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INFLUENCING BALANCE AND WATER ORIENTATION SKILLS THROUGH AN AQUATIC AND MOVEMENT INTERVENTION PROGRAM IN CHILDREN WITH CEREBRAL PALSY

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ABSTRACT. The aim of this paper is to determine the aspects and results following the application of an aquatic intervention program adjusted as part of the neuromotor rehabilitation treatment in children with cerebral palsy concerning their water orientation, independence in the water and balance skills. The 6-month aquatic therapy program consisted of 2 weekly sessions. The average length of a session was of 45 minutes. Water temperature was of 36º C. In addition to aquatic therapy sessions, children underwent 2 physiotherapy sessions included in the rehabilitation program of the institution of origin. The program included 24 children with different clinical types of cerabral palsy. The mean age was 12.5 ± 2.7 years. The evaluation methods included: the Pediatric Berg Balance Scale (PBS), a modified Water Orientation Skills (WOS) rating scale. The results obtained for the Pediatric Balance Scale showed statistically significant differences. ($p<0.001$) The average baseline score was 21.67, with a standard deviation of 14.349, the average total score was 30.00, with a standard deviation of 16.876. The Water Orientation Skills (WOS) rating scale indicates significant improvements. ($p<0.001$) The average baseline score was 6.92, with a standard deviation of 5.397, the average total score was 102.96, with a standard deviation of 36.643. A strong direct correlation between WOS and PBS score values has been observed ($r = 0.770$, $p<0.001$). The applied program had a statistically significant effect on improving children's balance as well as their learning abilities to move in the water and even to swim.

Keywords: cerebral palsy, balance, independence in the water, water orientation skills

REZUMAT. ***Influenţarea echilibrului şi a abilităţilor de orientare în apă în urma unui program terapeutic acvatic la copii cu paralizie cerebrală.*** În lucrarea de faţă ne-am propus să urmărim aspecte şi rezultate în urma aplicării

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unui program acvatic de intervenţie adaptat şi integrat în tratamentul de reeducare neuromotorie a copiilor cu paralizie cerebrală asupra echilibrului, independenţei şi abilităţilor de orientare în apă. Programul acvatic terapeutic a avut o durată de 6 luni, 2 şedinţe săptămânale. Durata medie a şedinţelor a fost de 45 de minute. Temperatura apei a fost de 36 º C. Pe lângă şedinţele de terapie acvatică copiii participă la 2 şedinţe de kinetoterapie inclusă în programa de recuperare a instituţiei de provenienţă. Au participat un număr de 24 de copii cu diferite forme clinice de paralizie cerebrală. Media de vârsta a fost de 12,5 ± 2.7 ani. Metodele de evaluare au fost Scala Pediatrică pentru Echilibru Berg (PBBS), Scala de Evaluare a Abilităţilor de Orientare în Apă - modificată (WOS). Pentru Scala Pediatrică pentru Echilibru Berg rezultatele obţinute au arătat diferenţe semnificative din punct de vedere statistic ($p<0,001$). Media scorului iniţial a fost de 21,67 cu o deviaţie standard de 14,34, media scorului final a fost de 30,00 cu o deviaţie standard de 16,87. Scala de Evaluare a Abilităţilor de Orientare în Apă (WOS) demonstrează îmbunătăţiri semnificative ($p<0,001$). Media scorului iniţial a fost de 6,92 cu o deviaţie standard de 5,39 şi media scorului final a fost de 102,96 cu o deviaţie standard de 36,64. Am observat o corelaţie puternică directă între valorile scorului WOTS şi BERG ($r=0,770$; $p<0,001$). Programul aplicat a avut un efect semnificativ statistic asupra îmbunătăţirii echilibrului şi de asemenea asupra învăţării abilităţilor copiilor de a se mişca în apă şi chiar a abilităţilor de a înota.

Cuvinte cheie: program acvatic terapeutic, funcţie motorie grosieră, spasticitate, mobilitate articulară, paralizia cerebrală

Introduction

Swimming and aquatic therapy are beneficial activities for children with neuromotor disabilities. (Adams-Cubbin 1991, Broach-Datillo 1996, Cole-Becker 2004, Fragala-Pinkam et all 2010, Routi at all 1997) They provide an oportunity to improve physiological and psychological achievements. Water activities influence the entire body without causing stress or excessive pressure on certain parts of the body. (Adams-Cubbin 1991, Broach-Datillo 1996)

An additional therapeutic quality of the aquatic environment is the effect of buoyancy, which enables the initiation of certain independent movement possibilities which are unlikely to be achieved on land. (Harris 1978, Hutzler 1998, Styler 1994)

As other therapeutic methods practiced within neuropediatric physical therapies, the main purpose of aquatic therapy is to improve activities of daily living and body functions.

