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PLYOMETRIC TRAINING VERSUS STRENGTHENING EXERCISE ON PHYSICAL AND PSYCHOSOCIAL FUNCTIONING IN CHILDREN WITH HEMIPLEGIA

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ABSTRACT

The aim of this study was to compare between the effect of plyometric training and strengthening exercise on physical and psychosocial functioning in children with hemiplegic cerebral palsy.

Thirty-four children with hemiplegic cerebral palsy (CP) from both sexes were participated in this study. Their ages were ranged from 8 to 10 years old and they were randomly assigned into two equal groups (A and B). Both groups received designed physical therapy program. In addition, children in groups (A) received strengthening exercise, while children in group (B) received plyometric training three sessions per week for twelve consecutive weeks. Physical and psychosocial functioning for each child were assessed before and after the treatment by Pediatric quality of life inventory (PedsQL).

The results showed that there was a significant improvement in physical and psychosocial functioning in group (A and B) post-treatment compared with pre-treatment ($p = 0.001$). By comparing post-treatment mean values of both groups, there was a significant improvement in favor to group (B).

It could be concluded that plyometric training is an effective treatment modality that can be used in improving quality of life in children with hemiplegic cerebral palsy.

Key Words: Children; Hemiplegia; Quality of life; Plyometric training; Strengthening exercise.

INTRODUCTION

Cerebral palsy (CP) is a term for a group of disorders characterized by non-progressive damage to the developing brain, resulting in impaired

motor function due to abnormal control of the central nervous system over skeletal musculature **(Seifart *et al.*, 2019).**

Among children with CP, 29% have hemiplegia, that is, one side of the body is affected much more than the other, and the upper limb is typically more involved than the lower limb **(Beaman *et al.*, 2015).**

Hemiplegic CP enormously affects the quadriceps and hamstring muscles. It causes weakness in the affected lower-extremity muscles in addition to muscle imbalance and inadequate power production, especially in the ankle plantar-flexor and knee extensor muscles. It also causes anomalous delayed myoelectrical action of the medial hamstring **(Hegazy *et al.*, 2021).**

Symptoms of hemiplegic CP range widely from spasticity, impaired motor organization and functioning, movement impairments, lack of postural control, changes in walk patterns, balance problems, motor control impairments to cognitive and intellectual problems **(Picelli *et al.*, 2017).**

Severity of CP is associated with low physical quality of life (QOL) **(Vargus-Adams, 2015).** QOL refers to the general well-being of individuals and societies, and is defined by the World Health Organization as "an individual's perception of their position in life in the context of the culture and value systems in which they live, and in relation to their goals, expectations, standards and concerns" **(Park, 2018).** Children with HCP experience reduced QOL and self-concept compared with typically developing peers **(Russo *et al.*, 2018)**.

Strength training has been increasingly evidenced as an effective therapeutic intervention for improving muscle strength, walking function and alignment as well as quality of life (QOL) of CP children. In addition, strengthening may improve mobility functions such as walking speed, wheel chair propulsion and sit-to-stand function **(Damiano *et al.*, 2010)**.

Plyometric training is defined as quick, powerful movement involving a system of reactive exercises and an eccentric contraction, followed immediately by an explosive concentric contraction. Plyometric training is built upon various scientific principles (stretch-shortening cycle, optimizing sarcomere length, and stretch reflexes) that can help individuals tremendously boost their power output **(McGill and Montel 2019).**

However, to our knowledge no studies compared between the effect plyometric training and strengthening exercise on improving quality of life in children with hemiplegic cp. Thus, the novel purpose of the present study was to compare the effect of plyometric training and strengthening exercise on quality of life in children with hemiplegic cp.

MATERIALS AND METHODS

Ethical consideration

The ethical committee of this study was approved by the Research Ethical Committee, Faculty of physical therapy, Cairo University, Giza, Egypt (P.T.REC/012/003540). The procedures of the study were explained to the parents, all of whom signed consent forms.

