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Effect of aquatic therapy on head control in cerebral palsy children.

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Abstract

Background: Head control is considered to be essential in the development of postural control to enable other skills to be developed. Objective: To investigate the effect of water-based exercises on head control and movement functional recovery in children with Cerebral Palsy (CP).
Method: Twenty-nine children with CP, whose ages ranged from 2 to 6 years old, from both sexes. The children were randomly divided into two groups: Control group (A) fourteen children have received designed land-based exercises for the head control. Study group (B): Fifteen were received designed water-based exercises for the head control. Gross Motor Function Measure (GMFM) and Vestibular Evoking Myogenic Potential (VEMP) were assessed before and after three months of treatment.
Results: The results of this study revealed non-significant improvement in dimensions A and B of GMFM, and significant improvement in P1 and N1 of cVEMP measures of right and left ear when comparing pre- and post-treatment values between both groups.
Conclusion: It was concluded that water-based exercises may be useful to improve head control and movement functional recovery in children with CP.

Keywords: Cerebral palsy, GMFM, Head control, Land-based exercises, VEMP, Water-based exercises.

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Introduction

Cerebral Palsy (CP) can be defined as a group of developmental disorders of movement and posture, causing activity limitation that was due to non-progressive disturbances that occurred in the developing fetal or infant brain. The motor disorders of cerebral palsy are often accompanied by disturbances of sensation, cognition, communication, perception, and/or behavior, also can be companied by seizure disorder and by secondary musculoskeletal disorders [1]. Postural control deficits are the major causes of disabilities in children with CP leading to the child's activity and participation restrictions [2]. Postural control is dependent on the integration of proprioception, vision, and vestibular systems of which vestibular input is particularly important [3]. Head control and poor ability to lift the head in prone after four months of age were associated with poor motor outcomes later, therefore, because delays in neuromotor development at the very earliest stage of development are likely to affect the development of subsequent neuromotor skills [4].

Aqua therapy is a type of complementary therapy for the treatment and rehabilitation of CP patients in conjunction with another conventional mode of treatment [5]. Aquatic therapy is an attractive form of exercise for children with CP. Buoyancy is water characteristics that decrease the effect of gravity and provides increased postural support. These characteristics may allow children with CP to exercise in the water with more freedom than on land. The resistive force of buoyancy and variety of aerobic and strengthening activity can be modified to accommodate the motor disability of CP children [6]. Hydrostatic pressure effects of water are reducing muscular spasticity and improving endurance to multi-sensory stimulants and increasing blood circulation [7]. The thermal properties of water help decrease pain and spasticity. The mechanical properties of water involve decreasing the effect of gravity and joint loading and assisting postural support and muscular strength [8]. Therefore, the present study aimed to investigate the effect of aquatic therapy in children with CP at GMFCS levels IV and V. To investigate the effect of under-water-based exercises on head control and movement functional recovery in children with CP.

Methods

Ethical committee approvals of the Faculty of Physical Therapy, Cairo University, as well as the written consent form from the parents about the agreement for participation of their children in the study and publication of the results were obtained before starting the study. Twenty-nine children with CP, whose ages ranged from 2-6 years old, from both sexes, were selected from thirty-nine children diagnosed with CP were screened to select children who participate in this study.

Water-based exercise and land-based exercise were carried over in Alnour pediatric hospital at Sohag city. The children were randomly divided into two groups of equal number are children each: Control group (A) fifteen children have received designed land-based exercises for the head control. Study group (B): Fourteen were received designed water-based exercises for the head control. The children were evaluated thoroughly at different time intervals; pre-treatment and three months later during which they received the treatment program. Head control and movement functional recovery were assessed by using GMFM and VEMP.

The children in study group B received water-based exercise for head control from different positions as the following: From prone position: The child was carried by the therapist, then asked the child to, raise (extend) his head and the therapist prevented the head from being immersed in water, elevate one or both upper limbs and play with toys, the therapist was moving the child horizontally forward and backward and also move the child side to side as righting reaction exercise. From supine position: the child was carried by the therapist, then asked the child, raise (flex) his head and therapist prevented the head to be immersed in water, elevate one or both upper limbs hand and try to reach toys, the therapist was moving the child horizontally forward and backward and sideways as righting reaction exercise.