There is a relationship between mechanical effects of fluids and mechanisms of body adaptation. It is widely accepted that the physical properties of any

environment are a constraint to maintain balance and require adapted motor behavior (e.g. widening the support area, using hands for support, hardening the body in order to stabilize the center of gravity). (Lambeck 2000)

Adapted motor behavior in the presence of hydrodynamic elements leads to a psycho-sensory-motor learning program. Generally accepted hydrodynamic elements that influence water therapy also play an important role. However, the metacentric effect is the most important mechanical effect of fluids. The term metacentre is used in naval architecture to describe a point where an imaginary vertical line (through the center of buoyancy) intersects another imaginary vertical line (through a new center of buoyancy) (Archimedes). Both gravity and buoyancy are equally important and influential and any small change to either of the two leads to imbalance. (Lambeck 2000, Lambeck 2001)

The shape, density and symmetry of a body will influence the metacentre (balance). In water, balance occurs when the body makes the necessary adjustments to make gravity and buoyancy forces equal and opposite. When these forces are not equal and collinear, the body will become unstable and will twist to achieve balance. The body uses automatic reactions to balance and stabilize its position. When the lack of balance can not be well coordinated, the body uses movement schemes based on primitive reflexes, such as: the asymmetrical tonic neck reflex (ATNR), the tonic labyrinthine reflex (TLR). These reactions may block unwanted rotations, especially those on the medial axis, in order to stabilize the position of the body. These reactions can be used to achieve symmetry on the medial axis as the starting point for controlling coordinated twisting. (Lambeck 2000, Lambeck 2001)

Purpose of research

This paper intends to observe the effects of a 6-month aquatic and land therapy program on water independence, balance and water orientation skills. This paper analyzes these abilities before and after carrying out an aquatic rehabilitation program.

It also aims to describe the relationship between water orientation skills and balance.

Materials and methods

General information about the group

The study included 24 children diagnosed with different clinical types of cerebral palsy (Spastic cerebral palsy: Paraparesis 5, Tetraparesis 10, Hemiparesis: right 2, left 2, Dyskinetic cerebral palsy: 4, Ataxic cerebral palsy 1); enrolled in two of the special schools in Cluj County. The study participants were aged between 8 and 16, 18 boys and 6 girls. Inclusion criteria were as follows: diagnosis, ability to

follow simple verbal instructions. None of the children has ever participated in an aquatic therapy intervention program.

Methods

The Gross Motor Function Classification System. The mobility of children and teenagers at home, at school and in the community can be best assessed with the expanded and revised version of the gross motor function classification system (GMFCS -E&R). GMFCS covers a wide range from Level I, where individuals work at an advanced level, being able or having the potential to walk without restrictions, to Level V, for individuals who are very limited in their ability to move by themselves and require a very high level of assistance.

Pediatric Berg Balance Scale. Pediatric Berg Balance Scale comprises a set of 14 tasks of increasing difficulty. These tasks are used to assess functional activities that are relevant for everyday life, such as getting up from sitting to standing, stretching forward exceeding the support surface. The tasks were designed in order to test the patient's ability to maintain and change body position. Support surface decreases to the end of these tasks. These tasks are performed within a well-established time limit or body positions need to be maintained for a defined period of time.

Each task is shown and/or instructions are given as indicated. The assessment observes the response category applicable for each task. At most points, the subject is asked to remain in a certain position for a certain period of time. Progressively, more points are deducted if the time or distance requirements are not met, if the performance involves supervising or if the subject uses external support or receives assistance from the examiner. Subjects must understand that they need to maintain balance while trying to achieve the given tasks. The choice of which leg to stand on or how much to stretch is up to the subject. Poor logic will negatively influence performance and accumulated points.

