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THE EFFECT OF AN ADAPTED EXERCISE PROGRAM ON MUSCLE STRENGTH OF A GIRL WITH UPPER LIMB MONOPLEGIA AND BRACHIAL PLEXUS INJURY

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Abstract:
Cerebral palsy and brachial plexus paralysis are chronic conditions that result in severe motor difficulties that affect an individual's motor function, co-ordination, posture and balance. The purpose of this study was to examine the effect of an adapted exercise program on the improvement of muscle strength of a child with upper limb monoplegia due to brachial plexus birth paralysis. The sample consisted of a 4.5-year-old girl, diagnosed with upper limb monoplegia and brachial plexus injury. Next, an adapted exercise program lasting 12 weeks, twice per week, of 45 minutes each session was structured, that included activities aiming to improve muscle strengthening and coordination. Measurement tools used prior and after the intervention program included the Oxford Scale, the Arm Curl Test and the medicine ball throw. Descriptive analysis between pre and post results showed obvious improvement of the child in all post measures. Future researches with larger samples are needed to further verify the results concerning the effect of adapted physical activity programs on children with brachial plexus injury.

Keywords: brachial plexus injury, upper limb monoplegia, adapted exercise

1. Introduction

Cerebral palsy (CP) is a chronic neurodevelopmental disorder commencing in early childhood due to permanent damage to areas of the brain that regulate, control and

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coordinate body movements and posture, which occurs in the fetal or infant brain, causing activity limitation. CP results in non-progressive disturbances in muscle coordination. Individuals with CP exhibit difficulties to voluntarily use their muscles, while these motor disorders are accompanied, among others, by disturbances of sensation, perception, cognition, communication and behavior (Rosenbaum et al., 2007). Exercise is a powerful tool in the effort to prevent and treat many motor disabilities, such as CP and its importance is undeniable. All children with disabilities have a need for participation in activities that provide a proper level of challenge, socialization and autonomy, as well as increase their confidence and reduce stress (Willis et al., 2018). Engaging in regular physical activity during childhood is beneficial for their physical, psychological and social well-being, with improvements in the individual's strength, balance, cardiorespiratory fitness, motor functions and physical pain (Zwier et al., 2010).

2. Literature Review

Monoplegia refers to one limb weakness either arm or leg. There are many causes of upper limb monoplegia including injury to multiple cervical roots, psychogenic, stroke, brachial plexus injury and head injury. In addition to mobility loss, the affected part of the body may present stiffness with occasional muscle spasms even atrophy as well as loss of sensation in the affected area (Manzoor et al., 2021). Brachial plexus injuries represent a rare pathology in the general population, with rates of incidence and prevalence not precisely determined (Belviso et al., 2020). Due to the variety of risk factors that contribute to the onset of obstetric brachial plexus palsy, careful history intake by health professionals is essential to make an accurate diagnosis and assess prognosis and treatment (Zafeiriou & Psychogiou, 2008).

Brachial plexus paresis is usually caused by trauma to the peripheral nerves usually due to high-energy injuries (e.g. traffic accidents) that affect mainly the young population in adults, while in newborns, plexus injuries result from traction during childbirth. The result is severe upper limb damage and impeded sensory mechanism in adults and children, with sufferers often experiencing muscle weakness, spasticity and reduced motor function in the shoulder, hand and palm areas. These symptoms often limit motor performance and participation in daily activities and lead to a preference for the strong limbs resulting in further use reduction of the less functional limb.

Review of the literature shows that there are studies that examined the positive effect of exercise in people with upper limb monoplegia due to CP and in people with brachial plexus injury, such as improvement in fitness, functional independence and quality of life in the former and improvements in spasticity, movement patterns and joint range of motion in the latter. Intervention exercise programs may include a progressive process of proprioceptive neuromuscular facilitation by determining upper extremity muscle strength and selecting an adequate range of motion recovery based on strength grading (de Oliveira et al., 2019), neuromuscular electrical stimulation during weight-bearing exercises (Elnaggar, 2016), gross and fine motor skill exercises (Abdel-Kafy et al.,

2013), plyometric training programs including weights (Abd Al-Wahab et al., 2016), as well as virtual reality programs with muscle strength exercises that aim to improve function, abduction and external rotation of shoulders (El-Shamy & Alsharif, 2017).