Sample size

Utilizing G*POWER statistical software (version 3.1.9.2; Franz Faull, Universidad Kiel, Germany), the minimum proper sample size for the current study was determined to be 34 children in both groups. Calculations were made using α=0.05, β=0.2 and effect size =0.4 and allocation ratio N2/N1 =1.

Study design

This study was a randomized comparative clinical trial that was applied from June to December 2022. Thirty-four children were assigned randomly to two groups using closed envelopes to avoid selection bias; group (A) included 17 children received strengthening exercise and designed physical therapy program, while group (B) included 17 children received plyometric training and the same designed physical therapy program.

Participants

Thirty four children with hemiplegic cerebral palsy were recruited from Out-Patient Clinic of the Faculty of physical therapy, Cairo University, Giza, Egypt.

The inclusion criteria was as follow: a) the children aged between 8 to 10 years, b) their level of spasticity ranged from grade 1 to grade 1+ according to Modified Ashworth scale (MAS) **(Meseguer-Henarejos *et al.*, 2018)**, c) their level of motor function was grade 1 according to Gross Motor Functional Classification System (GMFCS) **(Palisano *et al.*, 2018)**, d) they can understand and follow the orders. Children were excluded if they had i) orthopedic surgery past one year, ii) Visual or auditory problems that interfere with rehabilitation programs, iii) Botox injection in past 6 months prior to the study, iv) Cardiac problems or uncontrolled seizures.

Instrumentation

1- Pediatric Quality Of Life Inventory:

It's a questionnaire for the child about child's physical, emotional, social, and school functioning in the past one month. It is a 23-item generic health status instrument with parent and child forms that assesses

five domains of health (physical functioning, emotional functioning, psychosocial functioning, social functioning, and school functioning) in children and adolescents ages 2 to 18. The inventory takes approximately 5 minutes to complete. The PedsQL 4.0 has been proposed as a valid and reliable generic pediatric HRQOL measurement that can be used for self-reports in age groups ranging from 2 to 18 years and can also be used in clinical practice, clinical trials, and research, as well as school health settings, and community populations **(Varni *et al.*, 2005)**.

Procedures

Evaluation

1-Evaluation of pediatric quality of life (physical and psychosocial functioning):

Firstly the clinician read the instructions to the child and let him answered the questions. The child sat in comfortable room, far from any distributing factors. When the child could not answer a question, clinician asked him to choose the closest answer he/she feel. It took about 5 minutes to complete. On the PedsQL Generic Core Scales, for ease of interpretability, items were reversed scored and linearly transformed to a 0-100 scale, so that higher scores indicate better HRQOL (Health-Related Quality of Life). To reverse score, transform the 0-4 scale items to 0-100 as follows: 0=100, 1=75, 2=50, 3=25, 4=0 **(Stuart and Goldstein 2008)**.

Intervention

Both groups received designed physical therapy program (stretching exercises for hamstring and calf muscles, balance exercises and climbing stairs exercises) **(Rothermel, 2004 ; Berker and Yalçin 2008)** for 30 minutes per session, 3 sessions/week for 3 successive months. Children in groups (A) received strengthening exercise, while children in group (B) received plyometric training.

Strengthening exercises

Each child received strengthening exercise for quadriceps and hamstring muscles. The children were positioned in sitting for quadriceps and prone for hamstring with free weights attached to the ankle. The training weight used was 65% of the maximum isometric muscle strength value for each child for 3 sets (8-15) repetitions with one minute rest between each set. The session lasted for 30 minutes per session, 3 sessions/week for 3 successive months.

Plyometric training

Each child in this group received plyometric training program for 30 minutes per session, 3 sessions/week for 3 successive months. According to **McNeely and Sandler (2007)** as follows:

1- Vertical jumping:

Each child was asked to stand with feet about shoulder width apart. Swing the arms back and quickly squat until the knees bent to about 120 degrees. Explode upward extending the knees, hips, ankles and trunk while swinging the arms forward and upward as explosively as possible. Focused on completely extending the body, reaching as high as possible.

