prehensile dysfunction occurs as a consequence of lesions in the sensorimotor cortex and corticospinal tract. These children regularly have unpredictable prehension patterns, weakness, spasticity, incomplete finger fractionation, and sensory disturbances. Children with CP likewise have impairments in fingertip force control and timing during object manipulation. Among these impairments, they exhibit a deficit in anticipatory control, which utilized to scale the grip and load forces in light of internal representations of an object's physical properties[4].

Limited utilization of the hemiplegic arm was not basically due to motor disability, but instead that limited integration of that arm-hand into functional activities seemed to be due to learned nonuse[5].Accordingly, knowledge about the fundamental mechanism of the hand has contributed to an understanding of the difficulties children with hemiplegic CP experience in grasping, releasing, and manipulating objects[6].

The vestibular system is imperative for normal function in several ways. It is a basic framework for detecting the position and motion of the head, especially angular motions such as rotation[7].NumerousADLs include volitional and reflexive orienting of attention while the body positioned in many orientations. Vestibular inputs assume a noteworthy part in image stabilization during rotations and translations of the head[8].In addition, positioning upside down, lying prone and supine and sitting activate distinctive parts of the vestibular canals at different degrees. The horizontal position and particularly the prone position are more stimulating than the upright position. Shifting between different head positions is necessary for the stimulation of the vestibular receptors[9].

The lateral pinch performed between the pulp of the thumb and the radial lateral side of the middle phalange of the index finger. In this pinch the adductor musculature of the thumb plays a critical role. The first dorsal interosseous muscle supports the index that also assisted by the other ulnar fingers, and the thumb acts through the action of the muscles of the thenar region and the long flexor[10].

Understanding the interrelationships between hand skills and how these related to pinch strength in children with CP is crucial for planning and implementing the most appropriate rehabilitation interventions. However, limited research has examined the relationship between pinch and grip strength and functional performance.There is no consensus about the correlation between lateral pinch strength and functional activities.Hence, the aim of this study was to identify the relation between grasping skills and lateral pinch strength in response to vestibular stimulation in children with hemipareticCP.

Subjects and methods:

Subjects

This study approved by the Ethics Committee of Faculty of Physical Therapy, Cairo University. Sixty hemiparetic CP children of both sexes (40 boys and 20 girls) selected from the Outpatient Clinic of Pediatrics, Faculty of physical therapy, Cairo University. Children eligible to participate in this study if they met the following inclusion criteria: their age ranged from 4 to 6 years, diagnosed ascongenital hemiparetic CP confirmed by magnetic resonance images (MRIs) obtained from medical records or personal physicians, mild degree of spasticity; ranged from grade 1 to 1+ according to Modified Ashwarth Scale (MAS)[11]. The level of gross motor function ranged from I to II, according to Gross Motor Function Classification System (GMFCS)[12]. Able to understand and follow instructions included in the evaluation and training procedures. Children excluded from this study if they had fixed contractures or deformities of the spine, upper or lower extremities, visual or respiratory disorders. General characteristics of participants illustrated in table 1.

Table 1: General characteristics of the participating children in the three groups

	Group A (n=20)	Group B (n=20)	Group C (n=20)
Age (Year)	5.32± 0.59	5.22± 0.75	5.17± 0.61
Affected side			
Right	17 (85%)	18 (90%)	15 (75%)
Left	3 (15%)	2 (10%)	5 (25%)
Gender			
Girls	8 (40%)	6 (30%)	6 (30%)
Boys	12 (60%)	14 (70%)	14 (70%)

Parents of all eligible children signed an informed consent form authorizing the child's participation in this study. Randomization used for children allocation using computer generated random number list into three equal groups of 20 children each. The three groups received the same conventional physical therapy program. Study groups (group B and group C) received the same especially designed occupational therapy program given to group A. while the head was in 45 and 60 degrees from a prone position respectively.