However, the number of studies that examine the effect that exercise can have on improving these conditions are limited. Therefore, the purpose of this research was to investigate the effect of an adapted exercise program on the muscle strengthening and coordination of a child with upper limb monoplegia due to obstetric brachial plexus paresis.

3. Material and Methods

3.1 Sample

The sample of this study consists of a 4.5-year-old girl with upper limb monoplegia and brachial plexus injury. Parents were informed and provided consent prior to the voluntary and anonymous participation of their child. In addition, the research was approved by the Internal Bioethics Committee of the DPESS University of Thessaly (No. Prot. 2278/06-12-2023).

3.2 Instruments

The measurement tools used for research purposes were selected based on their reliability and validity and were the following:

- The Oxford Muscle Scale (No, 1976). Assessment of muscle strength based on the Oxford Muscle Scale is performed as part of an objective assessment and is an important component of the physical examination that can reveal information about neurological deficits. It is used to assess weakness and can be effective in differentiating true weakness from imbalance or poor endurance. This numerical rating Scale is used to quantify the strength produced by the contraction of a muscle and involves testing core muscles of the trunk, upper and lower extremities against the examiner's resistance and correspondingly rating the child's strength on a scale of 0 to 5.
- The Arm Curl test (Jones & Rikli, 2002), that assesses the muscle strength of the arms, measuring the number of as many arm bends as possible performed by the trainee in 30 seconds. The child sat on a chair holding a 200-gram dumbbell with arms vertically down, palm facing the body and hands attached to it. The arm was bent in such a way that the arm moved from the elbow down through the full range of motion and with the palm gradually turned upwards (supine position) during full arm flexion. The arm was then returned to the original vertical position with the arm extended downwards and the palm of the hand facing the body. The move was performed as many times as possible in a 30-second time period.
- Medicine ball throw (Stockbrugger & Haennel, 2001) from a sitting position with the participation of both upper limbs. This particular test is a highly reliable test of upper body strength in kindergarten students. The child sat on a chair placed

on the field, with her back "glued" to the back of the chair as support and both feet resting on the ground. Initially, two warm-up-practice throws were made, and then the distance of the next three throws was recorded with a 1-2 second break between each attempt. The shots were made with both hands, since they were placed in front of the chest. Measurements were conducted in the training area at the beginning of the intervention program and repeated at the end of the program.

3.3 Procedure

Initially, the child with upper limb monoplegia was assessed prior the start the adapted exercise program based on measurement tools used. The individualized exercise program of the child had a duration of three months (12 weeks), with a frequency of two times per week, of 45 minutes each session and included exercises such as running, walking, resistance exercises as well as gross, fine motor skills and coordination exercises.

The aim of the exercises was mainly focused on strengthening, prevention of formation of contractions and avoidance of muscle imbalance. Thus, a corresponding exercise program was formed based on exercises that positively affect muscle strengthening, with a variety of pleasant exercises that suit the age of the child combined with a reward after the end of each session. In general, the exercise program took into consideration:

- The adaptation and individualization of the most suitable exercises that suit the unique characteristics of the child according to adapted physical education principles.
- The use of reliable tests to assess the abilities and progress of the participant prior and after intervention.

3.4 Statistical Analysis

The resulting data (pre & post) were analyzed using the statistical package SPSS 29.00 with descriptive analysis included.

