Effect of Aquatic Therapy -Based Exercises on Motor Outcomes among Children Suffering from Spastic Hemiplegia

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Abstract

Spastic hemiplegia is a type of spastic cerebral palsy that affects one side of the body due to damage to the part of the brain controlling movement. Children with spastic hemiplegia have limited activities of daily living, such as dressing, feeding, and functional mobility, due to problems with hand function **Aim of the study** was to measure the effect of aquatic therapy-based exercises on motor outcomes among children suffering from spastic hemiplegia. A Quasi-experimental design was utilized in this study. **The setting** was the Physiotherapy unit in Children's Hospital affiliated to Ain Shams University Hospitals. **Sample**: A purposive sample consisted of 60 children with spastic hemiplegia aged from 6 to 12 years was included in the study. **Tools**:1- A structured Interviewing Questionnaire Sheet,2- Modified A shworth Scale,3- Range of Motion scale,4- Peabody Developmental Motor Scale. **Results:** It was found that before aquatic therapy-based exercises the mean muscle tone was 1.5±0.6 in the study group while after intervention it become 2.4±0.9 with a percentage change of 50% (0%-200%) with a highly statistically significant difference between the study and control groups (p value = < 0.001). Hand strength was improved in the study group more than in the control group (56.6% vs 40% respectively), the highest improvement was in holding objects with hands, followed by the ability to grasp objects. **Conclusion:** Evidence of reduction of spasticity in children with spastic hemiplegia after 12 weeks of aquatic therapy-based exercise. **Recommendation:** Replication of the study on large samples of children with spastic hemiplegia in different places in Egypt.

Keywords: Motor outcomes, Aquatic therapy-based exercises, Children, Spasticity.

Introduction

Spasticity in children occurs as a result of neuromuscular disorders, it is defined as "velocity-dependent increased resistance to passive muscle stretch, or as inappropriate involuntary muscle activity associated with upper motor neuron paralysis. Hemiplegia is found in 29% of children with cerebral palsy, around 70% to 90% of children are congenital and approximately 10 % to 30% are acquired in case of fetal distress that causes brain damage. Spastic hemiplegia can be caused by prematurity that leads to underdeveloped organs and hypoxic brain injury (***kinola, B.2021).***

Children with hemiplegic cerebral palsy suffer from spasticity, sensory deficit, and muscle weakness, affecting functions of the upper limb more than that of the lower limp, spastic hemiplegic causes problems with motor control, with inefficient movement patterns. Thus, they have a mass movement pattern and difficulty performing specific tasks ***(Esraa et al.,2018).***

Aquatic therapy-based exercise is applied to the body in three different ways: submerge the part in warm water, scour ice cubes or ice packs, or use vaporizing sprays such as ethyl chloride. After reducing spasticity, the ability of the muscles to perform their functions varies under different conditions ***(Akinola, et al.,2019).***

Aquatic interventions may be more suitable for children with CP because of the properties of water, and it may be more interesting and motivating for children than land-based exercise Aquatic interventions may be more suitable for children with CP because of the properties of water, and it may be more interesting and motivating for children than land-based exercise.

Physical exercise can reduce many secondary conditions of CP and can help improve posture, muscle tone, and balance. Aquatic exercises improve the musculoskeletal function and fitness, where the use of water decreases excessive joint loading, and muscle weakness and improves strengthening. Emersion in warm water (33 °C to 35 °C) reducing in gamma fiber activity which, decreases muscle spindle activity, spasticity, and increase muscle relaxation leading improve range of motion (ROM) and postural alignment. Moreover, aquatic therapy provides opportunities for children to learn, and enjoy new movement skills, which enhances mobility and builds self-confidence ***(Sevda, et al.,2017).***

Significant of the study:

Aquatic intervention is one of the most common supplementary treatments for children with neuromotor impairments. Aquatic therapy-based exercise is a type of rehabilitative therapy that is conducted in a pool for motivating to participate in physical activity, it provides stimulation to the body to promote or facilitate relaxation, strength, balance, and coordination in a variety of positions ***(Koen, et al., 2017).***

Aim of the Study:

This study aimed to measure the effect of aquatic therapy-based exercises on motor outcomes among children suffering from spastic hemiplegia

Operational definition:

Motor outcomes: It refers to the degree of spasticity, range of motion, and fine motor skills

Research Hypothesis:

Aquatic therapy-based exercises will reduce spasticity in children with spastic hemiplegia cerebral palsy.

