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Original research article

THE EFFECTS OF A PROGRAM OF SWIMMING AND AQUATIC EXERCISE ON FLEXIBILITY IN CHILDREN WITH CEREBRAL PALSY

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Abstract. *The objective of this study is to determine the effects of the applied program of swimming and aquatic exercise on improving the flexibility of children with cerebral palsy. The participants in the study were 15 children with cerebral palsy, aged 6 to 17, at GMFCS levels I, II and III. The applied exercise program comprised swimming and aquatic exercise. In the swimming program, the Halliwick method was used, as well as exercises for the backstroke, crawl and breaststroke. The aquatic exercise program included exercises for improving leg muscle flexibility and strength, and walking exercises. The exercise program lasted for 12 weeks with a frequency of three times a week and a class duration of 60 minutes. Based on the results of the tests for the assessment of flexibility or range of motion, 6 variables were obtained. The results indicate that the applied program contributed to a statistically significant increase in the range of flexion and abduction motions at the shoulder joint at the level of significance p=0.00. Regarding the range of extension and abduction motions at the hip joint, as well as dorsal flexion, improvement was also noted, however without statistical significance. Based on the analysis of the results obtained, we conclude that the applied program of swimming and aquatic exercise was efficient in the sense of increasing flexibility or the range of flexion and abduction motions at the shoulder joint, whereas the program requires modification to increase flexibility of the leg joints.*

Key words: *aquatic exercise, effects, shoulder joint, hip joint, cerebral palsy.*

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INTRODUCTION

Cerebral palsy is the most common neuromuscular disorder in children (Prosser and Damiano, 2012). In 2000, based on a comprehensive analysis of definitions, the European organisation for monitoring and registering cerebral palsy, Surveillance of Cerebral Palsy in Europe (SCPE), put forward a definition of cerebral palsy which views it as a cluster of disorders of movement, posture, and motor function, and a condition which is permanent but not immutable, identifying as its cause a non-progressive lesion, functional and structural impairment in the developing brain (Surveillance of Cerebral Palsy in Europe, 2000). Spasticity, altered muscle activation, poor coordination, and a primary inability to produce force are among the impairments caused by the primary neural insult in cerebral palsy. These impairments limit the amount and type of physical activity, leading to further muscle weakness and limited range of motion (Prosser et al., 2012).Owing to the attendant primary and secondary motor disorders (Papavasiliou, 2009), it is necessary to maintain motor and functional abilities at the level that would facilitate independence in everyday activities in children with cerebral palsy.

In this context, it is of particular importance to maintain and increase muscle strength and flexibility (Porretta, 2005). Spastic arm, leg and pelvic muscles lead to a decrease in mobility in children with cerebral palsy. If nothing is done to increase the range of motion, muscles can get contracted. For this reason, exercises for increasing the range of motion should form an integral part of the exercise program for children with cerebral palsy (Porretta, 2005).

In order to maintain flexibility, it is necessary to stretch muscles that are tight or spastic, while strengthening the muscles that perform the counter-movements in the same joint (Lockette & Keyes, 1994). To increase flexibility in children with cerebral palsy, the method of passive stretching with the help of a therapist, or that of prolonged stretching with the aid of certain props, can be used (Pin, Dyke and Chan, 2006). According to Wiart, Darrah and Kembhavi (2008), therapists use passive muscle stretching not only with the aim of maintaining and increasing the range of motion, but also to facilitate everyday functioning. Passive stretching is used for all muscle groups, especially hip flexors and adductors, knee-joint flexors, and plantar flexors (Wiart et al., 2008). Following Wiart et al. (2008), it is recommended that passive stretching and other exercises for increasing flexibility and range of motion be made an integral part of the fitness programs applied in children with cerebral palsy.

