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Effects of an aquatic program on gross motor function of children with spastic cerebral palsy

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ABSTRACT

The purpose of the present study was to examine the effects of a 10-week aquatic program on the gross motor function, on the range of motion and on spasticity of children with cerebral palsy (CP). Six students served as subjects for the experimental group and another 6 were assigned to the control group. The aquatic program was taking place twice a week and consisted of a warm up, the main training session and a cool down phase. Measuring instruments were the Gross Motor Function Measure (GMFM) (dimensions D and E), a goniometer and the modified Ashworth Scale. Pre-test and Post-test were executed before and after the intervention program.

Significant interaction effect was found with respect to: the active shoulder flexion ($p = .052$), the active shoulder abduction ($p = .052$), the passive hip abduction ($p = .001$) and the passive knee extension ($p = .045$). Interaction effect was found for spasticity of the hip adductors ($p = .002$) and knee flexors ($p = .049$). Results of the present study indicated that an aquatic program might have a positive effect in gross motor function as well as in range of motion and spasticity in students with spastic cerebral palsy.

KEY WORDS: *cerebral palsy, training, exercise, intervention, spasticity, range of motion, swimming.*

INTRODUCTION

Cerebral palsy (CP) is a general term used to describe a wide variety of motor disorders. It is characterized by damage to the developing brain that produces delimitation in gross and fine motor skills (3). The spastic form of CP is the most common form and additional clinical signs may include limited range of motion, diminished selective control and muscle weakness (27, 3, 2, 32). The severity of limitations in gross motor function among children with cerebral palsy varies greatly, as some can walk with or without assisting devices, while others, must use battery-powered wheelchairs (24). According to the severity, children with this impairment are limited from participating in physical activities. Their life is being at risk for developing health problems due to restricted and limited motor actions or skills (7).

Adapted aquatic exercise has been particularly recommended as a part of physical activity programs for persons with cerebral palsy. The buoyant nature of water gives the people with cerebral palsy the opportunity to feel their body free from constrains that they experience on land (8, 12). This type of exercise might include assisted stretching, assisted walking, swimming with and without flotation devices, group activities and free time to explore and play (7, 13). Further, the benefits of exercise in water are reduction of spasticity, improvements in cardio respiratory function, enhancement of muscle strength, increased range of motion in joints and finally improvement in self-perception and self-esteem (13).

There is limited evidence in the international bibliography concerning the effectiveness of aquatic programs to individuals with cerebral palsy. Specifically, Peganoff (26) studied the effects of an aquatic occupational program for an adolescent with cerebral palsy. The results showed an increase in shoulder flexion and abduction of the right upper extremity. Moreover, enhancement of gross motor functions, flexibility of the upper extremities and acceptance of self-image. Similarly, Mackinnon (15) reported increased gross motor functions for a child with spastic diplegia after a Halliwick swimming program. Moreover, Dorval et al, (6) stated that interventions programs in the water improved self-esteem and functional independence of the participated adolescents with cerebral palsy.

Hutzel et al (11) carried out a combined (movement and swimming) program to children with cerebral palsy. The participants improved their vital capacity, water orientation skills and respiratory function. Further, in a case study, Thorpe & Reilly (31) performed an aquatic resistive exercise program to an adult with cerebral palsy. After the 10-week intervention period an improvement was noted to the strength of the lower extremities' gross motor function and cardiovascular endurance. Finally, Ozer et al (23) performed a supervised swimming program to 13 children with cerebral palsy. According to the researchers the experimental group showed significant improvements in body awareness.

The purpose of the present study was to examine the effects of a 10-week swimming program on the gross motor function, range of motion and spasticity of students with cerebral palsy.

MATERIALS AND METHODS

Participants

Twelve students with cerebral palsy from 13 to 20 years of age, from a local school for students with physical disabilities, participated in the present study. Inclusion criteria were as follows: a) have been diagnosed as spastic tetraplegia or diplegia b) ability to walk with or without aids, c) ability to follow simple commands. Children were excluded if they had a surgery for the last 12 months or receive medication for spasticity (7, 14). Participants were randomly allocated (sealed envelopes) to the experimental (4 boys and 2 girls) and the control group (3 boys and 3 girls) (30). The demographic characteristics are presented in Table (1).