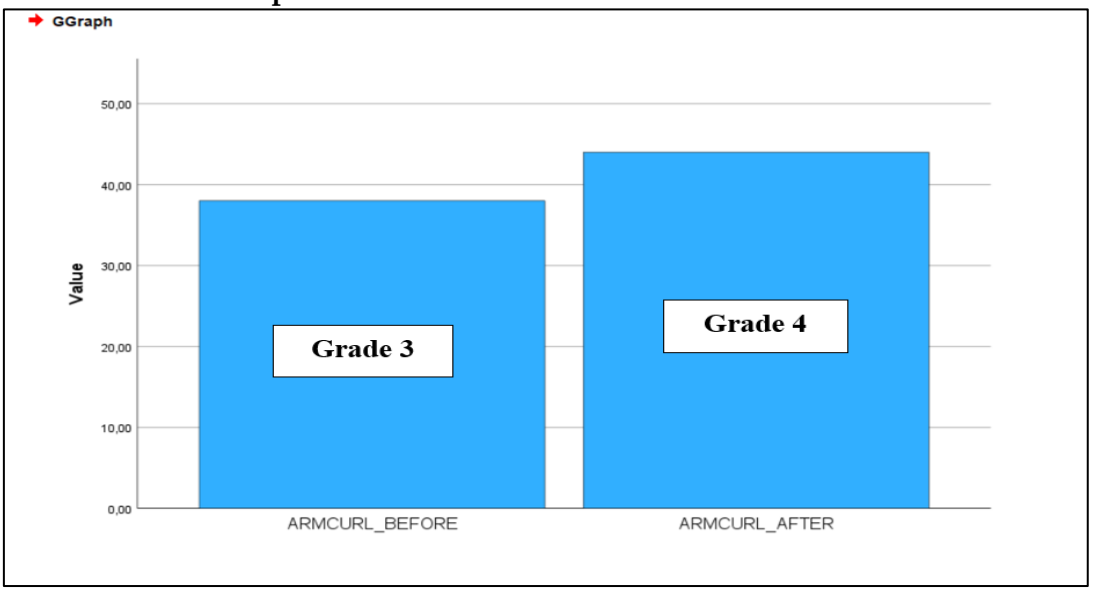
4. Results and Discussion

Results concerning the Oxford scale, showed that during the initial measurement the child was able to move the joint and perform elbow flexion only against the resistance of gravity (grade 3) and not against light resistance with a 200-gram dumbbell. By the end of the intervention the child was able to perform full range elbow flexion actively against the light resistance of a 200-gram dumbbell, thus, she improved her performance by one grade (grade 4). This improvement was clearly evident in the arm curl test improvement with a higher score achieved in post measurement where the child was able to perform more repetitions required (Table 3.1 & Graph 3.1).

Table 3.1: Oxford Scale and Arm Curl test results

Performance	Arm curl test	Oxford scale
Before	38 reps in 30 seconds (against gravity only)	Grade 3
After	44 repetitions in 30 seconds (with a 200-gram dumbbell)	Grade 4

Graph 3.1: Oxford Scale and Arm Curl test results

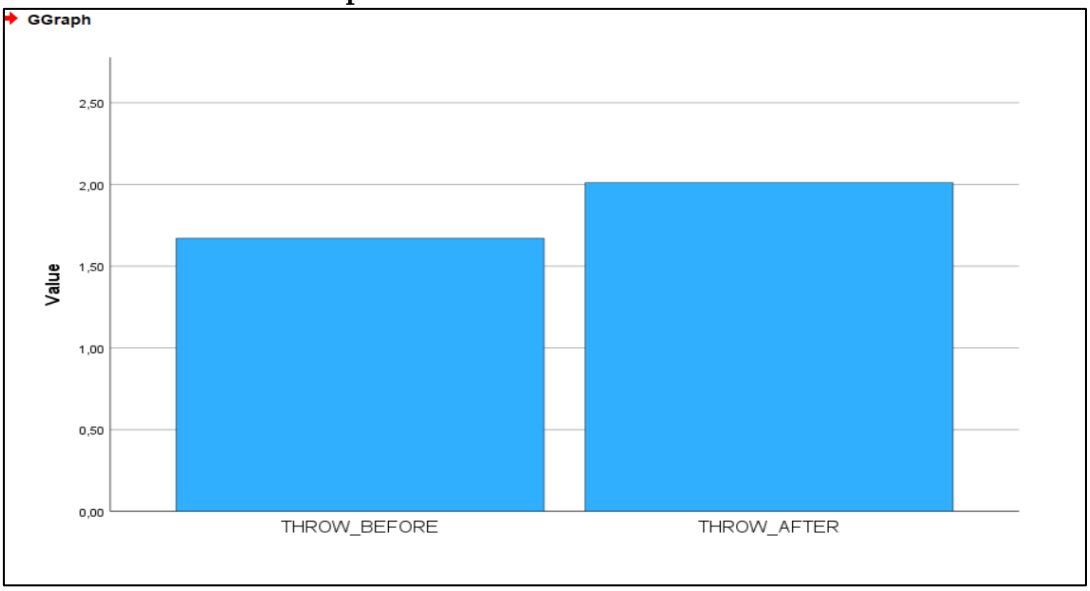


Furthermore, post-intervention results showed an improvement in throwing the one-kilogram medicine ball with two hands (Table 3.2. & Graph 3.2).