In addition to exercise on land, various swimming programs, as well as aquatic exercise programs, can be used as forms of fitness programs in children with cerebral palsy (Kelly and Darah, 2005). Positive effects of aquatic exercise are realized in children with cerebral palsy as a result of the simple physical characteristics of water, such as buoyancy, hydrostatic pressure and viscosity. What makes swimming and aquatic exercise particularly suitable for individuals affected by a range of physical disabilities, including cerebral palsy, is the fact that movement is comparatively unrestricted and muscles get to be used which otherwise struggle to overcome gravity-imposed limitations (Prins, 2009). Review articles (Getz, Hutzler and Vermeer, 2006; Gorter and Currie, 2011; Jorgić, Dimitrijević, Lambeck, Aleksandrović, Okičić and Madić, 2012) suggest that aquatic exercise has a positive effect on a range of motor and functional abilities. A number of studies have ascertained (or explored) the influence of swimming and aquatic exercise programs on increasing flexibility, in addition to their further effects on the abilities of children with cerebral palsy (Peganoff, 1984; Hung, 2003; Chrysagis, Douka, Nikopoulos, Apostolopoulou and Koutsouki, 2009; Fragala-Pinkham, Dumas, Barlow and Pasternak, 2009).

Studies on the effects of swimming and aquatic exercise programs on flexibility in children with cerebral palsy are few, and the design of the programs applied tends to vary in terms of exercises used and training intensity and volume, all of which points to possible future avenues of research. In view of the above, the **objective** of this study is to explore the effects of an applied program of swimming and aquatic exercise on increasing the flexibility of children with cerebral palsy.

METHOD

The available data for Serbia, or rather for the territory of Vojvodina, for the period between 1990 and 2009, state that the incidence of cerebral palsy was 0.65 children per 1,000 newborns, with the total number of affected children in the period studied 206 (Drljan, 2011). Due to the low numbers of children with cerebral palsy and the fact that our study was limited to children who, according to the gross motor function classification system (GMFCS), belong in groups I, II and III, we conducted our study with one experimental group, but with two initial (A1 and A2) measurements, and one (B) final measurement. The period between the two initial measurements is the control period, 12 weeks in duration, which was also the duration of the experimental exercise program itself. During the control period, the participants went about their usual daily activities without taking part in the aquatic exercise program. In this way we wanted to determine whether the parameters we wanted to influence were subject to change during the 12 weeks of the control period without the intervention of the program of aquatic exercise. The first initial measurement was conducted at the beginning of the control period, 12 weeks before the second initial measurement. The second initial measurement was performed at the end of the control period, immediately prior to the commencement of the experimental exercise program. The final measurement was taken at the end of the 12-week experimental program of swimming and aquatic exercise. This method has been used in earlier studies exploring the effects of programs of aquatic exercise in children with cerebral palsy (Fragala-Pinkham et al., 2008; Dimitrijević, Bjelaković, Lazović, Stanković and Čolović, 2012).

Sample

The sample comprised 15 children with cerebral palsy, forming one experimental group. The participants were between 6 and 17 years old, and residents of Niš, Bela Palanka, Kuršumlija and Merošina. All of the participants were members of local associations for children with cerebral palsy, or were at the time patients at the Clinic for Physical Medicine, Medical Centre Niš. Selection criteria included the following: 1. the child can move independently or with the help of aids or assistance; 2. the child can follow verbal instructions; 3. the child has not received a botulinum toxin injection type A over the last 6 months; 4. physical exercise is not completely contraindicated for the child; 5. the child can wade in the pool independently or with the help of an instructor; and 6. the parents have given consent for their child to participate in the experimental program of swimming and aquatic exercise. The basic descriptive data on the participants are presented in Table 1.

Table 1 The basic characteristics of the participants

Number of participants	15	
Height (cm)	150.27±10.67	
Weight (kg)	41.3±9.82	
BMI (kg/m^2)	18.07±2.8	
Age	Year range, in years (months)	6(10)-17(06)
	Average age in years (Mean±SD)	12.26±2.97
Sex	Male	6
	Female	9
GMFCS group	I	8
	II	4
	III	3
Type of cerebral palsy	Spastic	14
	Dyskinetic	1
	Ataxic	0
	Combined	0
Deficit distribution	Hemiplegia	8
	Diplegia	3
	Quadriplegia	3

Measures

In order to assess flexibility, 6 different tests were used to determine the following:
1. The range of flexion motion at the shoulder joint.
2. The range of extension motion at the shoulder joint.
3. The range of abduction motion at the shoulder joint.
4. The range of extension motion at the hip joint.
5. The range of abduction motion at the hip joint.
6. The range of dorsal flexion motion at the ankle joint.

Range of motion measurements were taken according to standard procedures (Heyward, 2006). Each movement range was measured three times, and, in accordance with what is recommended (Van Roy and Borms, 2009), the mean of the two closest results was taken as the result.