Table 1. *Demographic Characteristics*

Variable	Experimental	Control
Variable	162.66 ± 11.79	162.66 ± 11.79
Age	16 ± 2.89	16.66 ± 2.65
Height	162 ± 11.7	161 ± 15.1
Weight	61.66 ± 14.7	63.16 ± 16.86
Gender	4 boys, 2 girls	3 boys, 3 girls

Measurement instruments

1) The Gross Motor Function Measure (GMFM) (28) was used to evaluate the gross motor function. It consists of five dimensions: A: lying and

rolling, B: sitting, C: crawling and kneeling, D: standing, and E: walking, running and jumping. In the present study only the dimensions D and E were used since all the participants could walk independently with or without aids. Validity and reliability of the GMMF is well documented in the literature (29, 20).

2) Spasticity of the right- left hip adductors and knee flexors was evaluated according to the modified Ashworth Scale (4). The Scale is graded as follows: 0, 1, 1^{+}, 2, 3, 4. Modified Ashworth Scale is a common measurement tool for the evaluation of the muscle tone in cerebral palsy (2, 1) demonstrating moderate to good intra and inter-rater reliability (4).

3) Range of motion of the right-left shoulder, hip and knee was measured with a 30cm Plastic Goniometer (16). Specifically, passive and active movements in 1) shoulder flexion, 2) shoulder abduction, 3) shoulder internal rotation, 4) shoulder external rotation, 5) hip abduction and 6) knee flexion, were assessed through standard positions and procedures (21). According to McWirk & Glanzman, (17) Mutlu et al (18) reliability of the goniometric measurements in cerebral palsy vary from moderate to strong depending on the joint examined, position of the subject, experience of the examiner as well as the adequate stabilization of the proximal joints during the procedure.

Intervention program

Two members of the Laboratory of Adapted Physical Activity/Developmental and Physical Disabilities carried out the above measurements in the school gym at the beginning and at the end of the intervation program. The intervention took place twice a week for 10 weeks, within the school hours, in a 25 meters indoor swimming pool. Water temperature was 28 to 31°C. All the students continued their normal activities and physiotherapy sessions provided from the school staff (11, 7).

Two physical educators trained in swimming skills for children with CP from the school staff, were responsible for the swimming program. The program consisted of a warming up, main training session and a cool down phase. Specifically, during the warming up which lasted for 10 minutes, the students were walking in the water in the shallow side of the pool and performed static stretching for the upper and lower extremities. In the main program phase students worked on the basic backstroke and crawl swimming styles for 35 minutes per session. Training was individualized according to each participant's ability. Floating devices were used if it was necessary. Additionally, physical educators taught backstroke and crawl without eliciting abnormal patterns of the students (ie scissoring of the legs) who preserved a self paced swimming style. Finally, cool down phase consisted of free swimming and stretching (7, 13).

Institutional approval was obtained from a research committee of Faculty members in the University of Athens. Additionally, inform consent was obtained from the participants and their parents.

Statistical analysis

Data were analyzed with the SPSS for windows version 13 (22). Multivariate analysis of variance (MANOVA) 2×2 was used to examine the interaction of group (experimental-control) and time (0, 14 weeks), with respect to GMFM (D and E). Further, differences between right and left side, concerning spasticity and range of motion, were examined with independent t-tests. Separate univariate analyses (ANOVA 2×2) were conducted for spasticity of the hip adductors and knee flexors. In addition for the range of motion of the: a) shoulder flexion, abduction, internal and external rotation MANOVA 2×2 was conducted, b) hip abduction ANOVA 2×2 was used and c) knee extension ANOVA 2×2 was used. The .05 was set as the appropriate level of significance.

RESULTS

Twelve students participated in the research program and there was no drop out during the study. T-tests between right and left side, concerning spasticity and range of motion, revealed no significant differences. Thus, the scores of spasticity and range of motion were calculated according to the mean of the two sides. Levene F values were non significant ($p < .05$), indicating that there were no significant differences in the variability of scores between the experimental and control group, for GMFM, spasticity and range of motion scores.

GMFM

The interaction effect for the total GMFM scores (for both dimensions D and E) approached significance level ($F = 3.6$, $p = 0.89$). Further post hoc univariate analysis (ANOVA) showed no significant differences across time for a) dimension D ($F = .56$ $p = .47$) (Figure 1) and b) E ($F = 3.04$, $p = .11$) between groups (Figure 2). Examination of the mean scores, of the dimension E, demonstrated that the experimental group increased the mean walking scores to a wider extend ($M1 = 59.02$, $M2 = 65.04$) compared to the control group : ($M1 = 59.02$ $M1 = 59.95$).