2- Lateral jumping:

The objective was to jump as far sideways as possible, taking off and landing on both feet. Started with feet about shoulder width apart. Swing the arms back and quickly squat until the knees bent to about 120 degrees. Explode upward and sideways extending the knees, hips, ankles and trunk while swinging the arms forward and slightly sideways as explosively as possible.

3- Forward jumping:

Child stood in an upright position with knees slightly bent and feet about shoulder-width apart. Quickly dropped body by flexing the knees and rapidly explode upward and to the front. Swing arms forcefully upwards and out. Concentrated on maximizing the distance traveled forward, staying low to the ground. Upon landing, immediately repeat the jump.

4- Side to side jumping:

Child stood in an upright position with knees slightly bent and feet about shoulder-width apart. Quickly dropped the body by flexing the knees and rapidly, explode upward to the side. Swing arms forcefully upwards. Upon landing, immediately repeat the jump, but jump to the other side.

5- Box landing:

The box was high enough that the knees don't bend any more than 120° during the landing. After stepping up, child stood on the box with feet shoulder width apart. Step off the box and land with both feet by landing on the balls of the feet, bending the knees and slightly inclining the trunk**.**

6- Step jumping:

It required a step, in height about 5 inches. The step was solidly built with a non-slip landing surface. Child stood facing the step with feet about shoulder width apart. Rapidly, squat then swing the arms driving them upwards and jump onto the step. Child jumped just high enough to land on the step in a half squat position. Returned to the ground by stepping down or hopping off the step.

Each exercise took 3 minutes with 2 minutes rest**.**

RESULTS:

- General characteristics of the subjects:

Group (A):

Seventeen children with hemiplegia were included in this group. Their mean ± SD age, weight and height were 8.64 ± 0.7 years old, 28.76 ± 2.07 kg and 129.94 ± 2.63 cm respectively (Table 1).

Group (B):

Seventeen children with hemiplegia were included in this group. Their mean ± SD age, weight and height were 8.71 ± 0.84 years old, 29.52 ± 2 kg and 130.64 ± 3.42 cm respectively (Table 1).

Comparing the general characteristics of the subjects of both groups revealed that there was no significant difference between groups in age, weight, and height ($p > 0.05$).

Table (1): Comparison of age, weight and height between groups (A and B).

	Group (A)	Group (B)	MD	t- value	p-value	Sig
	$\overline{X}$ ±SD	$\overline{X}$ ±SD				
Age (years)	8.64 ± 0.7	8.71 ± 0.84	-0.07	-0.22	0.82	NS
Weight (kg)	28.76 ± 2.07	29.52 ± 2	-0.76	-1.09	0.28	NS
Height (cm)	129.94 ± 2.63	130.64 ± 3.42	-0.7	-0.67	0.51	NS

$\overline{X}$: Mean SD: Standard deviation MD: Mean difference
t values: Unpaired t values p values: Probability values NS: Non significant

- Sex distribution:

The sex distribution of group A revealed that there were 7 (41%) girls and 10 (59%) boys. The sex distribution of group B revealed that there were 6 (35%) girls and 11 (65%) boys as shown in Table (2). There was no significant differene between groups in sex distribution ($p = 0.72$).

Table (2): Comparison of sex distribution between groups (A and B).

	Group (A)	Group (B)	χ^2	p-value	Sig
Girls	7 (41%)	6 (35%)	0.12	0.72	NS
Boys	10 (59%)	11 (65%)			

χ^2 : Chi squared value p value: Probability value NS: Non significant

- Affected side distribution:

The affected side distribution of group (A) revealed that there were 9 (53%) children with right side affected and 8 (47%) children with left side affected. The affected side distribution of group (B) revealed that there were 8 (47%) children with right side affected and 9 (53%) children with left side affected as shown in Table (3). There was no significant difference between groups in affected side distribution ($p = 0.73$).