The following variables were obtained based on the range of motion measurements taken:
1. Mean of the flexion range of motion at the shoulder joint for both arms (SF).
2. Mean of the extension range of motion at the shoulder joint for both arms (SE).
3. Mean of the abduction range of motion at the shoulder joint for both arms (SAb)
4. Mean of the extension range of motion at the hip joint for both legs (HE).
5. Mean of the abduction range of motion at the hip joint for both legs (HAb)
6. Mean of the dorsal flexion range of motion for both legs (DF).

A standard goniometer (produced by ‘MSD Europe bvda’) and a dermographic pen were used to measure range of motion. Measurement precision is 1^0. Studies have confirmed the reliability of using the goniometer to determine the range of motion in children with cerebral palsy (Allington, Reloy and Doneux, 2002; McWhirk and Glanzman, 2006; Mutlu, Livanelioglu and Gunel, 2007). Range of motion measurements were conducted in the dedicated rooms of the Clinic for Physical Medicine, Medical Centre Niš. Measuring was conducted in accordance with the standards of the 2008

Helsinki Declaration on the Ethical Principles for Medical Research Involving Human Subjects (WMA, 2011).

Description of the applied experimental exercise program

The experimental exercise program took place over 12 weeks. The frequency of exercise was three times a week, and the total number of classes was 36. The exercise program was conducted at the Čair Sports Centre swimming pool, comprising a shallow end, 90cm deep, and a deep end, 180cm deep, with a 2m transition from one to the other. The pool's total length is 33m, and its width 10m. Each individual class lasted 60 minutes and comprised two parts, each of the approximate duration of 30 minutes. The objective of the class was to improve swimming skills, increase flexibility, enhance motor function and walking efficiency. In order to meet that objective, during the first portion of the class the Halliwick method for teaching swimming to children with disabilities was used, as well as swimming exercises used in teaching different swimming strokes to persons without disabilities, including crawl, breaststroke and backstroke.

The applied Halliwick method is a psycho-sensory motor learning process which has been found to be efficient with people who require active motor learning or re-learning in a 'slow' medium that limits mechanical influences (Stanat and Lambeck, 2001a; Stanat and Lambeck, 2001b). This swimming method consists of 10 points: 1. Mental adjustment; 2. Sagittal rotation control; 3. Transversal rotation control; 4. Longitudinal rotation control; 5. Combined rotation control; 6. Buoyancy or upthrust; 7. Balancing while still; 8. Turbulent gliding; 9. Simple progression; and 10. Basic (Halliwick) swimming (Lambeck and Gamper, 2009). Depending on the participants' initial levels of swimming ability, different points in the Halliwick program were more or less prominent. In the realization of the above points, the authors applied the exercises acquired at Halliwick courses held in Budapest in 2010, Skoplje 2011, and Lukovska banja 2012. The efficiency of these exercises was practically tested through swimming programs for people with disabilities, conducted as part of the University Swimming Club for People with Disabilities, 'Delfin', from Niš. In teaching crawl, backstroke and breaststroke, swimming exercises used to teach swimming to people without disabilities were used (Madić, Okičić and Aleksandrović, 2007). Seeing as one of the objectives of this study was to increase range of motion in the shoulder joint, during swimming exercises emphasis was placed on increasing the movement amplitude during backstroke and crawl stroke, as well as during the basic Halliwick technique which includes swimming while in a horizontal supine position using simultaneous strokes of both arms.

During the class' second portion, exercises were introduced with the aim of increasing walking efficiency, increasing flexibility or range of motion in certain leg joints, and increasing the strength of certain leg muscles. In order to increase the efficiency of walking, walking exercises with tasks were used. The participants were thus tasked with moving independently or with the help of an instructor as fast as possible from one edge of the pool to the other, switching to a different walk at every third crossing. They were required to move continuously in this way over a period of 10 to 15 minutes. In case a participant was unable to move continuously for 10 to 15 minutes, he or she was allowed to take short breaks.

The following exercises were used in order to increase the strength of leg muscles:

1. Simultaneous extension at the knee joint;
2. Extension at the hip joint;
3. Abduction at the hip joint.

During these exercises, the load or intensity was determined according to the relevant exercise recommendations for beginners and children (Brown, 2007). For strength exercises, weights between 0.5 and 2kg heavy attached at the ankle were used for load. For each exercise the number of repetitions was 10 to 15. Each exercise was done in three sets with a 30-second pause.