Table 3.2: Medicine ball throw results

Performance	Medicine ball throw
Before	1,67 meters
After	2,01 meters

Graph 3.2: Medicine ball throw results



The purpose of this study was to determine the effect of a 12-week adapted exercise program on the muscle strength of a 4.5-year-old girl with upper limb monoplegia due to obstetric brachial plexus palsy. Results showed the beneficial effect of the program through the variety of passive and active range of motion exercises, muscle strengthening of the upper limbs and fine and gross motor skills and co-ordination activities, so as the child could improve her overall performance.

The program corresponded to the child's condition and the intensity and the level of difficulty of the exercises gradually increased, whereas equipment such as dumbbells, weights, balls, hoops, bottles, tires, cones, etc. were used. There is evidence that shows a likely relationship between engaging in physical activity and positive health outcomes for children with a disability, since small amounts of physical activity can bring health benefits (Smith et al., 2022).

The findings of the present research agree with previous research efforts such as the Sahin & Karahan (2018) study in which 3, 6 and 12-months-old infants with brachial plexus palsy exhibited a significant muscle strength improvement as exercise participants. Their program included passive and active range of motion exercises of all joints of the upper limbs as in this case study, in which a program with similar exercises was also implemented, resulting in similar improvement of the child's muscle strength.

According to the systematic review based on proprioceptive neuromuscular facilitation (PNF) theory by Li et al. (2023), typical therapies include passive range of motion, active-assisted range of motion, active range of motion, and strength exercises. Also, Elnaggar (2016) study including the participation of 42 children with brachial plexus injury at a weight- bearing program, reported significant improvements with even better results noted for the intervention group in which a neuromuscular electrical stimulation was additionally applied. Similarly, Doucet et al. (2012) study concluded that neuromuscular electrical stimulation is effective for improving muscle strength, blood flow, decreasing atrophy and pain, and healing tissue.

In this case study, additional exercises were applied according to the principles of plyometric training, an effective training method for improving strength and active movement in children with brachial plexus birth palsy (Abd Al-Wahab et al., 2016). Similarly, a 5-minute warm-up and cool-down period with flexibility exercises and recovery was implemented in each session of the program.

In a study by Abdel-Kafy et al. (2013) involving 30 children, the feasibility of encouraging people with obstetric injury to use the affected arm based on modified Constraint-Induced Movement Therapy (mCIMT) was examined. The results of their study agree with other studies such as Naylor & Bower (2005) and Hoare (2008) in which improvements were observed with this kind of intervention, thus, mCIMT method may have functional benefits for children with hemiplegia.

Similarly, Ibrahim et al. (2011) observed that their treatment Weight Bearing Exercises Program (WBEP), on the affected arm, produced significant improvements in bone mineral density compared to traditional exercises. Similar improvement was also shown in El-Shamy & Alsharif (2017) virtual reality program, including application of

weight-bearing exercises with gradual resistance, proprioceptive neuromuscular facilitation, mobilization scapula exercises, hand activities such as throwing a ball, etc., that produced better results than the conventional exercise program. Nevertheless, Okafor et al. (2008), argue about the effectiveness of interventions using electrical stimulation compared to the conventional exercise programs in the early rehabilitation stage of paralysis.

5. Recommendations

As a case study, this research is limited by its own nature, thus, its findings cannot be considered generalizable and representative for brachial plexus injuries, although this is the first study in Greece. Thus, future researches using larger samples are needed to confirm research results for brachial plexus exercise programs. Nevertheless, the results of this case study are considered encouraging.

It is worth noting that in this study, benefits were observed not only in the child's performance, but also in her enjoyment which was evident throughout training as she participated with pleasure and a positive mood during teach session, exhibiting special interest and cooperation. Satisfaction was also evident in the rest of the family members attending the program. Therefore, future research should further focus on assessing the enjoyment of children with brachial plexus palsy participating in adapted exercise programs such as this one.

6. Conclusion

Overall, this case study demonstrated the effectiveness of an adapted exercise program on improving muscle strength in a young child with brachial plexus injury.

Conflict of Interest Statement

The authors declare no conflicts of interest.

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