The equipment required for testing consists of a stopwatch or a watch with three moving hands (indicating hour, minutes, seconds). The chairs used for the tests should be of reasonable height. The tasks range on an ordinal scale from 0 to 4, with the maximum score reaching 56 points. A higher score indicates better balance abilities. (Kembhavi 2002)

Water Orientation and Swimming Skills (WOS) Rating Scale - amended version. An adapted version of the Water Orientation Scale (Hutzler et al. 1998) containing 23 tasks was used to assess the level of adaptation to the aquatic environment and the swimming abilities. Our list contains 29 tasks on a 6-step scale ranging from 0 (unachieved task) to 5 (independently achieved task). The

maximum score is 145. Achieving all tasks means the ability to independently swim at least 25 m in a raw form of any swimming style (back stroke, front crawl and breast stroke).

The following tasks were added in our study:

W4 A – Maintaining orthostatism by controlling the lateral inclination of the body around a sagittal plane.

W6 – Barrel (the subjects trust that water supports them).

W9 B – Sliding back, instructor-induced movement without physical contact.

W10 B - Changing position – from floating on the back to orthostatism (near the bar by the side of the pool), (rotation around a transverse plane).

W11 B – Changing position – from floating on their back to orthostatism, in the middle of the pool (shallow water), (rotation around a transverse plane).

W17 B – Twisting using combinations of twists (around a longitudinal plane and a transverse plane).

Aquatic therapy program. The aquatic therapy program is a strategy for learning how to swim, useful in people with neuromotor impairments. The concept is based on the principles of fluid mechanics in order to allow subjects to achieve stability and controlled movement in the water.

The aquatic therapy program was conducted over a period of 6 months, consisting of 2 weekly sessions. Each session was 45 minutes long. Water temperature was 36^0C.

The aim of the method is independence which occurs through coordinated movements. Maintaining balance in the water requires accommodation with the mechanical changes of the aquatic environment. This accommodation is the result of a psycho-sensory-motor learning process, enabling the individual to learn how to maintain balance in an unstable environment. Together with balance (stability), movement can be initiated and controlled. (Lambeck 1996)

SPSS version 20 was used for **statistical analysis**. Data was classified as nominal or quantitative. Frequency and percentage were used for nominal variables, and average (mean) and standard deviation or median and 25th and 75th percentiles were used for quantitative variables, depending on the situation. Kolmogorov-Smirnov test was used to check the normality of the quantitative data.

To determine whether there are changes between pairs of variables we used the T test for pairs of variables or marginal homogeneity testing.

GLM repeated measures were used to check the influence of a parameter on value variation of pairs of variables. Statistical significance was set at a threshold value of 0.05.

Pearson correlation was used to emphasize the correlation between two continuous variables with normal distribution. Cronbach's Alpha coefficient was assessed to test internal consistency reliability of the modified WOS score.

Results

Berg Balance Scale

A significant increase in balance score was observed for the study group following completion of the aquatic therapy program.

Table 1. Pediatric Balance Scale Scores

	total initial score	total final score	initial % score out of maxim	final % score out of maxim
Media	21,67	30,00	38.68%	53,567%
Standard deviation	14,34	16,87	25.62%	30,13%
Minimum	0	1	.00%	1,78%
Maximum	48	53	85.71%	94,64%

The outcome of the Pediatric Berg Balance Scale, showed high statistically significant increases between pre and post-test scores. ($p<0.001$).

The average baseline score was 21.67 ± 14.34, the average final score was 30.00 ± 16.87.

The average of the maximum possible percentage score was 38.68% ± 25.62% for the baseline score, and 53.56% ± 30.13% for the final score.

For GMFCS Level II, the average baseline score was 34.30 ± 7.00 and the average total score was 43.50 ± 5.52. The result indicates high statistically significant differences ($p <0.001$).

For GMFCS Level III, the average baseline score was 37.27 ± 10.98 and the average final score was 58.03 ± 11.99.

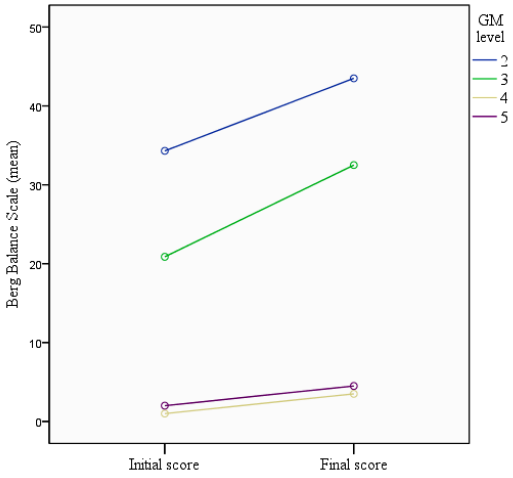

Chart 1. Berg Balance score evolution in children with GMFCS level II and III.