The following exercises were used in order to increase the flexibility or range of motion in certain leg joints, static passive stretching was used, including the following exercises:

1. Dorsal flexion of the feet;
2. Abduction at the hip joint;
3. Extension at the hip joint.

1. Dorsal flexion of the feet was performed in the following way: the participant would sit at the edge of the pool, legs bent at 90^0 at the knees and dangling freely in the water. With one hand, the instructor takes the participant's leg at the ankle joint, and, with the other, performs the motion of dorsal flexion by exerting pressure on the participant's foot from the plantar side. The motion is performed until reaching the threshold of pain, held for 30 seconds, and then the same motion is repeated with the other foot. The exercise was performed with three repetitions on each foot. The aim of the exercise was the stretching of the plantar flexor muscles of the foot.

2. Abduction at the hip joint was performed by having the participant stand in water, leaning against the wall of the pool with his or her pelvis and back. The instructor approaches the participant from the front, takes hold of his/her leg below the knee and leads it to the position of maximum abduction, using the other hand to hold the participant at the hip on the side of the leg that is not being moved. The movement is performed until reaching pain threshold and is held for 30 seconds, then the same is repeated with the other leg. Three repetitions are performed for each leg. The aim of this exercise is the stretching of abductor muscles at the hip joint.

3. Extension at the hip joint is performed by having the participant stand in water, leaning against the side of the pool with his/her stomach and front of the pelvis. The instructor approaches laterally, holds the leg at the thigh and leads it to the position of maximum extension. The movement is performed until reaching pain threshold, is held for 30 seconds, and then the same sequence is repeated with the other leg. Three repetitions are performed for each leg. The aim of the exercise is stretching the flexor muscles at the hip joint.

The applied stretching exercises were performed following the recommendations of the American College of Sports Medicine (2009), which state that each stretching exercise should be performed with at least four repetitions, with a frequency of two to three times a week. The end position of the stretch, when pain threshold is reached, should be held for a minimum of 15 to 60 seconds. Following the exercises, the participant floats on his/her back independently or with the help of an instructor for 60 seconds, which marks the end of the class.

Statistical analysis

All results obtained in this study were analyzed using the statistical packages STATISTICA 7 and SPSS 12. For all the variables obtained during the study, the following parameters were calculated: arithmetic means (Mean), standard deviation (SD), range (R), lowest result (Min) and highest result (Max). Due to the small sample size, the Kolmogorov-Smirnov Test (with the significance level set at $p< 0.01$) was used to assess the normality of data (Bala 1990). To determine the difference between the first (A1) and second initial measurements (A2), as well as between the second initial (A2) and final measurements (B), we used the t-test for dependent samples (Thomas, Nelson and Silverman, 2005). The level of significance up to 0.05 ($p \leq 0.05$) is accepted as statistical significance for differences in the results of the variables between the two measurements.

RESULTS

The results of the descriptive statistical analysis for the variables obtained in flexibility tests for all three measurements are presented in Table 2. Based on the results for the means, we find that the participants had the best results at the final measurement, whereas there were no significant differences in the results for all variables between the first and second initial measurements. The results of the Kolmogorov-Smirnov test indicate that the results distribution for all variables does not show a statistically significant difference from normal distribution, enabling us to use the dependent t-test for further analysis of the differences between the measurements.

Table 2 Descriptive statistics for flexibility variables at the 1st and 2nd initial measurements (A1 and A2) and at the final measurement (B)

Measurements	Variables	Mean	SD	R	Min	Max	K-S(p)
1st initial (A1)	SF	171.03	8.96	29.50	150.50	180.00	0.40
	SE	34.43	10.52	37.50	12.50	50.00	0.49
	SAb	164.67	16.23	42.50	137.50	180.00	0.35
	HE	7.97	4.31	13.50	0.00	13.50	0.26
	HAb	27.83	12.51	39.00	3.00	42.00	0.56
	DF	-3.30	8.80	39.00	-30.50	8.50	0.33
2nd initial (A2)	SF	170.73	9.17	29.00	151.00	180.00	0.34
	SE	34.33	10.63	37.50	12.50	50.00	0.48
	SAb	164.53	16.40	42.50	137.50	180.00	0.35
	HE	7.93	4.73	13.50	0.00	13.50	0.41
	HAb	27.47	12.85	39.50	2.50	42.00	0.59
	DF	-3.37	8.55	37.50	-30.00	7.50	0.44
Final (B)	SF	174.13	6.99	21.00	159.00	180.00	0.22
	SE	34.83	10.87	37.50	12.50	50.00	0.59
	SAb	167.20	14.46	34.50	145.50	180.00	0.21
	HE	8.23	4.78	13.50	0.00	13.50	0.22
	HAb	28.23	12.73	39.50	2.50	42.00	0.34
	DF	-2.50	9.01	39.50	-29.50	10.00	0.28