Children in control group A receive land-based exercises from different positions as the following: From a prone position on the wedge and head outside the edge, the child was asked to elevate the head while the therapist was assisting the child to raise the head, the child was asked to reach or play with toys in front of him by one or both hands, the child was prone lying on the ball and the therapist has supported the child's trunk and move him sideways, forward and backward as righting reaction exercise. From the supine position and the head outside the edge, while the therapist hands under the child' head, the child was asked to elevate the head, pull the child to sitting position from hands through sagittal and diagonal direction, from supine positions on the ball, the therapist was moved ball sideway as righting reaction exercise. From in-ring sitting position: The child's trunk supported by the therapist: The child was asked to elevate the head, the child was asked to reach toys by hands, in-ring sitting position on the ball, the child is supported from the trunk, then move forward and backward and move side to side as righting reaction exercise. Children in both groups were received gentle stretching exercises for all tight muscles in the upper and lower limbs.

Results

Demographic data

The mean values of age were 41.45 ± 9.832 and 32.00 ± 5.180 months old for the control and study groups respectively. The statistical analysis revealed significant differences between both groups. The gender distribution revealed the number (percentage) of girls and boys in the control group were 5 (38.5%), 8 (61.5%) respectively, while in the study group were 6 (54.5%) and 5 (45.5%), respectively. The statistical analysis by chi-square test revealed that no significant differences in distribution gender (P=0.431) between the control and study groups.

The distribution of cerebral palsy types revealed that the number (percentage) of ataxic, dyskinetic, and spastic CP in the control group were 3 (23.1%), 3 (23.1%), and 7 (53.8%) respectively, while in the study group were 3 (27.3%), 3 (27.3%) and 5 (45.5%) respectively. The statistical analysis by chi-square test revealed that no significant differences in the distribution of CP types (P=0.920) between the control and study groups.

Gross motor function measure

Dimension A (lying and rolling) of gross motor function measure:

- Comparison of dimension a of gross motor function measure pre-and post-treatment between both groups

Table 1 Show the comparison between the results of pre-and post-treatment of Dimension A of GMFM between both groups. The mean values of pre-treatment of Dimension A of GMFM for the control group and study group were 39.538% ± 17.4672% and 40.182% ± 20.4050%, respectively, whereas, the mean values of post-treatment of Dimension A of GMFM for control and study groups were 53.154% ± 20.3995% and 65.545% ± 22.0652%, respectively. The statistical analysis of pre-and post-treatment values of Dimension A of GMFM revealed that there were non-significant differences (P<0.05) between both groups either before and after treatment.

Items	Gross Motor Function Measure (GMFM-88)	
	Pre-treatment	Post-treatment
Control group	39.538% ± 17.4672%	53.154% ± 20.3995%
Study group	40.182% ± 20.4050%	65.545% ± 22.0652%
T-value	0.082	1.419
P-value (P<0.05)	0.935	0.171
Significance	NS	NS

Table 1. Comparison of mean values of dimension A of gross motor function measure pre-and post-treatment between both groups.

Data are expressed as mean and Standard Deviation (SD) P-value: Probability NS: Non-Significant

- Comparison of dimension a of gross motor function measure within each group

The comparisons of mean values between pre-and post-treatment of Dimension A of GMFM within each group are represented in Table 2. The statistical analysis of mean values of dimension A revealed there was a significant improvement (P<0.05) when post-treatment compared to pre-treatment values within the control and the study groups.

Items	Dimension A of gross motor function messure	
	Control group	Study group
Pre-treatment	39.538% ± 17.4672%	40.182% ± 20.4050%
Post-treatment	53.154% ± 20.3995%	65.545% ± 22.0652%
T-value	-10.002	-11.256
P-value (P<0.05)	0	0
Significance	S	S

Table 2. Comparison of means values of dimension A of gross motors function measure within each group.

