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Case Series

Evaluation of the strength of the upper extremity in children with hemiplegia after stroke: a case series study

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ABSTRACT

The brain is a system with multidimensional organization and architecture and requires a continuous supply of blood in order to normally function. If blood flow is interrupted for more than a few seconds, the brain is deprived of blood and oxygen, causing death in nerve cells in the affected area. Stroke in children after birth appears even more rarely than in adults. For the study, 10 children with hemiplegic cerebral palsy (7 boys and 3 girls) participated (mean age 10, 9 years), from the "General Hospital Hippocratio" of Thessaloniki, according to the inclusion criteria. The strength of the upper extremity was measured using the Jamar dynamometer and for the assessment of the balance the pediatric balance scale (PBS) affected and contralateral hands, results were analyzed and compared with norms for age and sex and related to the affected balance. It was found that the strength of the non-affected upper extremities was also reduced according to the data of the normal children and the balance was also affected because of the stroke. Physiotherapy programs may include exercises that give emphasis on the non-affected upper extremities, more similar research must be done on a bigger population.

Keywords: Children, Hemiplegia, Stroke, Jamar dynamometer, PBS

INTRODUCTION

The World Health Organization defines stroke as every damage of brain tissue or the spinal cord, that is caused by a disruption to blood circulation and they exist sudden symptoms. Stroke is included of the most important problems of world health and is recorded as the third cause of death after cancer and heart diseases. It is the result of ischemia (reduced blood circulation), either blockage, which is caused either by thrombosis or arterial embolism, or hemorrhage. As a result, the affected area of the brain dysfunctions, which leads to the appearance of neurological and mental dysfunctions.[1]

They are classified into ischemic, which includes arterial infarcts and venous sinus thrombosis, and hemorrhagic, and occur in the pediatric population more rarely than in adults.[2] They are also divided into perinatal, (developing between the 20th week of fetal life and the 28th day after birth) and strokes in children (appearing from the 29th day after birth to the age of 18 years).[2-5] Incidence rates vary in the international literature with a lower value in children 0.2/100,000 children/year and a higher 7.9/100,000 children/year and in newborns around 20-30/100,000 newborns/year (i.e. 1/4,000-5,000 births/year).[4,6] The incidence rate of stroke, either ischemic or hemorrhagic, is higher in boys than in girls (1.5/1 according to one study), and so is the mortality rate.[6-9]

The clinical manifestations of stroke vary due to the complex anatomy of the brain and vary, depending on the cerebral artery responsible and the area of the brain

affected. The clinical manifestations are always of sudden onset, focal and usually involve only one side of the body. The various deficits associated with involvement of a particular cerebral artery are collectively referred to as cerebrovascular syndromes, although there is often overlap between them. Signs and symptoms depend on the type of event that caused the stroke and the location of the clot or bleeding. It may appear: weakness; numbness; paralysis in one part of the body (face, arms, legs); difficulties speaking, understanding, confusion; visual difficulties (loss or reduction of vision in one or both eyes); dizziness, loss of balance, difficulty walking, loss of coordination of movements; severe, painful headache that comes on suddenly with no known cause; hemiplegia (when one side of the body is paralyzed) difficulty in moving the tongue; and strong burning smell. The symptoms of a stroke include the weakness and numbness of the extremities of one half of the body (hemiparesis), the inability to express or understand speech (aphasia), the difficulty in seeing (hemianopsia: loss of half of the visual field of one or both of two eyes. When the same half is lost in both eyes the condition is called homonymous hemianopsia), loss of balance or movement coordination disorder, gait disorders and functional impairment. Also, severe headache that occurs suddenly without a known cause, decreased level of consciousness, confusion and other physical symptoms such as drooping of one side of the face are some of the main symptoms of strokes.[15]

The purpose of this research was the evaluation of children with stroke, specifically their strength of the upper extremities. There is a lack of research regarding the measurements of the non-affected upper limb in children with hemiplegia and that was a motive to conduct the research.