Table (3): Comparison of affected side distribution between groups (A and B).

	Group (A)	Group (B)	χ^2	p-value	Sig
Right side	**9 (53%)**	**8 (47%)**	**0.11**	**0.73**	**NS**
Left side	**8 (47%)**	**9(53%)**			

χ^2: Chi squared value p value: Probability value NS: Non significant

- Spasticity grades distribution:

The spasticity grades distribution of group A revealed that there were 10 (59%) children with grade I and 7 (41%) children with grade I+. The spasticity grades distribution of group B revealed that there were 12 (71%) children with grade I and 5 (29%) children with grade I+ as shown in Table (4). There was no significant difference between groups in spasticity grades distribution (p = 0.47).

Table (4): Comparison of spasticity grades distribution between group A and B.

	Group (A)	Group (B)	χ^2	p-value	Sig
Grade I	**10 (59%)**	**12 (71%)**	**0.52**	**0.47**	**NS**
Grade I+	**7 (41%)**	**5 (29%)**			

χ^2: Chi squared value p value: Probability value NS: Non significant

- Comparison of GMFCS between control and study groups:

The median (IQR) of GMFS of group A was 1 (1-1) and that of group B was 1 (1-1). There was no significant difference in GMFS between groups (A and B) (p = 1) (Table 5).

Table (5): Comparison of GMFS between groups (A and B).

	Group (A) Median (IQR)	Group (B) Median (IQR)	U-value	p-value	Sig.
GMFS	1 (1-1)	1 (1-1)	144.5	1	**NS**

IQR, inter quartile range U- value, Mann-Whitney test value
p value: Probability value NS: Non significant

I. Pre-treatment mean values of PedsQL of both groups (A and B):

Physical functioning:

The mean ± SD value of physical functioning pre-treatment of group (A) was 36.27 ± 16.45 and that of group (B) was 34.56 ± 15.22. The mean difference between groups were 1.71. There was no significant difference in physical functioning between groups pre-treatment (p = 0.75) (Table 6).

Psychosocial functioning:

The mean ± SD value of psychosocial functioning pre-treatment of group (A) was 41.17 ± 11.49 and that of group (B) was 45.58 ± 9.82. The

mean difference between groups was -4.41. There was no significant difference in psychosocial functioning between groups pre-treatment (p = 0.23) (Table 6).

Table (6): Comparison of pre-treatment mean values of PedsQL between groups (A and B).

PedsQL	Group (A) $\bar{X}$ ± SD	Group (B) $\bar{X}$ ± SD	MD	t- value	p-value	Sig
Physical functioning	36.27 ± 16.45	34.56 ± 15.22	1.71	0.31	0.75	NS
Psychosocial functioning	41.17 ± 11.49	45.58 ± 9.82	-4.41	-1.2	0.23	NS

$\bar{X}$: Mean SD: Standard deviation MD: Mean difference
t value: Unpaired t value p value: Probability value NS: Non significant

II. Pre- and post-treatment mean values of PedsQL of group (A):

Physical functioning:

The mean ± SD value of physical functioning pre-treatment of group (A) was 36.27 ± 16.45 and that post treatment was 45.24 ± 11.11. The mean difference was -8.97 and the per cent of change was 24.73%. There was a significant increase in physical functioning of group (A) post treatment compared with pre-treatment (p = 0.001) (Table 7).

Psychosocial functioning:

The mean ± SD value of psychosocial functioning pre-treatment of group (A) was 41.17 ± 11.49 and that post treatment was 64.26 ± 12.86. The mean difference was -23.09 and the per cent of change was 56.08%. There was a significant increase in psychosocial functioning of group (A) post treatment compared with pre-treatment (p = 0.001) (Table 7).