Data are expressed as mean and Standard Deviation (SD) P-value: Probability S: Significant

Dimension B (sitting) of gross motor function measure:

- Comparison of dimension b of gross motor function measure pre-and post-treatment between both groups

Table 3 shows the comparison between the results of pre-and post-treatment of Dimension B of GMFM between both groups. The mean values of pre-treatment of Dimension B of GMFM for the control group and study group were 7.846% ± 5.3673% and 8.727% ± 5.1979%, respectively, whereas, the mean values of post-treatment of Dimension B of GMFM for the control group and study group were 13.077% ± 6.1841% and 16.818% ± 8.7957% respectively.

The statistical analysis of pre-and post-treatment values of Dimension B of GMFM revealed that there were non-significant differences (P<0.05) between both groups either before or after treatment.

Items	Gross Motor Function Measure (GMFM-88)	
	Pre-treatment	Post-treatment
Control group	7.846% ± 5.3673%	13.077% ± 6.1841%
Study group	8.727% ± 5.1979%	16.818% ± 8.7957%
T-value	0.408	1.185
P-value (P<0.05)	0.688	0.252
Significance	NS	NS

Table 3. Comparison of mean values of Dimension B of Gross Motor Function Measure pre-and post-treatment between both groups.

Data are expressed as mean and Standard Deviation (SD) P-value: Probability NS: Non-Significant

- Comparison of dimension b of gross motor function measure within each group

The comparisons of mean values between pre-and post-treatment of Dimension B of GMFM within each group are represented in Table 4.

The statistical analysis of Dimension B of GMFM revealed there was a significant improvement (P<0.05) when post-treatment values compared to pre-treatment values within the control and the study groups.

Items	Dimension B of gross motor function measure	
	Control group	Study group
Pre-treatment	7.846% ± 5.3673%	8.727% ± 5.1979%

Post-treatment	13.077% ± 6.1841%	16.818% ± 8.7957%
T-value	-8.147	-5.789
P-value (P<0.05)	0	0
Significance	S	S

Table 4. Comparison of mean values of dimension B of gross motor function measure within each group.

Vestibular evoked myogenic potential

Response to vestibular evoked myogenic potential:

The number and percent of children who have no response and response to VEMP stimulus are represented in table 5. In control group, no response and response of right ear pre-treatment were 7 (53.8%) and 6 (46.2%) respectively, while post-treatment was 2 (15.4%) and 11 (84.6%) respectively. The no response and response of left ear pre-treatment were 8 (61.5%) and 5 (38.5%) respectively, while post-treatment was 2 (15.4%) and 11 (84.6%) respectively. In study group, no response and response of right ear pre-treatment were 7 (63.6%) and 4 (53.8%) respectively, while post-treatment was 1 (9.1%) and 10 (90.9%) respectively and no response and response of left ear pre-treatment were 10 (90.9%) and 1 (9.1%) respectively, while post-treatment were 1 (9.1%) and 10 (90.9%) respectively.

Items		Groups			
		Control		Study	
		Rt	Lt	Rt	Lt
Pre-treatment	NR	7 (53.8%)	8 (61.5%)	7 (63.6%)	10 (90.9%)
	R	6 (46.2%)	5 (38.5%)	4 (36.4%)	1 (9.1%)
Post-treatment	NR	2 (15.4%)	2 (15.4%)	1 (9.1%)	1 (9.1%)
	R	11 (84.6%)	11 (84.6%)	10 (90.9%)	10 (90.9%)
Total		13 (100.0%)	13 (100.0%)	11 (100.0%)	11 (100%)

Table 5. Distribution of children with no response to children with response to VEMP stimulus in both groups. Data expressed as numbers (percentage), P-value: Probability, NR: Non-Response, R: Response, Rt: Right Ear, Lt: Left Ear.

Statistical analysis of P1 latency results of vestibular evoked myogenic potential pre-and post-treatment between both groups:

Table 6 shows the comparison between the results of pre-and post-treatment of P1 Latency of VEMP measures between both groups. The median values and range of pre-treatment of VEMP measures for the control and study group of right ears were 16.735 (14.6-19.1) and 15.590 (13.7-15.7) respectively and left ears were 15.88 (13-19) and 15.68 (16-16) respectively whereas, the median values and range of post-treatment of VEMP measures of right ears were 16.470 (12.4-18.9) and 11.510 (10.2-13.0) respectively and left ears were 16.260 (12.5-19.7) and 11.910 (10.2-13.5) respectively. The statistical analysis of P1 latency of VEMP measures revealed that there was a non-significant difference in pre-treatment values of right ear and left ear (P=0.201) and (P=0.770) respectively response. While there was a significant difference in post-treatment values of right and left ears (P<0.05) between both groups.