Subject and methods:

Research design:

A Quasi-experimental research design was utilized for conducting this study.

Setting:

The study was conducted at the Physiotherapy unit in Children's Hospital affiliated to Ain Shams University Hospitals.

Sample and sample size:

A purposive sample consisted of 60 children under the following inclusion criteria (aged from 6 to 12 years, suffering from spastic hemiplegic cerebral palsy) they were boys (45) and girls (15), and attending to the previously mentioned setting and accompanied by their mothers.

A simple random method was used to select them from the admission schedule of the unit. The sample size was calculated according to the whole number of admissions in the past three months from June to the end of August 2020 was 70, the following assumption of Power Analysis to define sample size.

$$n = \frac{t^2 \times P(P-1)}{m^2}$$

n= the required sample size.
t = the confidence level at 95% (standard value of 1.96).
p = estimated prevalence of children with spastic hemiplegic cerebral palsy.
m = the margin of error at 5% (standard value of 0.05).

So according to the assumption of Power Analysis to define sample size, the study sample that met the inclusion criteria was 60 children.

They were classified into 2 groups (30 for study and 30 for control). The study group received a manual passive range of motion on affected muscles of both upper and lower extremities followed by aquatic exercises in water (temperature 32 ºC -36ºC) while the control group received the same exercise intervention as those in the study group except for the aquatic therapy-based exercise.

Tools for data collection:

The study tools for data collection include the following four tools:

1- **A structured Interviewing Questionnaire Sheet**: It was designed and written in the Arabic Language by the researcher after reviewing related literature. It is concerned with studied sample characteristics including child' age, gender, education, mothers' age, and education.

Also, contain data about hand status such as (hand sensitivity, hand strength, hand speed, hand manipulation, and hand coordination).

2- Modified Ashworth Scale (MAS): Adopted from **Bohannon and Smith (1987)**, and used to quantify the degree of muscle spasticity for children in two groups, the spasticity degree is ranged from grade 0 to grade 4, it consists of (6) statements.

Scoring System:

According to the degree of muscle spasticity:

0 No increase in muscle tone

1 Slight increase in muscle tone, manifested by pickup and release or minimal resistance at the end of the range of motion when moving the affected part(s) in flexion or extension.

1+ Slight increase in muscle tone, manifested by pickup, followed by minimal resistance throughout the remaining (less than half) period of Range of Motion (ROM)

2 A marked increase in muscle tone through most of the ROM, but affected part (s) easily moved.

3 Considerable increases in muscle tone, passive movement difficult

4 Affected part(s) rigid in flexion or extension

3- Range of Motion (ROM): Adopted from **Boone and Azen (1979);** Elbow and wrist extension were measured by the electronic goniometer.

Scoring System:

According to the degree of elbow and wrist extension:

- Flexion of the elbow 150 degree
- Flexion of the wrist 60 degree
- Extension of the elbow 60 degree

4- Peabody Developmental Motor Scale (PDMS-2) Adopted from **Folio and Fewell (2000);** it was used to evaluate fine motor skills including grasping strength and visual motor integration.

Scoring System:

Grasping (Gr) - This subtest measures a children's ability to use their hands. It starts with the ability to hold an object with one hand and progresses to actions that involve controlling the use of fingers of both hands to button and unbutton garments.

Visual-Motor Integration (VMI) - This subtest measures a child's ability to use his or her visual perceptual skills to perform complex eye-hand coordination tasks such as reaching and grasping for an object, building with blocks, and copying designs.