CASE SERIES

Subjects

The patients were selected from the "General Hospital Hippocratio" of Thessaloniki. The selection criteria were children, who were diagnosed with hemiplegia and who all had independent functional mobility. The children age was between 4-18 years old. All the children were able to communicate and understand the instructions that were given to them and also were capable of using the upper limbs. Exclusion criteria from the research were children which were diagnosed with tetraplegia or diplegia and were younger than 4 years old and older than 18, if they were unable to grasp using their upper limbs, could not communicate or understand instructions.

Finally, ten children took part in the research, diagnosed with hemiplegia (according to the diagnosis of the pediatric neurologist), aged six to fifteen (mean age 10, 9), with a total of three girls and seven boys. Six children with left hemiplegia and four children with right hemiplegia were recorded as also somatometric characteristics of height and weight (Figure 4 and 5).

The study included a sample of (10) children after stroke of which 70% were boys and 30% were girls (Figure 1). The mean age for boys was 10.9 years and for girls 11 years (Figure 2). The percentage of left hemiplegia in the entire sample was listed at 70% and of right hemiplegia at 30% (Figure 3). With the boys scoring a total of 71% left hemiplegia and 28.65 right hemiplegia, while among the girls the percentages of left hemiplegia were 66.6% and 33.3% right hemiplegia.

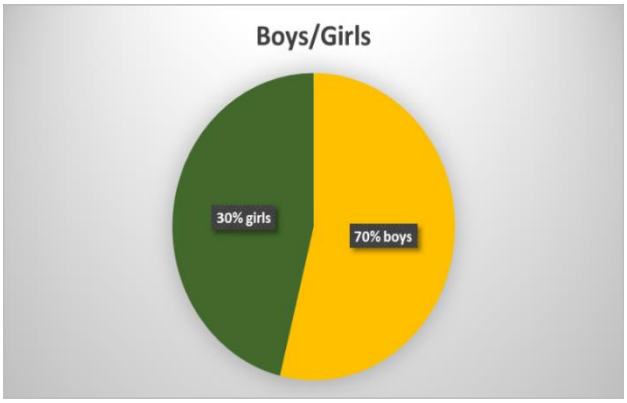


Figure 1: Percentages of boys and girls who participated.

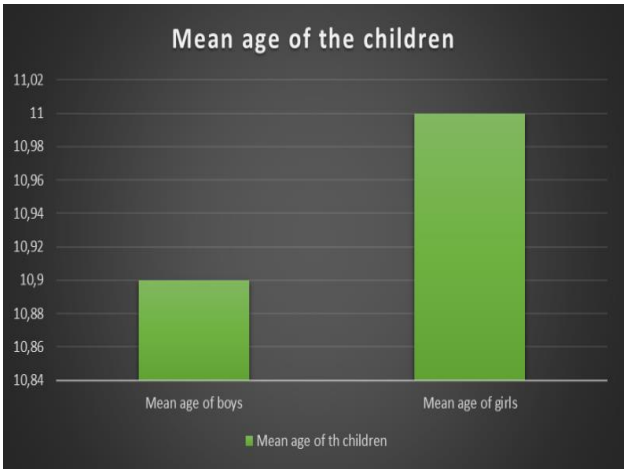


Figure 2: Mean age of boys and girls.

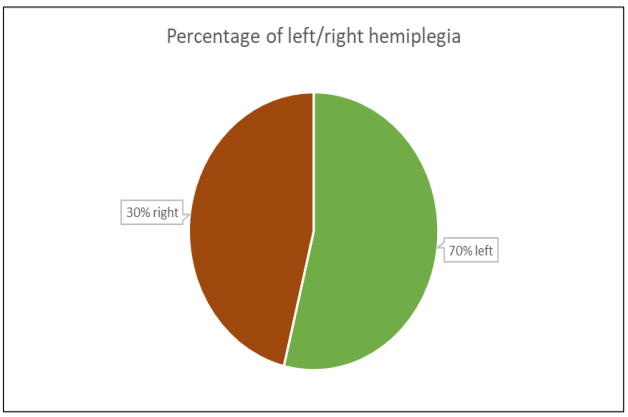


Figure 3: Rates of left and right hemiplegia.