Items	Time of assessment			
	Pre-treatment		Post-treatment	
	Rt	Lt	Rt	Lt
Control	16.735	15.88	16.47	16.26
	(14.6-19.1)	(13-19)	(12.4-18.9)	(12.5-19.7)
Study	15.59	15.68	11.51	11.91
	(13.7-15.7)	(16-16)	(10.2-13.0)	(10.2-13.5)
Z-value	-1.279	-0.293	-3.663	-3.554
P-value (P<0.05)	0.201	0.77	0	0
Significance	NS	NS	S	S

Table 6. Statistical analysis of median values of P1 Latency of VEMP measures between both group. Data are expressed as median and (range) P-value: Probability, S: Significant, NS: Non-Significant, Rt: Right Ear, Lt: Left Ear.

Statistical analysis of N1 latency results of vestibular evoked myogenic potential pre-and post-treatment between both groups:

Table 7 Show the comparison between the results of pre-and post-treatment of N1 Latency of VEMP measures between both groups. The median values and range of pre-treatment N1 Latency of VEMP measures for control and study group of right ears were 27.785 (27.3-28.8) and 26.165 (23.9-27.0) respectively, and left ears were 25.65 (24-29) and 26.78 (27-27) respectively whereas. The median values and range of post-treatment N1 Latency of VEMP measures of right ears were 27.340 (24.2-29.9) and 21.810 (19.3-23.5) respectively, and left ears were 26.660 (21.7-28.4) and 22.085 (19.2-22.7) respectively.

The statistical analysis of N1 latency of VEMP revealed that there was a non-significant difference in the left ear (P=0.770) and a significant difference in the right ear between both groups pre-treatment.

While post-treatment, there was a significant difference in right and left ear between both groups (P<0.05).

Items	Time of assessment			
	Pre-treatment		Post-treatment	
	Rt	Lt	Rt	Lt
Control	27.785 (27.3-28.8)	25.65 (24-29)	27.34 (24.2-29.9)	26.66 (21.7-28.4)
Study	26.165 (23.9-7.0)	26.78 (27-27)	21.81 (19.3-23.5)	22.085 (19.2-22.7)
Z-value	-2.558	-0.293	-3.874	-3.45
P-value (P<0.05)	0.011	0.77	0	0.001
Significance	S	NS	S	S

Table 7. Statistical analysis of median values of N1 Latency of VEMP measures between both group. Data are expressed as median and (range) P-value: Probability, S: Significant, NS: Non-Significant, Rt: Right Ear, Lt: Left Ear.

Discussion

This study aimed to investigate the effect of water-based exercises on head control and movement functional recovery in children with CP. The present study result showed that the current treatment protocol, when compared between both groups before and after treatment, revealed a non-significant improvement in dimensions A and B of GMFM, and significant improvement in P1 and N1 of cVEMP measures of right and left ear. Moreover, when post-treatment values were compared to pre-treatment values within each group, revealed that significant improvement in dimensions A and B of GMFM, and non-significant improvement in P1 and N1 of cVEMP measures of right and left ear.

It was intended to select children with CP at level V on GMFCS, to investigate the effect of water-based exercise on head control among those children.

This selection comes in line with the opinion of Roostaei et al. who revealed that the level of evidence is low for the majority of studies, especially for children classified according to GMFCS levels III–V [9].

Further research and information are needed to determine minimal criteria for dosing an aquatic program for children classified according to GMFCS levels IV and V.

Moreover, choosing aquatic therapy in this study is supported by many studies that concluded the pediatric aquatic therapy was considered as an alternative therapy for children with cerebral palsy even with poor GMFCS level [10-14].