Description of Performance for Subtest Standard Scores		**Description of Performance for Quotient Scores**	
17-20	Very Superior	31-165	Very Superior
15-16	Superior	121-130	Superior
13-14	Above Average	111-120	Above Average
8-12	Average	90-110	Average
6-7	Below Average	80-89	Below Average
4-5	Poor	70-79	Poor
1-3	Very Poor	35-69	Very Poor

Ethical consideration:

In the beginning, the researcher individually interviewed the child and his mother in the previously mentioned setting and introduced herself, explained the purpose of the study, and gave a clear and brief idea about it. The mother's verbal consent was obtained and informed them that they have the right to withdraw from the study at any time without giving any reason. They were also assured that anonymity and confidentiality will be guaranteed, as well the collected data will be used for the research purpose only. Ethics, values, culture, and beliefs were respected.

Pilot study

A pilot study was conducted on (6) children with spastic hemiplegic, which represented 10% of the total sample, to test the clarity and applicability of the tools and to calculate the required time to fill out the forms. Some modifications and clarifications of some questions were done accordingly. Pilot study children were not included in the main study sample.

Content Validity:

The study assessment tools were submitted to a panel of three experts in the field of pediatric nursing to examine the content validity (covering, clarity, wording, length, format, and overall appearance). A slight modification has been made.

Tools' reliability:

Internal consistency reliability of all items of the tools was assessed using Cronbach's Alpha test. It was 0.84 for the structured interviewed questionnaire, 0.89 for the Modified Ashworth Scale, and 0.86 for Peabody Developmental Motor Scale.

The field work:

The actual field work takes four months, starting from September 2020 up to the end of December 2020. The researcher was available in the study setting two days per week (Saturday and Thursday) during the morning shift. Each interviewing questionnaire was filled in, in the presence of the researchers and every questionnaire take 45 to 60 minutes for interviewing before aquatic therapy-based exercise sessions. The aquatic therapy-based exercise intervention was done on each child 2 times p/week (2 sessions p/week) for 3 months (12weeks) (a total of 24 sessions). aquatic therapy takes time 20 mint plus 10 mint preparation (a total of 30 min) for each child.

Followed by one month to measure the effect of aquatic therapy-based exercise.

Procedure:

- Children's aquatic therapy-based exercise intervention:

The study group received passive exercise with the exercised parts fully immersed in water of temperature ranging between 32-36 ºC, two sessions per week for 12 weeks.

Exercise: (Manual passive stretching): Passive stretch of each joint involving the spastic group of muscles and held in this for up to 60 seconds followed by relaxation of 30 seconds. This procedure was five times for each part and a passive range of motion was done.

The control group received the same exercise intervention as those in the study group except for the aquatic therapy-based exercise.

Children in two groups were reassessed after 4 weeks to evaluate the changes in spasticity using the Modified Ashworth Scale (MAS).

Safety Enhancement:

Ensuring the safety of children while performing the aquatic therapy exercises helps facilitate their participation and the success of interventions in children with different levels of mobility. Some of the most important safety features include: lift chairs, life jackets, children's equipment, and devices. The pool depth should be such that the child's feet should touch the bottom of the pool and safe control of water temperature.

Measuring the effect of aquatic therapy-based exercise:

According to Modified Ashworth Scale (MAS), the researchers measured the spasticity degree in the elbow and wrist flexors of children in two groups.

Every child was in a relaxed supine position then, starting position of testing each muscle group was a maximal placement of the joint in a position of their primary function and then maximally moved to a lengthened position opposite to their primary movement. The children were then scored based on the amount of resistance to passive movement as described in the MAS.

According to Peabody Developmental Motor Scale (PDMS-2), the researchers evaluated the fine motor skills including grasping and visual motor integration, and determining skills that are not completely developed.

The researchers measured the children's ability to use their hands and hold an object with one hand and progresses up to actions involving the controlled use of the fingers of both hands to button and unbutton garments.

The researchers also measured the children's visual perceptual skills to perform complex hand-eye coordination tasks including

reaching and grasping an object, building with blocks, and copying designs. Elbow and wrist extension were measured with an electronic goniometer.

Data analysis

Data were analyzed using SPSS version 20. Numerical data were expressed as mean ± SD and range. Qualitative data were expressed by frequency and percentage. The relations between different numerical variables were tested using Pearson's correlation. as well as, the Chi square test. A probability level of <0.05 was adopted as a level of significance and less than 0.001 was considered a highly significant.