Legend: SF- mean of the flexion range of motion at the shoulder joint for both arms, SE- mean of the extension range of motion at the shoulder joint for both arms, SAb - mean of the abduction range of motion at the shoulder joint for both arms, HE - mean of the extension range of motion at the hip joint for both legs, HAb - mean of the abduction range of motion at the hip joint for both legs, DF - mean of the dorsal flexion range of motion for both legs, Mean - arithmetic mean, SD - standard deviation, R - range, Min - lowest result, Max - highest result, K-S(p) - Kolmogorov-Smirnov Test (significance level $p < 0.01$). The same coding for variables is used in Tables 3 and 4 below.Table 3 presents the results of the dependent t-test between the two initial measurements A1 and A2. The results obtained in this table indicate that there is no statistically significant difference in the flexibility variables between the first and second initial measurements.

Table 3 Difference in the results for flexibility variables between the 1st initial and 2nd initial measurements (dependent t-test)

Variables	1st initial (A1)	2nd initial (A2)	T	df	p
SF	171.03 ± 8.96	170.73 ± 9.17	1.66	14	0.12
SE	34.43 ± 10.52	34.33 ± 10.63	0.90	14	0.38
SAb	164.67 ± 16.23	164.53 ± 16.40	1.47	14	0.16
HE	7.97 ± 4.31	7.93 ± 4.73	0.16	14	0.88
HAb	27.83 ± 12.51	27.47 ± 12.85	1.59	14	0.14
DF	-3.30 ± 8.80	-3.37 ± 8.55	0.27	14	0.79

Legend: Data are reported as means ± SD

Table 4 presents the results of the t-test for dependent samples between the second initial and final measurements (A2 and B).

Table 4 The difference in the results for flexibility variables between the 2nd initial and final measurements (dependent t-test)

Variables	2nd initial (A2)	Final (B)	T	df	p
SF	170.73 ± 9.17	174.13 ± 6.99	-4.01	14.0	0.00*
SE	34.33 ± 10.63	34.83 ± 10.87	-2.01	14.0	0.06
SAb	164.53 ± 16.40	167.20 ± 14.46	-3.80	14	0.00*
HE	7.93 ± 4.73	8.23 ± 4.78	-1.55	14.0	0.14
HAb	27.47 ± 12.85	28.23 ± 12.73	-1.72	14.0	0.11
DF	-3.37 ± 8.55	-2.50 ± 9.01	-1.60	14	0.13

Legend: Data are reported as means ± SD, *significantly different at $p \leq 0.05$

The results obtained in this table indicate that there is a statistically significant difference between the second initial and final measurements in the variables SF and SAb at the significance level p=0.00, whereas there is no statistically significant difference in the other variables.