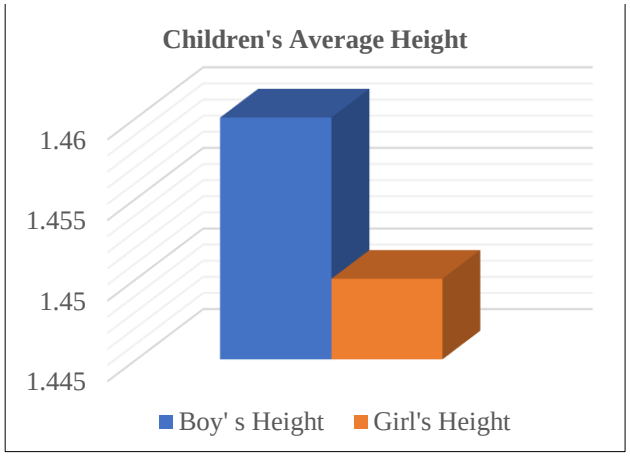


Figure 4: Average height from the children who participated.

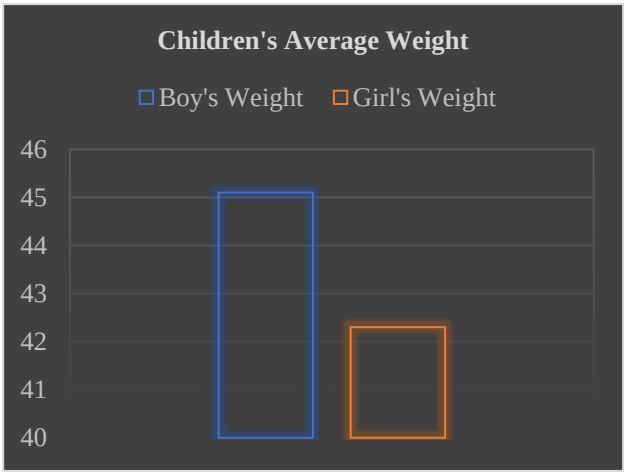


Figure 5: Average weight from the children who participated.

The aim of the study was to find differences in strength between right/left upper extremities (healthy and impaired) compared to data in the general population through dynamometry and if these results were related to the affected balance of the children, which were measured with the help of the PBS. All parents/guardians agreed to the participation of the children by signing a statement of informed consent.

Before conducting the research, permission was required from the bioethics and ethics committee of the physical therapy department of the International Hellenic University, which was issued under the protocol number EC XXXXX.

Measurements

The JAMAR dynamometer for the measurements of the upper limps was chosen and pediatric balance scale (PBS) for the assessment of balance. Handgrip strength (HGS) is used as a means of predicting a person's health throughout life. The HGS is an important indicator that helps identify the level of development and degree of disability. It also helps determine the effectiveness of rehabilitation and assess the integrity of upper extremity function. The JAMAR dynamometer has a dual scale readout that displays isometric grip force from 0-90 kg (0-200 lb). The outer dial registers the result in kg and the inner dial registers the result in lb. It has a peak hold needle which automatically retains the highest reading until the device is reset. The handle easily adjusts to five grip positions from 35-87 mm (1½-3¼") in 13 mm (½") increments. Always use the wrist strap to prevent the dynamometer from falling on the floor if accidentally dropped.

The PBS was originally developed in the United States as a modified version of the Berg balance scale (BBS). It consists of 14 items based on activities of daily living starting from the easiest to the most difficult. Each PBS item is rated on a 5-point scale, with zero indicating the inability to perform the activity without assistance, and four indicating the ability to perform the task completely independently. Each item's scores are summed to obtain the total PBS score (maximum=56 points). Intended for use in school-aged children (5-15 years) with mild to moderate motor impairments such as cerebral palsy and other pediatric disorders. It can be easily performed and scored in less than 20 minutes using minimal equipment commonly found in schools and clinics. Its purpose is to evaluate the functional balance and motor disorders of school-aged children with mild to moderate motor dysfunctions in the context of daily activities. PBS also has the ability to distinguish between normally developing children and those with mild motor impairments, as well as those with moderate to severe motor impairments. In the research, the form, which was used, was the Greek official edition.[13]

Assessment - procedure

In the research a non-random sample of 10 patients from the General Hospital of Thessaloniki "Hippocratio" was included with a diagnosis of hemiplegia.