Results

Table 1: As observed from this table, the mean age of the studied children in the study group was 10.0±1.0 and in the control group was 10.0±0.85. Moreover, 80.0% and 70.0% of children in the study and control group respectively were boys, also, 66.7% and 80.0% of them in the study and control group were illiterate respectively.

Table 2 illustrated that the mean of mothers' ages in the study group was 32.5±3.5 and in the control group was 31.1 ± 4.7. Moreover, 53.3% in the study group and 40% in the control group were read and written with a p –value= 0.538.

Table 3 represented the distribution of the children in the study and control group according to their hand speed and manipulation of objects before and after aquatic therapy-based exercise. It was found that there were statistically significant differences (P value = 0.286 and 0.009) between the two groups according to their hand speed and manipulating objects respectively. Where, the children's use of their hands in rapid movement before intervention was only 6.7%, while after aquatic therapy-based exercise, it was improved to 23.3%. Moreover, **table 3** showed that hand strength was improved in children in the study group after aquatic therapy-based exercise 56.6% vs 40% respectively with no statistically significant difference between the two groups (p = 0.579). Also, as regards manipulating the objects, improvement was found in the study group after aquatic therapy-based exercise 63.3%. vs 40.0% respectively, the highest improvement was in the holding objects with hands, followed by the ability to grasp objects 68.4% and 42.1% respectively.

Table 4 presented the mean and stander deviation of children in the two groups according to their degree of muscle spasticity before and after aquatic therapy-based exercise. It was found that before aquatic therapy the muscle tone was 1.5±0.6 in the study group while after aquatic therapy it become 2.4±0.9 with a percentage change of 50% (0%-200%), while in the control group no change was found in muscle tone and the percentage change was 0.0% with highly statistically significant difference between the two groups (p value = < 0.001).

Table 5 illustrated the mean and stander deviation of children in the two groups according to the passive exercise of the elbow and wrist before and after aquatic therapy. It was found that passive range of motion had a significant impact on the degree of children's joint spasticity in the study group more than in the control group. the elbow flexion 103.3±11.8 vs 100.7±6.6, wrist extension (19.6±5.7 vs 11.3±3.3), and wrist flexion 50.8±5.4 vs 47.5±6.5 respectively, with highly statistically significant difference (P value = < 0.001).

Table 6 showed the mean and stander deviation of children in the two groups according to children's grasping strength and their visual motor integration, as shown in this table, the study group was increased after intervention than before intervention 45.0±4.2 vs 42.1±4.6. Also, Visual motor integration of children was improved after intervention in the study group than in the control group 48.9±2.4 vs 43.3±4.9 respectively, with a highly statistically significant (p value = <0.001)

Table (1): Distribution of the children in the two groups according to their characteristics.

Items	Study Group (n=30)		Control Group (n=30)		Chisquare test	
	No	%	No	%	x^2	P
Age in years						
6 <9	24	80.0%	24	80.0%	0.000	1.000
9≤12	6	20.0%	6	20.0%		
$\bar{x}_{\pm SD}$	10.0±1.0		10.0±0.85			
Gender						
Boys	24	80.0%	21	70.0%	0.356	0.552
Girls	6	20.0%	9	30.0%		
Level of Education						
Illiterate	20	66.7%	24	80.0%	1.364	0.506
Read and Write	5	16.7%	3	10.0%		
Primary education	5	16.7%	3	10.0%		

Table (2): Distribution of children's mothers in the two groups according to their characteristics

Items	Study Group n=30		Control Group n=30		Chi-square	
	No	%	No	%	x^2	P
Mother age in years						
< 25	1	3.3%	1	3.3%	0.982	0.779
25 < 30	10	33.3%	12	40.0%		
30 < 35	1	3.4%	3	10.0%		
35 < 40	12	40.0%	10	33.4%		
≥40	6	20.0%	4	13.3%		
$\bar{x}_{\pm SD}$	32.5±3.5		31.1±4.7			
Level of education						
Illiterate	1	3.4%	1	3.3%	2.171	0.538
Read and Write	16	53.3%	12	40.0%		
Diploma	10	33.3%	10	33.4%		
High education	3	10.0%	7	23.3%		