Methods

Methods for evaluation

1-Peabody Developmental Motor Scale (PDMS-2): This scale provides a comprehensive sequence of gross and fine motor skills, from which the therapist can determine the relative developmental skills level of a child, recognize the skills that are not totally developed and arrange an instructional program to develop those skills[13]. In the present study, PDMS utilized to evaluate the fine motor skills (grasping subtest) before starting and at the end of the treatment program.

2-Jamar hydraulic Pinch Gauge: Pinch gauge is a quantitative assessment tool with high reliability and validity. It is easy to use and gives an accurate and repeatable pinch strength reading (tip pinch, lateral or key pinch and palmer or three jaw chuck pinch)[14]. It measures pinch force up to 45 lbs. In the present study lateral or key pinch strength only measured.

Methods for treatment

1. Especially designed wedges with selected reclined surfaces 45 and 60 degrees.
2. Light toys, cubes and toys of different colors and shapes utilized for the training of fine motor skills.
3. Mats, rolls, medical balls and balance board utilized for conducting physical therapy program.
4. 4-A table and chair with adjustable height and back support.

Procedures

Procedures for evaluation

Evaluation of grasping skills

Each child asked to sit on a chair-table that permits him/her to comfortably place feet on the floor. The examiner tested continuously the items in PDMS-2graspingsubtest until a ceiling established. After administration of all tests in grasping subtest (24-item) raw and standard scores calculated[13].

Evaluation of pinch strength

Lateral pinch strengths measured by utilizing a Jamarpinch gauge. The standardized functional positions utilized[14].The children asked to pinch with his/her affected hand; other end of the pinch gauge held by the examiner. An explanation was given to all children how to press the pinch gauge. Then, they allowed being familiar with the instrument by a sub-maximal practice trial. Finally, they asked to pinch the handle of pinch gauge as strong as possible and measurement taken (in Ibs). The same maneuver repeated for 3 times, allowing a 10 seconds rest between the measurements. An average of 3 measurements calculated and recorded[10].

Procedures for treatment:

Training of fine motor skills that involve different patterns of reach, grasp, and release conducted for all children for one hour per session (three sessions/ week) over a period of six months. For control group A occupational therapy program applied from sitting position on a chair-table. For the study groups B and C, the occupational therapy program applied while the child lying prone on specially designed wedges reclined 45 and 60 degrees respectively, with straps at the level of the child's waist and knees for safety. The therapist assisted all children to perform different types of occupational exercises, including: Forming tower of cubes of different colors, sorting similar colors and similar shapes together; e.g. square cubes together in a column, cylindrical cubes together. Grasping molded cylinder rubber, hammer and different shapes of cubes and triangles. Placing balls in their column, circular shapes of different sizes in their right place and transferring objects between both hands.Release objects like cubes in a defined area or container with different sizes.

All children in the three groups experienced a one hour conventional physical therapy session (three sessions/ week) over a period of six months. This program included Neurodevelopment technique (NDT) [15]that focused on normalization of muscle tone, encouraging normal movement patterns, and positioning. Weight bearing activities carried out, especially on the affected side. Training of postural mechanism; including facilitation of righting, equilibrium and protective reactions. Manual passive stretching exercises to restore flexibility of muscles e.g.ankle planterflexors, knee and hip flexors, hip adductors, flexors of the fingers, wrist and elbow, forearm pronators, shoulder adductors and internal rotators. Strengthening exercises for upper and lower limbs, and gait training.

Statistical analysis

The collected data analyzed using SPSS version 18. Descriptive statistics of mean and standard deviation calculated for all measured variables. The Pearson's correlation coefficient test used to determine the relationship between grasp and lateral pinch strength. A P-value of less than 0.05 considered statistically significant.