First, the strength of both upper limbs was measured using a JAMAR dynamometer, and then the PBS tests were recorded. Each subject was placed in a straight-backed chair with both feet flat on the floor. Arm placement was demonstrated by the assessor, and then each child was instructed to place their left hand on the left thigh, and vice versa, and to place the shoulders in adduction without turning. For the arm to be tested, the elbow was to test the arm, the elbow was flexed to 90°, the forearm and wrist are in neutral positions, and the fingers were flexed so that the thumb touches the child's index finger.

The procedure we followed was: first the participant was asked to remove any objects that they wore. After they sat in a chair, that was chosen for the test and it was demonstrated how to hold the dynamometer and it was explained that the best result would be given if they squeeze the dynamometer tightly. Then the child had to

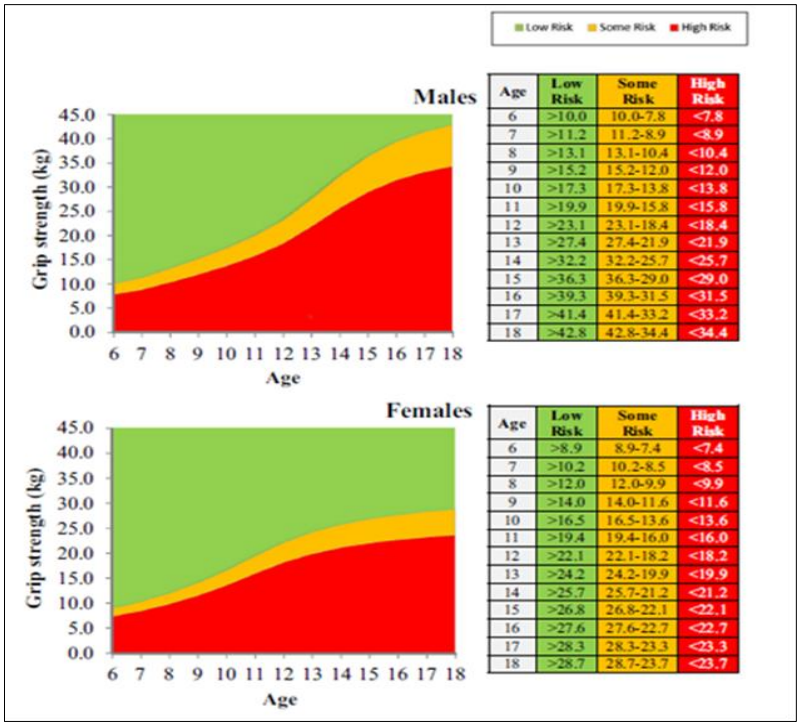
rest their forearms on the arms of the chair and keep their feet flat on the floor. Their feet had to stay flat on the floor when they squeezed the dynamometer. Then they were asked to position their thumb around one side and their fingers around the other side of the handle. It was ensured that the position of the handle was adjusted according to the size of the children's hands. Before the measurement, it was ensured that the red needle was in the "0" position by turning the dial. Children had to squeeze the dynamometer as tight as possible. The procedure was repeated twice and it was recorded the average of the results.

Results

In the results of the measurements of the strength of the upper limb (hand grip) according to the general population, increased deviations were recorded in the whole sample with results of the strength of the upper limb recording a high degree of difficulty and risk (high risk) an average degree of difficulty and risk (some risk) and low level of difficulties (low risk). Specifically, on the hemiplegic side of children, 80% of boys with left hemiplegia belonged to (high risk) while 20% to (some risk) while on the right hemiplegia, 100% belonged to (high risk). Also, 100% of the boys with right hemiplegia belonged to (some risk) according to their non-hemiplegic side. As for the hemiplegic side of the girls, 100% of them with left hemiplegia belonged to (high risk) while with right hemiplegia 100% as (high risk). Noteworthy was the report of measurements that record percentages of upper extremity strength deviations on the non-hemiplegic side. The boys with left hemiplegia, their unaffected upper limb belonged to 57.1% at high risk, 28.6% at (some risk), and 14.3% at (low risk). In girls, the 100% left non-hemiplegic upper limb belonged to (some risk) and the right non-hemiplegic 100% to (some risk) (Table 1).