The result indicates high statistically significant differences ($p<0.001$).

We showed that patients enrolled in a lower GMFCS level (II, III) will achieve significantly higher increases in Berg test score ($p<0.001$; Chart 1).

There were no statistically significant differences in children with higher GMFCS level (IV, V), ($p = 0.1$).

Water Orientation Score (WOS)

Major changes in water orientation skills were noticed at the end of the 6-month aquatic intervention program.

We calculated a reliability coefficient or the internal consistency for the modified WOS. A value greater than 0.7 of Cronbach's Alpha coefficient indicates a scale with good internal consistency. In our case, Cronbach's Alpha reliability coefficient equals 0.828 and indicates a scale with good internal consistency.

Water Orientation Scores (WOS) indicated highly significant increases between pre and post-test scores. ($p <0.001$)

Table 2. Water Orientation Scores

	total inițial score	total final score	inițial % score aut of maxim	final % score aut of maxim
Media	6,92	102,96	4,77%	71,00%
Standard deviation	5,39	36,64	3,71%	25,26%
Minimum	0	19	0%	13.10
Maximum	14	142	9,65%	97,93%

The average baseline score was 6.92 ± 5.397 and the average final score was 102.96 ± 36.643.

There was a significant change between the initial and the final assessment, from 4.77% to 71.00% of the maximum value of 100%.

For GMFCS Level II, the average baseline score was 10.3 ± 3.94 and the average final score was 125.60 ± 16.78. The results indicate an increase from 7,10% to 86,62% of the maximum 100%. ($p<0.001$)

For GMFCS Level III, the average baseline score was 7.63 ± 4.59 and the average final score was 110.25 ± 28.01. The results indicate an increase from 5.26% to 76.03% of the maximum 100%. ($p<0.001$)

For GMFCS Level IV, the average baseline score was 0 ± 0 and the average final score was 61.5 ± 13.43. The results indicate an increase from 0% to 42.41% of the maximum 100%. ($p= 0.04$)

For GMFCS Level V, the average baseline score was 0.5 ± 1 and the average final score was 52.5 ± 34.10. The results indicate an increase from 0.34% to 36.20% of the maximum 100%. (p= 0.05)

We demonstrated that patients with a lower GMFCS level (II, III) will indicate significantly higher increases in Water Orientation Scores (p<0.001; Chart 2).

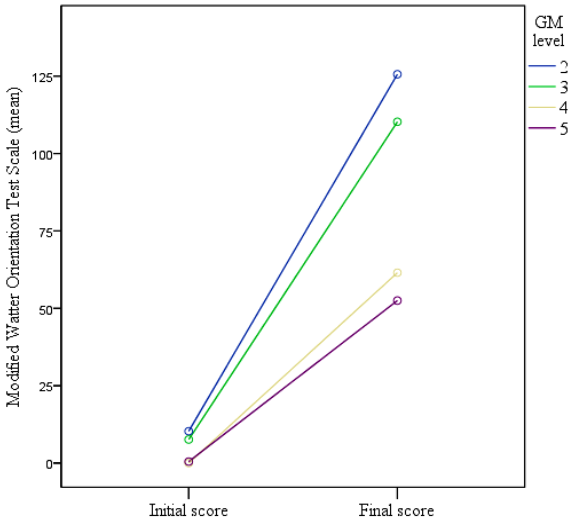

Chart 2. Evolution of Water Orientation Scores (WOS).

Correlation between Water Orientation Score and Berg Balance Scale

There is a strong direct correlation between Water Orientation Score and Berg Balance Scale (r=0.770, p<0.001).

Discussion

This study evaluated aspects and results influencing the level of adaptation to the aquatic environment and the swimming abilities in children with cerebral palsy after applying a 6-month aquatic intervention program overlapped with a physical therapy program.

For the Pediatric Balance Scale, results indicated high statistically significant increases between the baseline and the final scores (p<0.001), the average baseline Berg score was 14.34 ± 21.67 and the average final score was 30.00 ± 16.87.

In a study on the effects of aquatic exercises on motor function and balance conducted on two groups, Hoon-Kang (2012) indicated a significant increase in the Berg score from the average baseline score of 14.27 ± 10.69 to the average final score of 18.27 ± 11.52 (p<0.05) for the group undergoing aquatic therapy

alone, and significant results from the average baseline score of 14.73 ± 7.08 to the average final score of 17.93 ± 6.47 ($p<0.05$) for the group undergoing land rehabilitation sessions.