It was observed that the water-based exercise and land-based exercise improved the head control and movement functional recovery which led to significant improvement of all scores of GMFM dimension A and B within the control and study groups.

These findings agree with Akinola et al. who studied the effect of a 10-week aquatic exercise training program on gross motor function in children with spastic CP [15]. They found a significant difference within the experimental group only in all dimensions of gross motor function in favor of the aquatic exercise training program.

Moreover, Tufekcioglu et al. reported that Watsu (aqua therapy program) improved GMFM significantly, but the effect of aqua therapy without correlation with the control group as in the current study [16].

In the present study, the non-significant difference obtained after treatment between both groups may be due to more time was needed for the study group before intervention to learn some aquatic skills to decrease the effect of abnormal muscle patterns that restricts normal movement. This opinion agrees with Roostaei et al. who reported that participants may not have had sufficient time to perform active movement and functional strengthening by restricting abnormal muscle patterns [9]. This may have limited the carryover to land-based movement recorded on the GMFM.

In the current study, a non-significant difference was recorded after treatment between the two groups may be indicated that these children were needed to share in home functional activity as long as period in-between session, to maintain functional recovery obtained during the session, as water-based exercise does not depend on the hard supporting surface as land activity. These reports agree with Dimitrijevic et al. who investigate the effect of an aquatic intervention on the gross motor function and aquatic skills of children with CP [12]. Found that no difference in GMFM score (post-treatment score, pre-treatment score) between the groups at the end of 9 weeks, who revealed that the result indicates that permanent involvement in a physical therapeutic activity is necessary for children with CP to ensure that their motor functions can be maintained at a higher level.

The present study, VEMP was used in the current study to investigate the effect of water-based exercise on head control because it can detect the difference in VCR which affects motor development of head control in cerebral palsy children. This selection of VEMP agrees with Brookhouser et al. revealed that the most common presentation of peripheral vestibular loss in young children is delayed motor development and loss of postural control. Moreover, Rine et al. reported that undiagnosed and untreated vestibular dysfunction can have a significant impact on children's motor development and agree with Akbarfahmini et al. who revealed that significant differences in the cVEMP parameters between children with spastic CP and healthy controls were found [2,17,18]. Such differences may be related to deficits in the VCR pathway, motor development delay, and neuromuscular dysfunctions. In the current study, we use cVEMP which is a reliable objective method to investigate the vestibular system.

In current study assess head control pre-treatment and post-treatment by measuring the vestibular system mainly saccular function and the inferior vestibular nerve, saccular function by VCR responsible for head orientation in space. This interpretation comes in agreement with Allum et al. who mentioned that the automatic mechanism of postural control (head control) includes the vestibular colic reflex that is responsible for stabilizing the head in space and vestibule-colic stretch reflex which aligns the head with the thorax [19].

In the current study, the head rotation technique was used instead of head elevation to measure the VCR in CP children at level V GMFCS and with poor head control. This technique is confirmed by Wang et al. who reported that the head rotation method may serve as an alternative for eliciting VEMPs in those who cannot sustain SCM muscle contraction by head elevation [20]. Also, Beyea et al. used VEMP with limited neck strength volunteer and revealed that VEMPs can be elicited from the majority of volunteers [21]. The test is easy to perform, and it is only mildly uncomfortable for most patients using the head rotation method.

Some children in the present study recorded no response and prolonged latency of P1 and N1 which may be due to incomplete maturity of VCR causing delays in head control. This explanation comes in agreement with Chen et al. who stated that prolonged or absent VEMPs in newborns may reflect incomplete maturity of the saccule-colic reflex pathway [22]. Also, absent or prolonged latency of P1 or N1 can is detected in cerebral palsy children. Additionally, Akbarfahmini et al. reported that the absence of the cVEMP response in some children with CP might be related to bilateral dysfunction of the saccular system and the corresponding neural afferents (cVEMP reflex pathway) [2]. As such, the unilateral responses might be attributed to unilateral dysfunction of the saccule and related afferents, as well as the level of the gross motor function and the type of CP.