Table 1: Results of the test with the Jamar dynamometer.

Gender/age	Hemiplegia	Measurements of the left upper limb	Measurements of the right upper limb
Male/15,5	Left	High risk, 80%	Low risk, 14,3%
Male/7	Left	High risk, 80%	High risk, 57,1%
Male/7	Right	Some risk, 100%	High risk, 100%
Male/14	Left	High risk, 80%	Some risk, 28,6%
Female/14	Right	Some risk, 100%	High risk, 100%
Female/7	Left	High risk, 100%	Some risk, 100%
Male/16	Right	Some risk, 100%	High risk, 100%
Female/12	Left	High risk, 100%	Some risk, 100%
Male/10	Left	High risk, 80%	Some risk, 28,6%
Male/7	Left	Some risk, 20%	High risk, 57,1%



Age	Low Risk	Some Risk	High Risk
6	>10.0	10.0-7.8	<7.8
7	>11.2	11.2-8.9	<8.9
8	>13.1	13.1-10.4	<10.4
9	>15.2	15.2-12.0	<12.0
10	>17.3	17.3-13.8	<13.8
11	>19.9	19.9-15.8	<15.8
12	>23.1	23.1-18.4	<18.4
13	>27.4	27.4-21.9	<21.9
14	>32.2	32.2-25.7	<25.7
15	>36.3	36.3-29.0	<29.0
16	>39.3	39.3-31.5	<31.5
17	>41.4	41.4-33.2	<33.2
18	>42.8	42.8-34.4	<34.4

Age	Low Risk	Some Risk	High Risk
6	>8.9	8.9-7.4	<7.4
7	>10.2	10.2-8.5	<8.5
8	>12.0	12.0-9.9	<9.9
9	>14.0	14.0-11.6	<11.6
10	>16.5	16.5-13.6	<13.6
11	>19.4	19.4-16.0	<16.0
12	>22.1	22.1-18.2	<18.2
13	>24.2	24.2-19.9	<19.9
14	>25.7	25.7-21.2	<21.2
15	>26.8	26.8-22.1	<22.1
16	>27.6	27.6-22.7	<22.7
17	>28.3	28.3-23.3	<23.3
18	>28.7	28.7-23.7	<23.7

Figure 6: Rates of the normal strength of children based on their age.

Measurements of PBS

Percentages of deviations also refer to the balancing ability of the children with the largest percentage of 40% of the sample recording 49/56, 20% recording the highest percentage of score 53/56, and correspondingly the lowest balance 41/56 in 20%, while 10% the average values of scores are found with 50-52/56. The whole sample records difficulties in balancing ability with score deviations lowest score being recorded as min=41/56 and the highest max=53/56 (Table 2).

Table 2: Results of the pediatric balance scale test.

Participants	Score on pediatric balance scale	Percentage
Male with left hemiplegia	41/56	10
Male with right hemiplegia	41/56	10
Male with left hemiplegia	49/56	40
Female with left hemiplegia	50/56	10
Female with right hemiplegia	52/56	10
Female with right hemiplegia	53/56	10
Male with left hemiplegia	53/56	10

DISCUSSION

The human hand performs various complex and detailed functions that allow humans to complete tasks such as writing, computing, and many others. In an effort to explore the functional sophistication of the hand, several methods have been introduced for the development of an objective evaluating system. Grip strength has been described as the power of the combined contraction of the extrinsic and intrinsic muscles of the hand that flex the joints of the hand. Accurate measurements of muscle strength can provide insights into children's development. Until today it hasn't been reported if the handgrip of the non-affected hand on the children population was affected because of the stroke, although research on adults has been conducted. Through this research, it's been clear that as physiotherapists we need to give attention to both hands giving the children exercises for empowering the muscles. From the above results, it follows that the handgrip of children with hemiplegia after stroke is importantly affected. Regarding strength, the hemiplegic upper limb was affected which was expected but it was shown that strength was also affected in the healthy upper limb (L/R). There is research that concluded that in adults with mean age 60 years the grip strength of the unaffected side of patients with hemiplegia was found to be significantly lower.[14] However similar research for children and adolescents has not been implemented since now.