The study conducted by Hoon-Kang included 15 children aged 8.40 ± 2.19 and lasted for 8 weeks with 3 weekly sessions. The results show significant increases in Berg scores in both groups (Hoon- Kang 2012).

Our research study detected improvements in balance caused by two factors: aquatic therapy and physiotherapy sessions performed simultaneously, the scores being higher than those obtained by Hoon-Kang. We could not establish the share of these two factors in their influence on the outcome, but higher scores in our study could be an indicator for the simultaneous use of the two types of therapy that leads to higher Berg scores.

In a study conducted on a group of 9 patients with spastic diplegia, aged 7 through 31 years, Thorpe (2000) assessed balance using the Functional Reach test which coincides with task 8 of the Berg Balance Test. Thorpe's (2000) conclusion is that aquatic exercises improve balance.

At the end of the 6 months of intervention sessions, we observed major changes in achieving water orientation skills. The average baseline score was 6.92 ± 5.397, the average final score was 102.96 ± 36.643. ($p<0.001$).We showed a significant change between the initial and the final assessment, from 4.77% to 71.00% of the maximum of 100%. ($p<0.001$).

Hutzler et al. (1998) conducted a 6-month study on the effects of a movement and swimming program on vital capacity and water orientation skills including 46 children (23 children in the control group receiving four weekly 30-minute physical therapy sessions, 23 children in the experimental group receiving one physiotherapy session and two aquatic therapy sessions of 30 minutes per week), aged 5 through 7 years.

They achieved significant results in terms of water orientation skills score improvements and the final conclusion of the study was to highly recommend the use of aquatic therapy in the rehabilitation program for children with cerebral palsy. (Hutzler et al 1998)

The same author achieved significant results in terms of water orientation skills improvement in a study on the effects of a movement and swimming program on water orientation skills and self-esteem in 1998. (Hutzler et al 1998)

Various authors have used different tests and have estimated statistically significant increases in achieving and improving water orientation skills.

Declerck et al. (2010) determined significant improvements (average increase was 14.8%, $p=0.018$) using the Water Orientation Test of Alyn 2 (WOTA 2) in a group of seven children with a mean age of 10.2 ± 2.3, through a 6-week aquatic program with 2 weekly sessions.

Sršeň et al. (2010) determined significant improvements in water orientation skills using the Swim Test.

Fragala-Pinkam et al. (2010) applied the Swimming Classification Scale to a group of 16 children aged between 6 and 12 and achieved highly statistically significant results ($p<0.001$) in improving swimming skills. The program lasted 14 weeks and consisted of 2 weekly sessions.

Following a 6-week aquatic therapy program consisting of 2 weekly sessions, using the WOTA 2 test, Dimitrijevic et al.(1012) achieved significant results ($p<0.01$) in improving water orientation skills. The age of participants ranged between 5 and 14 years. (8)

Bijan Jorgic et al. obtained significant results ($p=0.02$) for increased water orientation skills scores, from 35.62% to 60.85% of the maximum of 100%, using the WOTA 2 test. The study was conducted over a period of six weeks with two weekly sessions and included 7 children with a mean age of 9 years and 5 months ± 1 year and 3 months and consisted of Halliwick therapy sessions and swimming exercises of 45 minutes each.

The results of the above studies indicate that regardless of the tests used, aquatic therapy programs improve water orientation skills, swimming skills and enable children with cerebral palsy to learn how to move in the water and to swim without help from others. (Bojan et al 2012)

Conclusions

After analyzing the results of this study we conclude that an aquatic program combined with physical therapy sessions can significantly improve balance, water orientation abilities and swimming skills.

Thus, aquatic activities have enabled children with cerebral palsy aged 7 through 16 years to improve balance and water orientation skills.

Our research study detected improvements in balance caused by two factors: aquatic therapy and physiotherapy sessions performed simultaneously. We could not establish the share of these two factors in their influence on the outcome, but results could be an indicator for the simultaneous use of the two types of therapy that leads to higher Berg scores.

Aquatic program can provide major improvements in water orientation skills, therapeutic quality of the aquatic environment enables the initiation of certain independent movement possibilities which are unlikely to be achieved on land.

Aquatic program enable children with cerebral palsy to learn how to move independent in the water and to swim without help from others.

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