Table (3): Distribution of children in the two groups according to their hand speed and manipulating objects before and after aquatic therapy Based Exercise

Items	Study Group n=30				Control Group n=30				Chi-square test	
	Before		After aquatic therapy Based Exercise		Before		After physiotherapy only		x^2	p-value
	No	%	No	%	No	%	No	%		
(Hand speed) Ability to use the hands in rapid movement										
Yes	2	6.7	7	23.3	6	20	7	23.3	3.785	0.286
No	28	93.3	23	76.7	24	80	23	76.7		
Hand strength										
Yes	12	40%	17	56.6%	14	46.6%	16	53.3	1.967	0.579
No	18	60%	13	43.4%	16	53.4%	14	46.7		
(Hand Manipulating) Manipulating objects										
Yes	12	40	19	63.3	7	23.3	9	30	11.577	0.009
No	18	60	11	36.7	23	76.7	21	70		
Hand coordination)										
Ability to seize objects with hands										
Ability to hold objects with hands	5	41.7	7	36.8	3	42.9	3	33.3	4.296	0.890
Ability to grasp objects with hands	7	58.3	13	68.4	4	57.1	6	66.7		
Ability to turn objects with hands	4	33.3	8	42.1	5	71.4	5	55.6		
	1	8.3	2	10.5	3	42.9	3	33.3		

Table (4): Mean and stander deviation of children in the two groups according to their degree of muscle spasticity before and after aquatic therapy-Based Exercise

Modified Ashworth Scale (MAS)	Study Group n=30	Control Group n=30	p value
	Mean ±SD	Mean ±SD	
Before aquatic therapy Based- Exercise	1.5±0.6	1.7±0.7	0.250
After aquatic therapy Based -Exercise	2.4±0.9	1.7±0.7	0.001
Percentage change	50% (0%-200%)	0.0%	< 0.001

Table (5): Mean and stander deviation of children in the two groups according to the passive exercise of elbow and wrist before and after aquatic therapy Based Exercise

Range of Motion(ROM)	Study Group (n=30)	Control Group (n=30)	p value
	Mean ±SD	Mean ±SD	
Elbow Flexion			
Before range of motion	78.2±14.4	99.7±6.5	< 0.001
After range of motion	103.3±11.8	100.7±6.6	0.292
Wrist Extension			
Before range of motion	10.8±3.7	9.7±2.6	0.186
After range of motion	19.6±5.7	11.3±3.3	< 0.001
Wrist Flexion			
Before range of motion	37.3±6.2	47.4±4.9	< 0.001
After range of motion	50.8±5.4	47.5±6.5	0.036

Table (6): Mean and stander deviation of children in the two groups according to their grasping Strength and visual motor integration

Peabody Developmental Motor Scale (PDMS-2)	Study Group n=30	Control Group n=30	p value
	Mean ±SD	Mean ±SD	
Grasping Strength			
Before intervention	42.1±4.6	42.6±4.5	0.672
After intervention	45.0±4.2	42.5±4.5	0.030
Percentage change	0.0 (0.0-21.1)	0.0	
Visual motor integration			
Before intervention	44.2±4.7	42.9±4.8	0.265
After intervention	48.9±2.4	43.3±4.9	<0.001
Percentage change	6.6 (6.1-21.1)	0.0 (0.0-21.1)	

Discussion

The effects of aquatic therapy-based exercise can increase soft tissue elasticity, reduce pain, and spasticity. Exercising in water reduces the effect of gravity, enhances postural support, decreases joint loading, and increases aerobic and muscular strength for children with cerebral palsy. These benefits make aquatic therapy a desirable environment for children with cerebral palsy (Becker, 2009). So, this study aimed to measure the effect of aquatic therapy-based exercises on motor outcome among children suffering from spastic hemiplegia. Decreased muscle tone and spasticity in children with CP have important implications for the treatment of CP and among them, exercises that can reduce muscle tension by using the aquatic therapy. Our study found that the children's muscle tone and spasticity were improved after aquatic therapy in the study group more than in the control group with a percentage change reaching half percent with a highly statistically significant difference found between the two groups. These findings have matched the results of another study conducted by **Dimitrijević, et al., (2012)** who stated that exercise pattern easily and also reduces muscle tension and the load placed onto the joints. In addition, warm water can decrease muscle tension and muscle spasms. Also, **agreed with Chrysagis et al., (2009)** who reported that there were changes in the muscle spasticity among children with CP treated with aquatic therapy, affecting positioning and mobility, in different situations after coming out of the water. While **Pin, et al., (2007) & Adar et al., (2017)** mentioned that, putting the body in warm water (33-35ºC), the water can increase muscle elasticity and