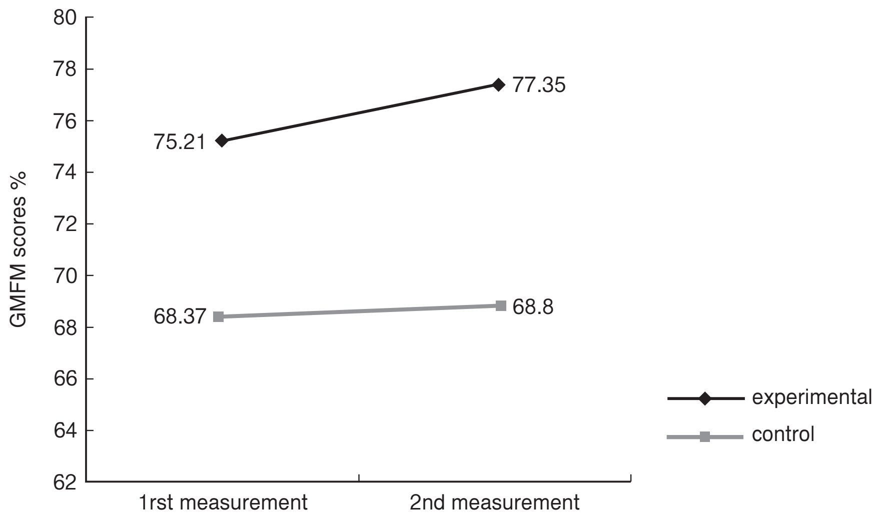

Figure 1: *Interaction between group and time with respect to the GMFM (D standing) scores (F = .56, p = .47, η_2 = .05).*

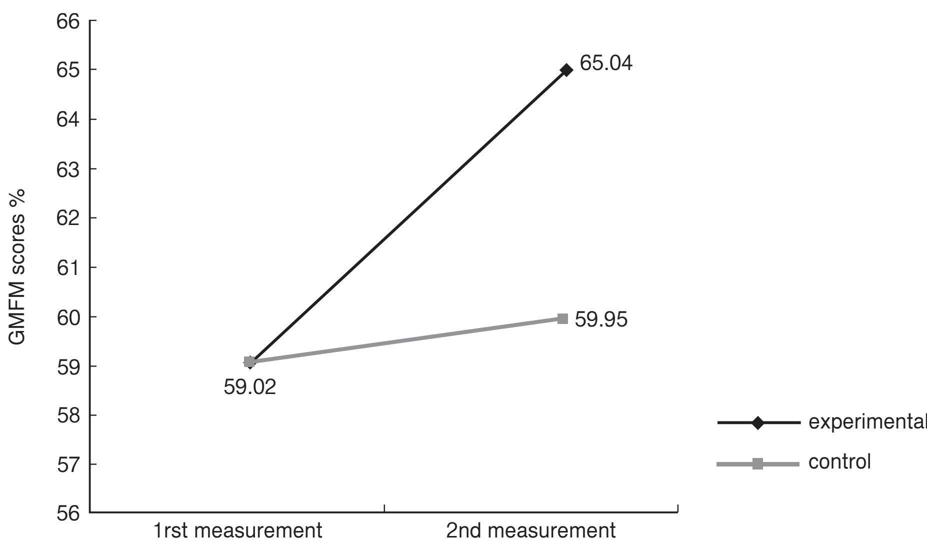

Figure 2: *Interaction between group and time with respect to the GMFM (E walking) scores (F = 3.04, p = .11, η_2 = .23).*

Passive Range of motion

There was no significant interaction effect between group and time concerning the range of motion of the shoulder (F = .97 p = .480). Post hoc univariate analysis (ANOVA) revealed no significance for external rotation

(F = .891, p = 3.68) and internal rotation (F = 1.603, p = 2.34) while analysis for flexion (F = 3.708, p = .083) and abduction (F = 4.033, p = .072) approached significance. Significant interaction effect was found with respect to the hip abduction (F = 20,97, p = .001) and knee extension (F = 5.28, p = .045). Passive range of motion scores for the experimental and control group are presented in Table 2.

Table 2. *Passive range of motion mean scores for the experimental N = 6 and control N = 6 groups*

	Pre training	Post training
Experimental group		
Shoulder flexion	152.41 ± 16.66	170.25 ± 5.75
Shoulder abduction	142.08 ± 21.60	161.25 ± 12.31
Shoulder external rotation	74.08 ± 18.96	82.75 ± 8.81
Shoulder internal rotation	54.08 ± 18.95	67 ± 7.67
Hip abduction	24.66 ± 6.92	31.66 ± 8.72*
Knee extension	34.66 ± 25.67	41.41 ± 23.48*
Control group		
Shoulder flexion	142.75 ± 10.71	147 ± 13.98
Shoulder abduction	129.08 ± 15.97	126.75 ± 14.35
Shoulder external rotation	75.50 ± 14.79	77.66 ± 14.96
Shoulder internal rotation	42.25 ± 16.15	44.75 ± 15.84
Hip abduction	23.25 ± 9.38	24.25 ± 10.08
Knee extension	33.91 ± 17.87	34.50 ± 18.47

