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Equine-assisted intervention in children with spastic quadriplegia: The effect on function and balance
A prospective study

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Παρέμβαση υποβοηθούμενη από άλογα σε παιδιά με σπαστική τετραπληγία: Η επίδραση στη λειτουργικότητα και στην ισορροπία. Προοπτική μελέτη

Περίληψη στο τέλος του άρθρου

OBJECTIVE **To investigate the efficacy of equine-assisted intervention (EAI) in children with spastic quadriplegia. The parameters that evaluated were gross motor function, performance, balance, and spasticity, and whether the resulting improvement remained two months after the completion of the EAI.** METHOD **Fourteen children with spastic quadriplegia participated in the study that lasted 28 weeks. The intervention lasted 12 weeks and took place once per week for 30 minutes. Gross Motor Function Measure (GMFM), Gross Motor Performance Measure (GMPM), Gross Motor Function Classification System (GMFCS), Pediatric Balance Scale (PBS), Modified Ashworth Scale (MAS) and Wechsler Intelligence Scale for Children (WISC III) were used for the evaluation of each child's physical performance and mental capacity.** RESULTS **The results showed statistically significant improvements in total GMFM and in all subcategories ($p<0.05$), also in total GMPM, and all subcategories ($p<0.05$), and PBS. These GMFM and PBS results remained present two months after the last session of EAI. A spasticity improvement trend was seen but without reaching statistical significance.** CONCLUSIONS **The results of our study suggest that EAI improves gross motor function, gross motor performance and balance in children with spastic quadriplegia, with clinical significance.**

Key words

Balance
Equine-assisted intervention
Gross motor function
Quadriplegia
Spasticity

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Cerebral palsy (CP) is a permanent, non-progressive encephalopathy that occurs in the immature brain during its development, before, during, and up to two years after birth. Its clinical manifestations depend on the extent, type and location of the damage in the central nervous system (CNS), as well as on the ability of the CNS to adapt or get reorganized in response to changes.[1] Take into account its anatomical (topographic) distribution, CP classified according to the number of limbs affected such as hemiplegia, diplegia, triplegia and quadriplegia. When the lesion is more extensive and extends into subcortical areas, the diagnosis is usually that of spastic quadriplegia.[2] Children with spastic quadriplegia present reduced control of balance, muscular weakness and spasticity, which contribute to abnormal walking patterns.[3,4] In addition to seizures,[2] they could also present additional limited communication capabilities,[5,6] and significant visual, cognitive and perceptual deficits.[2]

The movement of horses is used to improve the functional status of individuals with movement disorders.[7,8] Their muscles are strengthened, while the range of motion of joints increases. Simultaneously, the synergy of muscles, the coordination of the movement, the displacement of weight shift and the control of the balance are improved.[9,10] The oscillation of patients has been reduced as a result of their effort to maintain their posture on the horseback.[11,12] It enhances the stability of hip and truck, the hip and pelvic flexibility,[13,14] appears to assist in the support, the stability and the coordination of the trunk and the head,[9] as well as in the alignment of the shoulders, the trunk, the pelvis and the hip.[13–15] As a result of these beneficial actions, the patient's pelvic motion tends to normalize,[16] resulting in an improvement in energy expenditure[17] and better control of posture.

The purpose of this study was to investigate by presenting outcome measures that children with spastic quadriplegia benefit from equine movement and exercise on the horseback during this procession. We aimed to present data of the improvement achieved on children's motor function, motor performance, static and dynamic balance, and spasticity. A secondary outcome was to investigate whether these improvements continue to persist two months after the completion of the last session of EAI.

MATERIAL AND METHOD

In order to conduct this research, the approval of the Scientific Committee (12/24.8.2011; θ. 17) and Administration Board (38/3.10.2011; θ.33) of the University Hospital of Ioannina was requested and received. Similarly, permission was requested and received from the clinical trials database; clinicaltrials.gov (NCT01621984 unique protocol ID: 274/21.9.2011). All procedures performed in studies involving human or animal participants were in accordance with the ethical standards of the institutional and/or national research committee and the 1964 Helsinki declaration and its lated amoudoneuts or comporable ethical standards.

In addition, after the researchers provided patients' parents with all necessary information regarding the study and its objectives, written consent was requested. Following the relevant code of ethics, anonymity of the participants, as well as confidentiality regarding all their personal data was ensured. The data were collected from March 2016 to November 2016.

The EAI lasted 3 months (12 weeks) with each session lasting 30 minutes and held once a week.

Candidate participants were sought through the registry of the Clinic of Physical Medicine and Rehabilitation and the Department of Pediatrics of the General University Hospital of Ioannina, as well as through the "MERIMNA" non-profit organization. Assessment and selection of children, who met the inclusion criteria, followed. Therapeutic procedure took place in the Ioannina Therapeutic Riding Center, Greece, while therapists and instructors participating in the intervention were all trainers certified in the applied approach.

Initially, clinical evaluation of all chosen participants was based on medical history and examinations, and specialist advice so that all eligibility criteria for participation in the study apply. Therefore, children with spastic CP who met the inclusion and exclusion criteria were recruited for this study.

Inclusion criteria: (a) Children 3 to 18 years old suffering from spastic quadriplegia, (b) the ability to abduct the hip to sit astride, and (c) written parental consent.

Exclusion criteria: (a) Uncontrolled epileptic seizures, (b) musculoskeletal disorder which may be aggravated by the movement of the horse, (c) allergy to the dust of the arena, (d) previous experience in horse riding, (e) botulinum toxin injections in any muscle during the last 6 months and (f) any surgery within a year prior to the study.