Table (7): Comparison between pre- and post-treatment mean values of PedsQL of group (A).

PedsQL	Pre treatment $\bar{X}$ ± SD	Post treatment $\bar{X}$ ± SD	MD	% of change	t-value	p-value	Sig
Physical functioning	36.27 ± 16.45	45.24 ± 11.11	-8.97	24.73	-3.33	0.004	S
Psychosocial functioning	41.17 ± 11.49	64.26 ± 12.86	-23.09	56.08	-7.2	0.001	S

x̄: Mean SD: Standard deviation MD: Mean difference
t value: Paired t value p value: Probability value S: Significant

III. Pre- and post-treatment mean values of PedsQL of group (B):

Physical functioning:

The mean ± SD value of physical functioning pre-treatment of group (B) was 34.56 ± 15.22 and that post treatment was 53.72 ± 8.81. The mean difference was -19.16 and the per cent of change was 55.44%.

There was a significant increase in physical functioning of group (B) post treatment compared with pre-treatment (p = 0.001) (Table 8).

Psychosocial functioning:

The mean ± SD value of psychosocial functioning pre-treatment of group (B) was 45.58 ± 9.82 and that post treatment was 76.03 ± 9.76. The mean difference was -30.45 and the per cent of change was 66.81%. There was a significant increase in psychosocial functioning of group (B) post treatment compared with pre-treatment (p = 0.001) (Table 8).

Table (8): Comparison between pre- and post-treatment mean values of PedsQL of group (B).

PedsQL	Pre treatment $\bar{x}$ ± SD	Post treatment $\bar{x}$ ± SD	MD	% of change	t-value	p-value	Sig
Physical functioning	34.56 ± 15.22	53.72 ± 8.81	-19.16	55.44	-9.55	0.001	S
Psychosocial functioning	45.58 ± 9.82	76.03 ± 9.76	-30.45	66.81	-8.75	0.001	S

$\bar{x}$: Mean SD: Standard deviation MD: Mean difference
t value: Paired t value p value: Probability value S: Significant

IV. Post treatment mean values of PedsQL of both groups (A and B):

Physical functioning:

The mean ± SD value of physical functioning pre-treatment of group (A) was 45.24 ± 11.11 and that of group (B) was 53.72 ± 8.81. The mean difference between groups was -8.48. There was a significant increase in physical functioning of group (B) compared with that of group (A) post treatment (p = 0.01) (Table 9).

Psychosocial functioning:

The mean ± SD value of psychosocial functioning pre-treatment of group (A) was 64.26 ± 12.86 and that of group (B) was 76.03 ± 9.76. The mean difference between groups was -11.77. There was a significant increase in psychosocial functioning of group (B) compared with that of group (A) post treatment (p = 0.005) (Table 9).

Table (9): Comparison of post treatment mean values of PedsQL between groups (A and B).

PedsQL	Group (A) $\bar{x}$ ± SD	Group (B) $\bar{x}$ ± SD	MD	t- value	p-value	Sig
Physical functioning	45.24 ± 11.11	53.72 ± 8.81	-8.48	-2.46	0.01	S
Psychosocial functioning	64.26 ± 12.86	76.03 ± 9.76	-11.77	-3.01	0.005	S

$\bar{X}$: Mean SD: Standard deviation MD: Mean difference
t value: Unpaired t value p value: Probability value S: Significant

DISCUSSION:

This study was applied to compare between the effect of plyometric training and strengthening exercise on quality of life in children with hemiplegic cp. The current results revealed that there were a statistical

significant difference in the post treatment mean values of the outcome measures between both groups post treatment in favor to group (B).

Arnaud *et al.*, (2008), proposed that social interactions, school environment, and other social factors play a larger role in determining a child's psychosocial QOL.