DISCUSSION

The results indicate that during the control period between the two initial measurements, when no exercise program was applied, there were no statistically significant changes in flexibility in the tested group of children with cerebral palsy. This indicates that the control period between the two initial measurements, in the duration of 12 weeks, was stable, with no changes in flexibility during the period due to the tested group's growth and development. After following the experimental program of swimming and aquatic exercise, a statistically significant increase was perceived in flexibility or range of motion for flexion and abduction motions at the shoulder joint (SF, SAb, p=0.00). Flexion at the shoulder joint increased by 3.4^0, whereas abduction at the shoulder joint increased by 2.7^0. At the end of the applied experimental exercise program, there was a nearly statistically significant increase in flexibility of extension at the shoulder joint (SE, p=0.06). Regarding the increase in range of motion for flexion and abduction at the shoulder joint, the results obtained in our study are similar to the results obtained in the study by Chrysagis et al. (2009). Following the application of a swimming program, these authors also identified a statistically significant improvement in flexion and abduction at the shoulder joint. Unlike in our study, the range of motion increase in theirs was more substantial for the above motions at the shoulder joint, with 15^0 for flexion and around 20^0 for abduction. The exercise program consisted solely of swimming lessons in the duration of 45 minutes, a frequency of two times a week, and a total program duration of 10 weeks. The participants in their study were six children with cerebral palsy, with diplegia and quadriplegia. Similar to their study, Peganoff (1984) also identified an increase in range of motion at the shoulder joint, of 15^0 for flexion and 10^0 for abduction, in a single female child with right hemiplegia after applying a swimming program for 8 weeks with a class frequency of twice a week. Hung (2003) also identified an increase in range of motion at the shoulder joint in 8 children with diplegic cerebral palsy, following a 20-week swimming program, with 60-minute lessons given three times a week. One reason behind the lesser resultant increase in the range of motion at the shoulder joint in our study, compared to Peganoff (1984) and Chrysagis et al. (2009), lies in the different way of measuring the range of motion. Furthermore, the different focus of the programs applied could be another reason. The emphasis in the above studies was on swimming and the performance of the crawl and backstroke swimming techniques, where shoulder joint movements are dominant, whereas in our study other aquatic exercises were applied in addition to swimming.

Regarding the range of motion for extension and abduction at the hip joint, as well as for dorsal flexion, the applied program of swimming and aquatic exercise did not lead to a statistically significant increase in range of motion. Numerically, there was an improvement in flexibility after the applied exercise program; however, these changes were not statistically significant. Similarly, Hung (2003) found no statistically significant increase in range of motion in the above joints and their related motions. As in our study, Chrysagis et al. (2009) found no increase in the active range of motion for abduction at the hip joint, but did find this increase in the passive range. Fragala-Pinkham et al.'s (2009) study of a child with spastic diplegia found no increase in the passive range of motion for dorsal flexion after a 6-week program of aquatic exercise and exercise on land. Armstrong and Yaggie (2001) studied a program which comprised, among other elements, aquatic activities for one hour over 9 weeks, and its effects on increasing flexibility at the joints of the hip, knee and foot in children with cerebral palsy. Based on the results they obtained, these authors concluded that aquatic activities do not hold long-term effects related to increasing range of motion in the joints of the lower extremities.

Based on the analysis of the results obtained in our and similar studies, we believe that the increase in range of motion for flexion and abduction at the shoulder joint in children with cerebral palsy is primarily due to the he fact that this joint is significantly engaged in swimming, or, more precisely, in performing the stroke in the backstroke, crawl, and in the Halliwick swimming technique (point 10 of the Halliwick program), which includes swimming in a horizontal position on the back with simultaneous strokes of both arms. We propose that there is no increase in the range of motion in the leg joints due to the smaller motion amplitude in these joints when swimming, compared to the relevant motion amplitudes at the shoulder joint. We also acknowledge that the weekly frequency and number of repetitions for passive stretching exercises in our study was not sufficient to lead to a statistically significant increase in range of motion for extension and abduction at the hip joint, or for dorsal flexion. These results are similar to the review article by Pin et al. (2006), which found that certain results recommend the application of passive stretching in children with cerebral palsy, noting that the effects obtained are small. In accordance with the above, we propose that further studies are needed where, instead of passive stretching exercises, specific active aquatic exercises would be used so as to evaluate their influence on increasing the range of motion and flexibility at the hip joint and dorsal flexion in children with cerebral palsy.

CONCLUSIONS

Based on the analysis of the obtained results, we conclude that the applied program of swimming and aquatic exercise was efficient in that it increased flexibility, which leads to increased the range of motion of flexion and abduction at the shoulder joint in the tested group of children with cerebral palsy. The effects that were identified were primarily a result of the increased amplitude of motion and engagement of the shoulder joint when performing the stroke, alternately or simultaneously, during the backstroke, which is the most common swimming technique in children with cerebral palsy. Regarding the increase in the range of flexion and extension motions at the hip joint and dorsal flexion, the applied program also led to positive changes in the form of increasing the range of motion, but without statistical significance. We therefore conclude that the program of swimming and aquatic exercise should be modified when it comes to increasing the flexibility of leg joints. Consequently, a program of active exercises for the increase of the range of motion at the hip joint and dorsal flexion could be applied in children with cerebral palsy, and their effects assessed. Regarding the increase in abduction and flexion at the shoulder joint, the results achieved with the applied program are satisfactory.