decrease spasticity by using its thermal effects to decrease gamma fiber activity.

In our opinion, warm water in aquatic therapy encourages relaxation by affecting the children's neuro muscular junctions, resulting in decreased muscle tone and spasticity.

The present study found that more than half of children in the study group their hand strength was improved after 12 weeks of aquatic therapy more than in the control group, but no statistically significant difference was found. Most hand strengths were the ability to lift and lower objects and the ability to push and pull objects. While the least hand strength was about the ability to squeeze the object with as much force as possible. These findings were matched the study findings of **Franzen, and Tryniszewski, (2013)** who reported that aquatic therapy programs of 6-36 weeks duration caused statistically significant improvements in more than half of the children studied, and nearly half of the study group could squeeze the object after therapy compared to about a third before therapy.

In our opinion, the reason for no significant difference between both groups following 12 weeks of aquatic therapy-based e exercises in this present study, may be needed to go further beyond 12 weeks to get a significant improvement.

The current study showed that children's grasping and fine motor strength in the study group was improved after intervention than before the intervention. Also, Visual motor integration of children was improved after intervention in the study group than in the control group, with a highly statistically significant. These findings were agreed with another study conducted by **Adar et al. (2017)** who reported that after aquatic therapy there was an improvement in fine motor and social function, ability to handle paper and pencil, and participation in group activities. Also, matched another by **Fragala-Pinkham et al. (2009)** who reported improvements in ROM, strength, balance, pain reduction, functional mobility, and motor skills after aquatic therapy.

In our opinion, warm aquatic therapy-based exercise strengthens the muscles that allow children with cerebral palsy to move and exercise more freely and strengthen their musculoskeletal system to grasp and curry up the object.

Our study found that there were statistically significant differences between the study groups according to their hand speed and manipulating objects. Few percent of children before intervention could use their hands in rapid movement, but after aquatic therapy, their ability was improved. As regards manipulating the objects, the highest improvement was about the holding objects, followed by grasping objects with hands. These results matched the results of another study conducted by Lai**, et al., (2015)** who stated that pediatric aquatic therapy enhances motor function for children with spastic cerebral palsy. The improvement in gross motor function was greater in the pediatric aquatic therapy group than in the control group.

In the present study, there was a statistically significant improvement was observed in the study group regarding spasticity of elbow flexion, wrist extension, and wrist flexion after the passive range of motion and manual passive stretching more than in the control group. This finding was agreed with another study conducted by **Akinola, B. (2021)** who stated that the experimental group showed a significant reduction in spasticity of all the tested muscle groups, while the control group showed no significant improvement in spasticity of wrist flexors and knee flexors. No significant difference was observed in the change in spasticity between the two groups. Also, **Fragala-Pinkham, et al., (2014)** stated that aquatic therapy utilizes different properties of water to aid children with decreased postural control and muscle weakness by reducing joint loads.

Conclusion

The results of this study provide evidence of reduction of spasticity in children with spastic hemiplegia after 12 weeks of aquatic therapy-based exercise There was significant improvement was observed regarding spasticity of elbow flexion, wrist extension, and wrist flexion after the passive range of motion and

manual passive stretching in study group more than the control group.

Recommendation

Based on the study results, the following recommendations are proposed:

- Implant the aquatic therapy-based exercise management/procedure to reduce spasticity in children with spastic hemiplegia and improve hand function activities.
- Replication of the study on large samples of children with spastic hemiplegia in different places in Egypt.