The post treatment improvement in physical and psychosocial functioning among children in group (A) may be due to the effect of strengthening exercises that improve strength of lower limb muscles, reduce risk of falls and maintain independency that is supported by **Abd-Elfattah *et al.*, (2022),** who found that strengthening training has the potential to produce significant improvements in hip and knee extensor strength and functional walking capacity. That will enhance QOL in children with hemiplegic CP indirectly.

Also, these results are supported by **Eagleton *et al.*, (2004),** who stated that strengthening exercise increase balance, step length, sense of well-being and self-confidence allowing them to adapt better to the demands of walking. The combination of the above factors resulted in ability to ambulate faster with less energy expenditure. In consequence leading to improve psychosocial QOL in children with HCP.

The post treatment improvement in physical and psychosocial functioning among children in group (B) may be due to the effect of plyometric training improves weight-bearing symmetry in children with hemiplegic CP .This come in agreement with **Elnaggar *et al.*, (2019),** who stated that the plyometric training is more likely to provide a favorable clinical impact on weight-bearing on the affected side and more transfer of the body-weight. Due to the overreliance on the uninvolved lower extremity and inability of the musculature in the involved side to adequately support the body weight during standing and walking activities.

In addition , these results are supported by **Elnaggar *et al.*, (2022),** who reported that plyometric group demonstrated that 8–12 weeks of training were enough to yield significant changes in several aspects of motor function such as muscle strength, postural control, balance and functional ability to respond to environmental threats and improve gait. As a consequence of this improvement, participation of children in community and environment increase that indirectly improve their QOl.

Also, the improvement in the outcome measures among children in group (B) is supported by the study conducted by **Johnson *et al.*, (2014),** who reported that plyometric training improves gross motor

ability, agility, and upper extremity power in children with unilateral cerebral palsy.

Limitations:

The current study was limited to one type of children with cerebral palsy, age ranged from 8-10 years and GMFCS was at level I only. So, other studies are required on another type of CP, another age range and different level on GMFCS.

CONCLUSION

Plyometric training is more beneficial modality in improving physical and psychosocial functioning and can be used as a rehabilitation program in children with hemiplegic cerebral palsy to improve their quality of life.

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تدريب البليوميترك مقابل تمارين التقوية علي الآداء الجسدي والنفسي في الأطفال المصابين بالفالج الشقي

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3- قسم العلاج الطبيعي لاضطراب النمو والتطور عند الأطفال وجراحتها – كلية العلاج الطبيعي – جامعه القاهره.

الهدف من هذه الدراسة هو مقارنة تدريب البليوميترك مقابل تمارين التقوية على الآداء الجسدي والنفسي في الأطفال المصابين بالفالج الشقي.

أربعة و ثلاثون طفلا من المصابين بالفالج الشقي من الجنسين شاركوا في هذه الدراسة، حيث تتراوح اعمارهم بين 8-10 سنوات و تم تقسيمهم عشوائيا الى مجموعتين متساويتين (أ ، ب). المجموعتين تلقوا برنامج العلاج الطبيعي التقليدي (تمارين الاطالة لعضلات الركبة الخلفية والسمانة، تمارين الاتزان و تمارين صعود السلم). المجموعة (أ) تلقوا تمارين التقوية بينما المجموعة (ب) تلقوا تدريب البليوميترك ثلاث مرات اسبوعيا لمدة 12 اسابيع متتالية. تم تقييم الاطفال قبل و بعد العلاج بواسطة مقياس جودة حياة الأطفال.

أظهرت النتائج وجود فروق ذات دلالة إحصائية للآداء الجسدي والنفسي للمجموعتين. كما أظهرت وجود فروق ذات دلالة إحصائية لجميع المتغيرات لصالح المجموعة (ب) عند مقارنة بين المجموعتين (أ ، ب).

يمكن استنتاج ان تدريب البليوميترك هو طريقة علاج فعالة يمكن استخدامها في تحسين نوعية الحياة لدى الأطفال المصابين بالفالج الشقي.