REFERENCES

Allington, N., Leroy, N., & Doneux, C. (2002). Ankle Joint Range of Motion Measurements in Spastic Cerebral Palsy Children: Intraobserver and Interobserver Reliability and Reproducibility of Goniometry and Visual Estimation. *Journal of Pediatric Orthopedics B*, 11 (3), 236-239.

American college of sports medicine (2009). *ACSM guidelines for exercise testing and prescription, eighth edition.* Baltimore: Lippincott Williams & Wilkins.

Armstrong, W., & Yaggie, J. (2001). The effect of play therapy on the flexibility of children with cerebral palsy, *Medicine & Science in Sports & Exercise,* 33 (5), S1, 248.

Bala, G. (1990). *Logičke osnove metoda za analizu podataka iz istraživanja u fizičkoj kulturi, (The logical bases of the methods for data analysis in studies of physical education).* Novi Sad: SIA.

Brown, L. (2007). *Strength training*. Champaign: Human Kinetics.

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. *Biology of Exercise,* 5 (2), 13-25.

Dimitrijević, L., Bjelaković, B., Lazović, M., Stanković, I., Čolović, H., Kocić, M., & Zlatanović, D. (2012). Primena hidrokineziterapije u lečenju dece s cerebralnom paralizom, (Aquatic Exercise in the Treatment of Children with Cerebral Palsy), *Srp Arh Celok Lek,* 140 (11-12), 746-750.

Drljan, Č. (2011). *Faktori rizika i karakteristike dečje cerebralne paralize.* (*Cerebral palsy in children: risk factors and characteristics).* Unpublished doctoral thesis, Novi Sad: Faculty of medicine, University of Novi Sad.)

Fragala-Pinkham, M., Dumas, H., Barlow, C., & Pasternak, A. (2009). An aquatic physical therapy program at a pediatric rehabilitation hospital: a case series. *Pediatric Physical Therapy,* 21 (1), 68-78.

Getz, M., Hutzler, Y., & Vermeer, A. (2006b). Effects of aquatic interventions in children with neuromotor impairments: a systematic review of the literature. *Clinical Rehabilitation,* 20 (11), 927-936.

Gorter, J., & Currie, S. (2011). Aquatic Exercise Programs for Children and Adolescents with Cerebral Palsy: What Do We Know and Where Do We Go? *International Journal of Pediatrics,* 2011, 1-7.

Heyward, V. (2006). *Advanced fitness assessment and exercise prescription,* 5th edition. Champaign: Human Kinetics.

Hung, M. (2003). *A study of swimming teaching strategy for diplegia spastic type cerebral palsy children: evaluation with angle of joint.* Master thesis. Graduate Institute of Elementary Education. Nađen 10. 10. 2012, WWW: http://140.133.6.46/ETD-db/ETD-search/view_etd?URN=etd-0721104-085231

Jorgić, B., Dimitrijević, L., Lambeck, J., Aleksandrović, M., Okičić, T., & Madić, D. (2012). Effects of aquatic programs in children and adolescents with cerebral palsy: systematic review. *Sport science,* 5 (2), 49-56.

Kelly, M., & Darah, J. (2005). Aquatic exercise for children with cerebral palsy. *Developmental Medicine & Child Neurology,* 47 (12), 838-842

Lambeck, J., & Gamper, U. (2009). *The Halliwick Concept*. In: L. Brody, & P. Geigle, Aquatic Exercise for Rehabilitation and Training (pp. 45-71). Champaign: Human Kinetics.

Lockette, K.F., & Keyes, A.M. (1994). *Conditioning with physical disabilities.* Champaign: Human Kinetics.

Madić, D., Okičić, T., & Aleksandrović, M. (2007). *Plivanje.* (*Swimming).* Niš: Faculty of Sports and Physical Education, University of Niš.

McWhirk, B., & Glanzman, A. (2006). Within-Session Inter-Rater Realiability of Goniometric Measures in Patients with Spastic Cerebral Palsy. *Pediatric Physical Therapy,* 18 (4), 262-265.

Mutlu, A., Livanelioglu, A., & Gunel, M. (2007). Reliability of goniometric measurements in children with spastic cerebral palsy. *Medical Science Monitor,* 13 (7), 323-329.