Results

As shown in table 2 and figure 1**,** there was a non-significant weak direct correlation between grasp and pinch strength with correlation coefficient (r) value of 0.36(p = 0.119) in group A. There was significant strong direct correlation between grasp and pinch with correlation coefficient (r) value of 0.631 (p = 0.003) in group B as shown in table 3 and figure 2, while there was significant moderate direct correlation coefficient (r) value of 0.593 (p = 0.006) in group C as shown in table 4and figure 3.

Table 1: Correlation between grasp and lateral pinch strength in group A

	$\bar{X}$ **±SD**	**r**	**P value**
Grasp	21.99±3.78	0.360	0.119
Lateral pinch strength	4.24±0.61		

$\bar{X}$: Mean; SD: Standard Deviation; r: Pearson's Correlation Coefficient Value; *Significant at p<0.05

Table 2: Correlation between grasp and lateral pinch strength in group B

	$\bar{X}$ **±SD**	**r**	**P value**
Grasp	31.19±4.56	0.631	0.003*
Lateral pinch strength	5.12±0.76		

$\bar{X}$: Mean; SD: Standard Deviation; r: Pearson's Correlation Coefficient Value; *Significant at p<0.05

Table 3: Correlation between grasp and lateral pinch strength in group C

	$\bar{X}$ **±SD**	**r**	**P value**
Grasp	23.60±3.47	0.593	0.006*
Pinch strength	4.11±0.65		

$\bar{X}$: Mean; SD: Standard Deviation; r: Pearson's Correlation Coefficient Value; *Significant at p<0.05