Improvement (increase number/percentage of children who had a response to cVEMP stimulus) post-treatment in both groups. There was (8 children in the control group and 10 children in the study group) had no response before treatment. While, after treatment, only 2 children in the control group and one child in the study group had no response. This increase in the percentage of children having responded to cVEMP indicated improvement in VCR and response to cVEMP. This opinion agrees with Akbarfahmini et al. who investigated the cVEMP responses in 21 children with CP [2]. These children showed a bilateral response and only 8 children showed unilaterally response while the response was absent in two children with CP. Also, they clarified the significance of the saccular function assessment using the cVEMP in children with spastic CP.

In the current study, P1 and N1 latency were chosen to be assessed as a parameter of cVEMP to investigate the effect of water-based exercise on motorhead control. The selection of these parameters agrees with Akbarfahmini et al. who examined the P1 and N1 latency parameters of VEMP in the assessment of the saccular function in children with CP.

Using of VEMP in the assessment of children with CP for early detection of the vestibular problems affecting head control agrees with Sheykholeslami who reported that VEMP in neonates with various audio-vestibular problems provides useful information about vestibular function in this population and may provide information that leads to better care and rehabilitation for neonates at risk of developmental and motor system delay [23].

In the current study, a water-based exercise that provides an enjoyable environment for CP children enables them to do their best and move freely with little load on joints, as the effect of gravity decrease enables the children could perform several tasks that could not be done in land-based exercise. The ability to perform movements more easily in water promotes a level of control and independence, which many CP children achieve on land. This opinion agrees with Lepore who mentioned that the buoyant nature of water gives people with CP the opportunity to feel their body free from the restrictions that they experience moving against gravity [24]. Moreover, Becker stated that the water is motivating, and the buoyancy of water reduces the effects of gravity and provides postural support, and facilitates movement [25]. Additionally, Lai et al. reported that hydrotherapy provides CP children the ability to do body movements; especially among children who enjoy doing training activities in which moving on the ground is difficult for them [14].

In the present study, water-based exercise is proposed as a complementary therapy to enhance postural control and impact on head control by its bounced property especially among children with CP have a poor functional level, agree with Roostaei et al. revealed that children with CP often have postural control and movement limitations, buoyancy may assist children to exercise at a high enough intensity in the water to have significant effects in achieving therapeutic goals and agrees with Ballington et al. revealed that movements that children were unable, and/or perceived themselves unable, to perform on land were performed in the water [8,9].

In this study, water-based exercise improves head control and movement function recovery, as it is more safety for children with CP in level V GMFCS to enable him to move freely, agree with Roostaei et al. revealed that intervention is safe and has minimal to no adverse effects [9].

Water-based exercise in the current study, was designed to training of head control from a supine and prone position, to stimulate vestibular system and righting of the head on floating trunk, would improve head control, balance, and postural control defect in these children, matched with Lepore who reported that the aquatic activities allowed the participants to enhance vestibular input through movement from horizontal to the vertical plane, matching with Sekendiz et al. mentioned that exercise on an unstable support surface stimulates tactile sensation, vestibular sensations, proprioceptive sensations, etc. to induce posture and balance reactions, thereby promoting dynamic stability [24,26].

Improvement in movement functional recovery gained in the present study may be due to neural plasticity as the program was designed according to functional related movement as reaching. This interpretation is supported by Michaelsen et al. revealed that therapists treating people affected by a neurological disorder should be prescribing task-specific training in their therapy [27]. The strength of the task-specific training approach is in its origin. There is increasing evidence of neural plastic changes associated with training. Also, Song confirmed that functional task training related to movement frequently used in daily life is considered to have a more positive effect on the recovery of motor functions than repetitive training using simple movement [28].

The limitation of the study was mostly due to potential sources of error in clinical measurement due to factors related to children (fear or attention) and testing location (distraction), irregular attendance of the children due to repeated chest infection, cold weather atmosphere in December, January, February, and March during study months, total country epidemic condition of covid-19 limited the participation of some children in this study.

Conclusion

It can be concluded from this study that water-based exercises may be useful to improve head control and movement functional recovery in children with CP. In addition, no difference between the effect of water-based exercises and land-based exercises on improving movement functional recovery in those children.

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