References

Adar, S., Dündar, Ü., Demirdal, Ü., Ulaşlı, A., Toktaş, H., and Solak1, Ö. (2017): The effect of aquatic exercise on spasticity, quality of life, and motor function in cerebral palsy. Turkish Journal of Physical Medicine & Rehabilitation (2587-0823), 63(3), 239–248.

Akinola B., Gbiri C., and Odebiyi D. (2019): Effect of a 10-Week Aquatic Exercise Training Program on Gross Motor Function in Children with Spastic Cerebral Palsy. Global Pediatric Health 6: 1-7.

Akinola, B. (2021): Aquatic Exercise Intervention Is Effective for Spasticity Inhibition in Children with Cerebral Palsy: A Clinical Controlled Study Progressing Aspects in Pediatrics and Neonatology, 3(2)- 2021, 225-231. PAPN.MS.ID.000156. DOI: 10.32474/PAPN.2021.03.000156.

Becker B. (2009): Aquatic therapy: scientific foundations and clinical rehabilitation applications. Phys Med Rehabil. 2009; 1:859-872.

Bohannon and Smith (1987): Modified Ashworth Scale (MAS)**,** Physical Therapy 67(2):206-7 March 1987

Boone and Azen (1979): Range of Motion (ROM), . 1979 Jul;61(5):756-9.

Chrysagis, N., Douka, A., Nikopoulos, M., Apostolopoulou, F., Koutsouki, D. (2009): Effects of an aquatic program on gross motor function of children with spastic cerebral palsy. J. Biol. Exerc. 2009, 5, 13–25.

Dimitrijević, L., Bjelaković, B., Lazović, M., Stanković, I., Čolović, H., and Kocić, M. (2012): Aquatic exercise in the treatment of children with cerebral palsy. Srp Arh Celok Lek. *140*, 746-50.

Esraa, A.; Amira E., and Asmaa, O. (2018): Relationship between Spasticity and Motor Abilities in Children with Hemiplegia Med. J. Cairo Univ., Vol.86, No. 7, December: 4047-4052, 2018 www.medicaljournalofcairouniversity. net The Department of Pediatric Physical Therapy, Faculty of Physical Therapy, Cairo University

Fragala-Pinkham M., Dumas H., Barlow C., Pasternak A. (2009): An aquatic physical therapy program at a pediatric rehabilitation hospital: a case series. Pediatr Phys Ther. 2009; 21:68–78.

Fragala-Pinkham, M., Smith, H., Lombard, K., Barlow, C., and O'Neil, M. (2014): Aquatic aerobic exercise for children with cerebral palsy: a pilot intervention study. Physiotherapy Theory & Practice, 30(2), 69–78.

Franzen, K., and Tryniszewski, P. (2013): Effectiveness of Aquatic Therapy for Children with Neurodevelopmental Disorders: A Systematic Review of Current Literature. In Partial Fulfillment of the Requirements for the Degree of Doctor of Physical Therapy.

Koen J., Dekkers, Eugene A., Rameckers, Rob J., Smeets, Yvonne J., Janssen-Potten. (2017): Upper Extremity Strength Measurement for Children with Cerebral Palsy: A Systematic Review of Available Instruments. Physical Therapy. 2017; 94(5): 609-21.

Lai, C., Liu, W., Yang, T., Chen, C Wu, C., and Chan, R. (2015): Pediatric Aquatic Therapy on Motor Function and Enjoyment in Children Diagnosed with Cerebral Palsy of Various Motor Severities. Journal of Child Neurology 2015, Vol. 30(2) 200-20sagepub.com/journalsPermissions.nav. DOI:10.1177/0883073814535491 jcn.sagepub.com.

Pin, T., Dyke, P., and Chan, M. (2007): The effectiveness of passive stretching in children with cerebral palsy. Dev Med Child Neurol. 2007 Oct;49(10):797-800, doi: **10.1017/S0012162206001836.**

Sevda ,A.,Ümit ,D., Ümit ,S., Alper ,M., Hasan ,T., and Özlem, S., (2017) : The effect of aquatic exercise on spasticity, quality of life, and motor function in cerebral palsy, Turkish Journal Physical Medicine Rehabilitation. June; (2017) 63(3): 239–248.