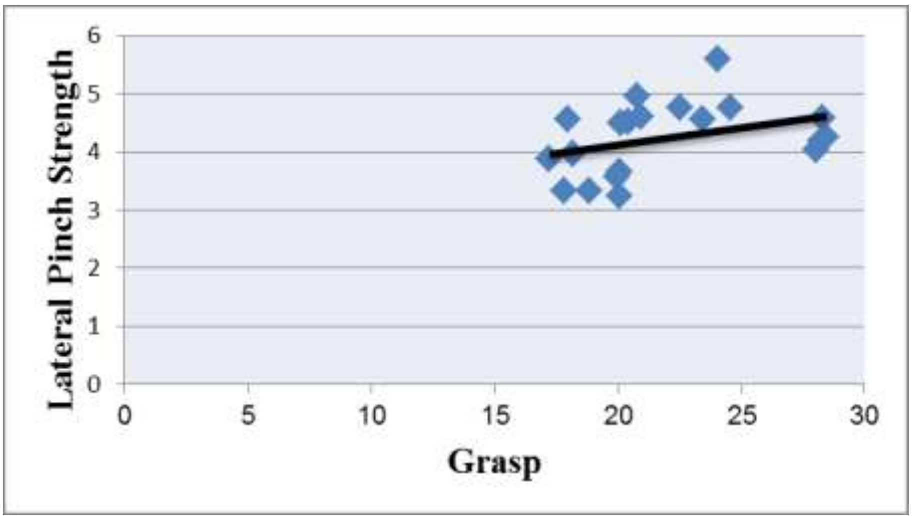

Fig 1:Scatter plot of correlation between grasp and pinch strength in group A

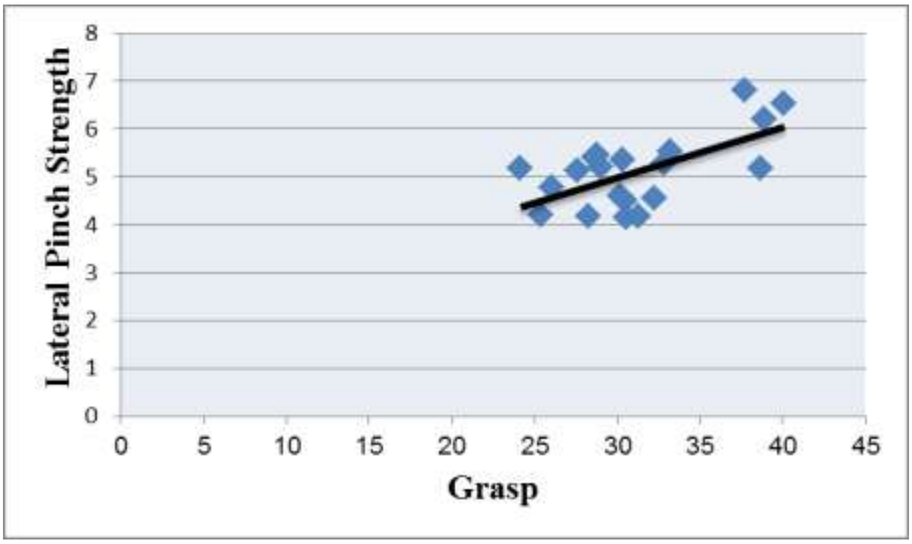

Fig 2: Scatter plot of correlation between grasp and pinch strength in group B

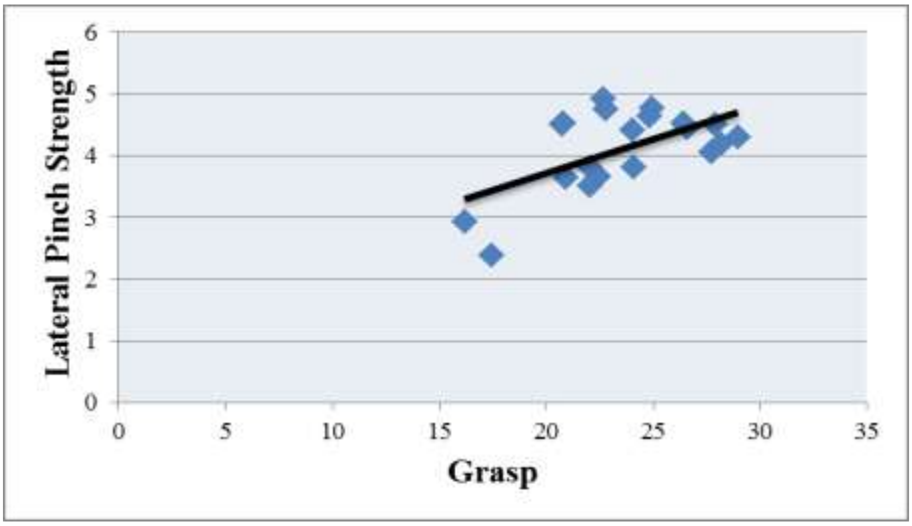

Fig 3: Scatter plot of correlation between grasp and pinch strength in group C

Discussion

The current study investigated the relationship between grasp and pinch strength in response to vestibular stimulation in hemiparetic children. Hand functioning, the ability of the hands to perform properly in various contexts, requires the integrity of the CNS and therefore, may be disturbed by different brain disorders. The human manual function largely reflected by skillful utilization of the fingers in grasping, lifting, and manipulating objects between the pulps of thumb and one of the four fingers (finger pinch)[16].

Cerebral palsy may affect the hand and its components (e.g., muscles, joints, and bones), as well as several body functions (e.g., muscle strength, control of rapid coordinated movements, touch-pressure detection, and recognition of common objects and shapes). It might likewise restricts activities which refer to the ability to execute an essential task or ADLs (e.g., eating, drinking, or dressing)[17].

By exploring the process by which pinch strength related to grasping skills, this study highlights potential treatment priorities to enhance hand functioning in children with hemiparetic CP. The findings of this study emphasized the significance of vestibular stimulation in improving grasping and pinching skills. Vestibular system is a critical variable in the accomplishment of normal motor development and coordination. Stimulation of vestibular receptors utilized for normalization of muscle tone by enhancing otolith organ input[18]. The improvement of fine motor skills and pinch strength in both study groups supported by the findings of Unayik and Kahiyan[19] who revealed that vestibular stimulation is one of the treatment approaches to CP children coordinated toward stimulation for the improvement of visual-motor coordination and normalization of muscle tone.