Papavasiliou, A. (2009). Management of motor problems in cerebral palsy: A critical update for the clinician. *European Journal of Paediatric Neurology,* 13 (5), 387-396.

Peganoff, SA. (1984). The use of aquatics with cerebral palsied adolescents. *American Journal of Occupational Therapy,* 38 (7), 469-473.

Pin, T., Dyke, P., & Chan, M. (2006). The effectiveness of passive stretching in children with cerebral palsy. *Developmental Medicine & Child Neurology,* 48 (10), 855-862.

Porretta (2005). *Cerebral palsy, traumatic brain injury, and stroke.* In J. Winnick (Ed.), Adapted physical education and sport. (pp. 235-254). Champaign: Human Kinetics.

Prins, J.H. (2009). Aquatic rehabilitation. *Serbian Journal of Sports Sciences*, 3(1-4), 45-51.

Prosser, L., & Damiano, D. (2012). *Biomechanical and neuromuscular aspects of motor development in children with cerebral palsy.* In M. De Ste Croix, & T. Korff, Paediatric Biomechanics and Motor Control: theory and application (pp. 283-306). Abingdon, Oxon: Routledge.

Stanat, F., & Lambeck, J. (2001a). The Halliwick method. *AKWA,* (15), 39-41.

Stanat, F., & Lambeck, J. (2001b). The Halliwick method: Therapeutic application. *AKWA,* 39-42.

Surveillance of cerebral palsy in Europe (2000). Surveillance of cerebral palsy in Europe: a collaboration of cerebral palsy surveys and registers. *Developmental Medicine & Child Neurology*, 42 (12), 816-824.

Thomas, J. R., Nelson, J. K., & Silverman, S. J. (2005). *Research method in physical activity, 5th edition.* Champaign: Human Kinetics.

Van Roy, P., & Borms, J. (2009). *Flexibility*. In Eston, R., & Reilly, T. Kinanthropometry and exercise physiology laboratory manual, Tests, procedures and data, third edition. (pp 129-160). Routledge: New York.

Wiart, L., Darrah, J., & Kembhavi, G. (2008). Stretching with Children with Cerebral Palsy: What Do We Know and Where Are We Going? *Pediatric Physical Therapy*, 20 (2), 173-178.

World Medical Association (2011). Hand book of WMA policies. Accessed 15. 11. 2012, WWW: http://www.wma.net/en/30publications/10policies/b3/index.html.

UTICAJ PROGRAMA PLIVANJA I VEŽBANJA U VODI NA FLEKSIBILNOST DECE SA CEREBRALNOM PARALIZOM

Cilj ovog istraživanja bio je da se utvrde efekti primene programa plivanja i vežbanja u vodi na poboljšanje fleksibilnosti dece sa cerebralnom paralizom. U istraživanju je učestvovalo 15 dece sa cerebralnom paralizom, starosti 6 do 17 godina, sa GMFCS nivoima I, II i III. Primenjen program vežbanja sastojao se od plivanja i vežbanja u vodi. Program plivanja obuhvatao je Halivik metodu, kao i vežbanje različitih stilova plivanja, leđno, prsno i plivanje slobodnim stilom. Progam vežbanja u vodi sastojao se od vežbanja za poboljšanje fleksibilnosti mišića nogu i vežbi snage, kao i vežbi hodanja. Program vežbanja trajao je 12 nedelja, tri puta nedeljno, a svaki čas je trajao 60 minuta. Na osnovu rezultata testova za procenu fleksibilnosti ili opsega kretanja, prikupljeno je 6 varijabli. Rezultati ukazuju na to da je primenjeni program doprineo statistički značajnom povećanju u rasponu fleksibilnosti i pokreta abdukcije ramenog pojasa na nivou značajnosti od p=0.00. Što se tiče opsega ekstenzije i pokreta abdukcije kukova, kao i dorsalne fleksije, poboljšanje je takođe utvrđeno, ali bez statistički značajne razlike. Na osnovu analize *postignutih rezultata, zaključili smo da je primenjem program plivanja i vežbanja u vodi efikasan način za povećanje fleksibilnosti ili raspona fleksibilnosti i pokreta abdukcije ramenog pojasa, dok program zahteva modifikacije kako bi doprineo poboljšanju fleksibilnosti zglobova nogu.*

Ključne reči: *vežbanja u vodi, ishod, rameni pojas, kukovi, cerebralna paraliza.*