Lee and his colleagues found that children with hemiplegia had significant muscle weakness in their affected upper limbs compared to their unaffected limb. The study also reported that the degree of muscle weakness in the affected limb was significantly correlated with the severity of the hemiplegia.[17] These findings support the results reported in the current study where children with left hemiplegia had a higher percentage of high-risk upper extremity strength on their hemiplegic side. Krumlinde-Sundholm investigated the use of the assisting hand assessment (AHA) in evaluating upper extremity function in children with hemiplegia.[18] The study found that the AHA was a reliable and valid tool for measuring upper extremity function in children with hemiplegia. This tool could potentially be used in future studies to assess the upper extremity function in children with hemiplegia after stroke. A study conducted by Gordon and his colleagues investigated the relationship between muscle strength and upper extremity function in children with hemiplegia.[19] The study found that muscle strength was significantly correlated with upper extremity function in children with hemiplegia, with stronger muscles being associated with better upper extremity function. These findings further support the importance of assessing upper extremity strength in children with hemiplegia after stroke. Finally, another study investigated the effect of intensive upper extremity training on muscle strength and upper extremity function in children with hemiplegia.[20] The study found that the intensive training led to significant improvements in both muscle strength and upper extremity function in the affected limb. These findings suggest that targeted interventions aimed at improving muscle strength could potentially improve upper extremity function in children with hemiplegia after stroke.

Regarding Balance, the average score was 48.6, with an excellent 56, which indicates a disturbance of balance, which was expected due to the spasticity they displayed on the hemiplegic side, so there was a poor base of support, reduced balancing reactions, and alignment in the trunk. Balance is a complex process that involves input from multiple sensory systems, including vision, proprioception, and the vestibular system. The ability to maintain balance relies on the integration of sensory information, which is then used to adjust muscle activity and posture to maintain a stable position. Handgrip strength may play a role in this process by providing feedback to the brain about the position and stability of the upper limb. Some studies have investigated the relationship between handgrip strength and balance in children with hemiplegia. One study found that children with hemiplegia who had weaker handgrip strength on their affected side had poorer balance control compared to those with stronger handgrip strength.[21] Another study found that children with hemiplegia who received handgrip training had improvements in both handgrip strength and balance control.[22] These findings suggest that

handgrip strength is an important factor in balance control in children with hemiplegia.

There are several possible mechanisms by which handgrip strength may affect balance in children with hemiplegia. First, handgrip strength may provide feedback to the brain about the position and stability of the upper limb, which can then be used to adjust muscle activity and posture to maintain balance. Second, weaker handgrip strength may lead to decreased use of the affected limb, which can result in muscle atrophy and decreased proprioceptive feedback from that limb. This, in turn, can affect balance control by decreasing the amount of sensory information available to the brain.

The use of electronic dynamometers should also be considered since this might reduce limitations of the measurements performed with the hydraulic dynamometer mainly due to deviation of wrist position from the optimum one.

Based on the results of our study an international effort for the establishment of coefficients for grip strength evaluation should be the future target. These coefficients should incorporate anthropometric parameters such as sex, weight, height, and BMI in order to evaluate the optimal normal grip strength and the strength of the hemiplegic hand. Finally, it might be possible that the affected strength of the non-affected hand might be a factor that affects the balance of these children. This could be a motive for research.

CONCLUSION

The conclusion from this research is that the strength of the healthy upper limb in children with Hemiplegia was also affected. Handgrip strength is an important factor in balance control in children with hemiplegia. Children with weaker handgrip strength on their affected side are more likely to have poorer balance control compared to those with stronger handgrip strength. Physiotherapy programs must include exercises for the strength of both upper limbs. Handgrip training may be an effective intervention for improving both handgrip strength and balance control in children with hemiplegia. Further research is needed to determine the underlying mechanisms for the relationship between handgrip strength and balance control in this population.

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