Significant direct correlation between grasp and pinch strength in both study groups could attribute to motor learning effect as multiple repetitions of movement with intensive training required for new motor skill acquisition and inducing long-term brain plasticity[20]. Accordingly,improvement of grasping skills could result in improvement in lateral pinch strength through training of hand activities combined with vestibular stimulation.

The findings of the present study revealed that there was a significant positive association between grasping skills and pinch strength in both study groups. This comes in agreement with Park et al.[21]who reported that manual ability has moderate to high relation to other hand motor skills (e.g., active range of motion, muscle tone, strength, coordination, and quality of movement. Furthermore, Gayathri and Prabhu[22]claiming a positive relationship between hand functions and pinch strength. They concluded that there is a moderately positive correlation between ROM, grip and pinch strength with the hand activity impairment, while sensory, muscle tone and pain showed a moderately negative correlation. Similar findings clarified by Bleyenheuftand Gordon[23]who studied the interaction between precision grip control and sensory impairments in children with hemiplegic cerebral palsy.

The results of the present study revealed that grasp and pinch strength directly correlated in the three groups. This comes in accordance with Rajan et al.[24] who found that hand strength and functional activities of daily living (ADLs) are directly correlated, as when hand strength increased, the ability to do the basic daily activities also increased and vice versa. Therefore, improvement in muscle strength directly related to motor function and motor learning process. Engagement in treatment program requires objects handling leads to increase adaptations of the child to develop daily life skills.

In the present study, lateral pinch strength directly correlated with function. This comes in accordance with Alaniz et al.[25]who reported that self-care activities are an important childhood task in the home environment. Moreover, numerous self-care skills, such as manipulating fasteners, opening packages, and tying shoes, require pinch strength and fine motor control. They found that grip and pinch strength correlated with independence in functional activities.

The results of the present study after the recommended period of treatment demonstrated that there wasa significant moderate to strong direct correlation between grasp and pinch strength in both study groups which could be due to vestibular stimulation that provides information about the position and motion of the head and the direction of gravity. These findings come in agreement with Herdman[26]who stated that the vestibular system is one of the most important parts of the CNS for postural control. Moreover, the vestibular framework works as both sensory and motor systems it provides a schema or a map of the position and movement of the entire body (sensing and perceiving self-motion) in the surrounding environment (orienting vertical). As a motor system, provides necessary information in order to control center of mass, and stabilize the head.

The findings of the study groups at the end of the treatment period indicated improvement in fine motor functions and the ability to hold an object with one hand and progresses up to activities involving the controlled utilization of fingers. This may attribute to vestibular input which helps the children to effectively interact with their environment for fine motor, visual motor coordination. This agrees with the work of Kranowitz[27]who reported that vestibular input is important for children's development as it helps them maintain balance and trunk control, fine motor and self-care activities. Vestibular input can also help a child to feel directed with a specific end goal to keep them focused and attentive.

According to the results of this study, the improvement in pinch force may result from the improved overall hand function coming about because of vestibular stimulation. This finding comes in agreement with Ranganathan et al.[16] who found that training with skilled finger movements enhances the capacity to maintain a steady pinch force and finger-pinch posture, as well as to move small objects quickly with finger grip. These improvements may be due to training-induced adaptations in the central and peripheral nervous systems. In addition, the training program induced a positive change in the excitability of motoneurons innervating a muscle that is important in controlling finger pinch.

Conclusion

The current study shows that there is a significantly moderate to strong positive correlation of lateral pinch strength with grasping skills. So the improvement of grasp abilities following vestibular stimulation may be considered as an influential variable in improving the pinch strength, which is an essential component of hand functions.

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Conflict of interest

The authors declare that there is no conflict of interest in this study.

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