* Significant $p < .05$ interaction effect

Active Range of motion

A significant interaction effect was found between group and time concerning the active range of motion of the shoulder (F = .20, p = .05). The post hoc univariate analysis showed significance for flexion (F = 4, 848 p = .052) and abduction (F = 4,867 p = .052). No interaction effect was found for external rotation (F = 2.962 p = .116) and internal rotation (F = .077 p = .787). Analysis ANOVA 2 × 2 with respect to the hip abduction (F = 3.922, p = .076) (figure) and knee extension (F = 3.529, p = .090) didn't reach significance. Active range of motion scores for the experimental and control group are presented in Table 3.

Table 3. *Active range of motion mean scores for the experimental N = 6 and control N = 6 groups*

	Pre training	Post training
Experimental group		
Shoulder flexion	138.58 ± 21.02	154.25 ± 11.63*
Shoulder abduction	124.41 ± 24.35	144.08 ± 11.11*
Shoulder external rotation	59.08 ± 20.97	77 ± 9.62
Shoulder internal rotation	44.16 ± 19.44	52.16 ± 8.44
Hip abduction	18.16 ± 4.9	23.58 ± 8.31
Knee extension	23.41 ± 20.67	27.58 ± 19.98
Control group		
Shoulder flexion	124.50 ± 16.35	126.41 ± 18.15
Shoulder abduction	111.41 ± 19.68	109 ± 17.12
Shoulder external rotation	63.16 ± 18.46	67.75 ± 19.78
Shoulder internal rotation	32. ± 19.37	37 ± 19.8
Hip abduction	16.25 ± 10.6	17.25 ± 10.71
Knee extension	24.91 ± 19.53	25.33 ± 19.11

* Significant $p < .05$ interaction effect

Spasticity

The 2 × 2 ANOVA revealed significant interaction for the spasticity of the hip adductors (F = 16.35 p = .002) (Figure 3) and knee flexors (F = 5.33, p = .049) (Figure 4).

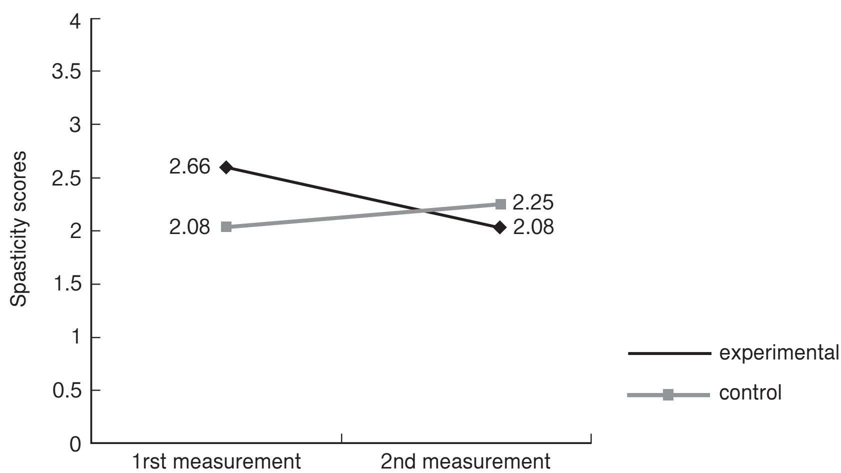

Figure 3: *Interaction between group and time with respect to the spasticity of the hip adductors ($F = 16.35$, $p = .002$, $\eta_2 = .62$).*

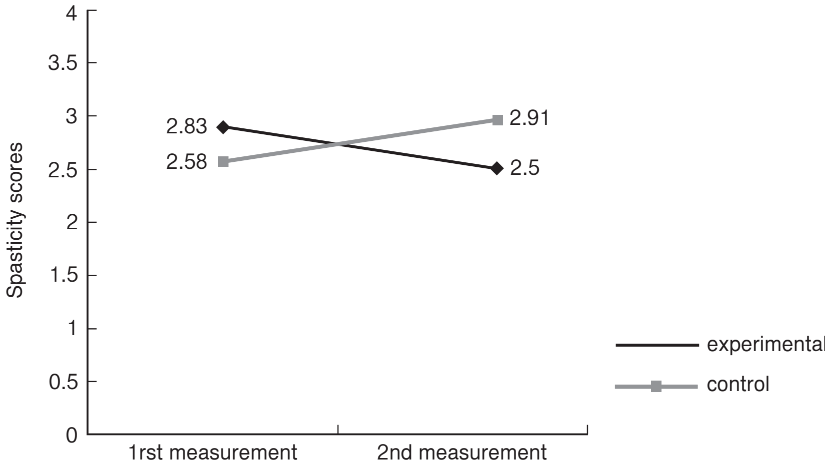

Figure 4: *Interaction between group and time with respect to the GMFM (D standing) scores (F = 5, p = .04, η_2 = .33).*

DISCUSSION

The purpose of the present study was to examine the effects of an adapted aquatic program on the gross motor function, on the range of motion and the spasticity of students with spastic cerebral palsy. Therefore the interaction between group and time with respect to the previously mentioned depended variables was examined.

The interaction effect for the overall GMFM scores approached significance. The experimental group increased the mean scores of the walking dimension to a wider extend compared to the control group. Concerning range of motion significant interaction was found to the a) active shoulder flexion, b) active shoulder abduction c) passive hip abduction and d) passive knee extension. Additionally, analysis for a) passive shoulder flexion, b) passive shoulder abduction, c) active hip abduction and d) active knee extension approached significance. No interaction effect was found for a) passive external rotation, b) passive internal rotation, c) active external rotation and d) active internal rotation. Finally, interaction effect was established for the spasticity of the hip adductors and the knee flexors.

In this study the experimental group improved in walking, running and jumping activities as these were measured with GMFM. Findings are in agreement with Peganoff (26) and Thorpe & Reilly (31) who found improvements in gross motor function after an aquatic training program. However, the above researchers carried out case studies while in the present study experimental and control groups were present. Additionally, Thorpe & Reilly (31) used an aquatic strength-training program focusing on the lower extremities while in this study the main purpose of the intervention program was instruction of the swim strokes. Finally, Mackinnon (15) found increased GMFM scores when he conducted a Halliwick swimming program to a child with spastic diplegia.

The aquatic activities gave the opportunity to the participants to enhance vestibular input through movement from horizontal to vertical plane (13). Also they were found improved in gross motor function by walking in the water (in the swallow side of the poo) and performing reciprocal movements of the upper and lower extremities during the training. Moreover, participants had the experience of moving and balancing in the water resulting in improving these skills on land (15). Similarly Peganoff stated that the reciprocal movements of the extremities during swimming strengthen muscles and improve gross motor coordination. Additionally, Horvat et al (10) stated that, swimming activities strengthen muscles by creating the necessary stability for locomotor and object control skills.

As it refers to active range of motion improvement was found for shoulder flexion, shoulder abduction, hip abduction and knee extension. The present findings are in agreement with Peganoff (26) who found improvements in active and passive shoulder flexion and abduction. This chance might be attributed to the reciprocal movements during backstroke that activate the shoulder flexors (26, 9, 12). Further, during the intervention an attempt was made not to elicited scissoring pattern in order to decrease spasticity of the hip adductors. In that way, the not scissoring swimming drill may contribute to the improved abduction of the hip (13). Finally, repeated kicking during backstroke and crawl may improve the knee extension range of motion (9). As it refers to passive range of motion results to all improved joints could be explained from the studies mentioned above.

Also, an interaction effect was found concerning the spasticity of the hip adductors and knee flexors. The buoyant nature of water gives the people with cerebral palsy the opportunity to feel their body free from the restrictions that they experience of moving against gravity (13). The warm water, as well as, the reciprocal movements of the lower extremities, without scissoring, may contribute to the reduction of the hip adductor spasticity (13, 5). However, it must be noted that results concerning spasticity may be affected from the difficulties of the scale to discriminate between scores 1, 1+ and 2 (25).

The small number of the participants as well as the different categories of spastic diplegia and tetraplegia constitute a major limitation of the present study. Moreover, performance of the students for the gross motor function, spasticity and range of motion may be diverse according to the familiarization of the examiner and the different time of testing (30, 16). Further, according to Nash et al (19), the degree of spasticity may vary from day to day in cerebral palsy.

Implications for further research

Future researchers may evaluate the effectiveness of aquatic programs with longer duration, a wider sample size, or the retention of the effects in a follow up assessment. Further, different parameters may be evaluated such as muscle strength, anaerobic and aerobic capacity.

CONCLUSION

Considering the factors that support the results of the present study, we conclude that, an aquatic training program is beneficial for students with spastic cerebral palsy, according to gross motor function, range of motion and spasticity. Swimming is an alternative and pleasant exercise for students with cerebral palsy, and should be included in the educational or rehabilitation programs.

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