As a next step, gross motor function and performance, static and dynamic balance, as well as spasticity of all participants who were included in the study were assessed. All participants were categorized according to their mental capacity with Wechsler Intelligence Scale for Children (WISC III) and with the Gross Motor Function Classification System (GMFCS). Participants were categorized according to their mental capacity and relevant functional classification.

Successive assessments of the children were carried out by two independent researchers, who were experienced in their use and were blinded on results of previous assessments of the children or the aims of the study. The evaluators of WISC III were child psychiatrists and this assessment took place in the State Pediatric Educational Center in Ioannina. For each patient, six measurements took place using the GMFM, Pediatric Balance Scale (PBS), and the MAS. The first took place eight weeks before the intervention, the second four weeks before the intervention, the third just before the planned intervention, the fourth in the middle of the intervention (six weeks from the beginning), the fifth at the completion of the last session (12 weeks from the beginning), and the sixth eight weeks after the final session of the intervention had taken place. The final evaluation has been done to determine if the results in gross motor function, static and dynamic balance and spasticity were maintained two months after the completion of the EAI. The GMPM and dynamic plate were used in two different moments in time, before and after the intervention.

Instruments

The outcome measures used in this study for the evaluation of gross motor and performance ability were the GMFM[18] and the GMPM,[19] respectively. GMPM has been designed to be used in combination with GMFM.[19] For the evaluation of balance, both the PBS[20] and a foot pressure sensitive walkway-dynamic plate were used. Finally, the Modified Ashworth Scale[21] was used to assess spasticity.

Static balance was assessed with the foot pressure sensitive walkway Win-Track. The Win-Track is a foot pressure sensitive walkway, 161×65 cm, with 12,288 sensors, for the static, posturogaphic and gait analysis with total freedom in stance and motion acquisition.

The dynamic plate was placed at a distance of about one meter from the wall, where a mark was placed at each child's eye level. The children were asked to look at the mark during the measurements. Then, they were asked to stand on the special platform for 10 seconds with bare feet, with the legs spread as wide as the shoulders. In children who needed support to maintain their standing position, the examination was done with the help of the examiner. Several trials took place in each of the two measurements (before and after), to familiarize the child with the dynamic plate. In every measurement, three evaluations were scored, and the best was recorded for each child.

Intervention

Children received passive or assisted mobilization on the horseback, directional changes, gradient stimuli depending on their needs and limitations. Each child was passively placed by the therapist upon a horse walking straight line or in circles or performing the shape of "eight" between cones and serpentines with open or closed eyes while also the horse's gait varied in different speed in walking or trotting, stopping, or starting abruptly. The first goal for the children was to be able to sit independently, aligned, to keep the symmetry between head, trunk, and lower limbs and generally to improve their balance. In order to achieve the desirable benefit from the EAI, a series of sets of exercises was performed.

Statistical analysis

For the GMFM scale, a longitudinal analysis was performed. Univariate and multivariate mixed effects linear regression models were used. For the PBS scale, a longitudinal analysis was carried out. Univariate mixed effects linear regression model was used. For GMPM, the comparison of the scale values was done univariately manner in pair t-tests and multivariately using longitudinal analysis methods. In the multivariate models, we adjusted for possible confounders, such as sex, age, assessment based on WISC III and the GMFCS level for the three types of assessment tools. For the force plate, univariate analyses using paired t-test were performed. Multivariate analyses were not done due to the small sample size for the force plate and PBS. Finally, for the modified Ashworth Scale, the statistical criterion Fisher's exact test was used. Statistical significance was set at $\alpha=0.05$. Statistical analyses were conducted using Stata 14.1 (StataCorp, College Station, TX, USA).

RESULTS

Out of a total of 21 children who met the criteria, 14 children from 4 to 18 years old took part in the research finally. The characteristics of the sample as a whole and per GMFCS level are shown in tables 1 and 2.

Gross Motor Function Measure – Gross Motor Performance Measure

In the GMFM Scale, as well as in all its subcategories, a major statistical significance increase was observed between the assessments 3, 4, 5 and the initial measurement before the intervention (assessment 1), as it can be seen in table 3, using both the univariate and multivariate models.

More specifically, between the 2nd and 3rd assessment, a statistically significant improvement was observed in all subcategories of GMFM, except E and C. The last tended to be statistically significant (GMFM-A: $p=0.001$, GMFM-B: $p=0.0089$, GMFM-C: $p=0.0574$, GMFM-D: $p=0.0119$, GMFM-E: $p=0.1288$, GMFM total: $p=0.0001$). On the other hand, between the 3rd and 4th measurement (two months after the last EAI session), no statistically significant change in values was observed in any of subcategories (GMFM-A – GMFM-E, $p>0.05$). Nevertheless, a statistically significant decrease of the total GMFM score was observed between the 3rd and 4th assessment (two months later) ($p=0.0169$). However, the total GMFM in the 4th assessment was still significantly better than the 1st assessment and about the same with the 2nd assessment ($p<0.001$).

A statistically significant increase in GMPM in all subcategories has been observed, both with paired t-test values and with the multivariable model, except for the subcategory of alignment which using paired t-test tended to be statistically significant, as shown in table 4. More specifically, in alignment, a subcategory of GMPM, the improvement tends to be statistically significant ($p=0.0644$) only for the paired t-test while in multivariate model there was a statistically significant improvement.

Static balance in dynamic plate

In the dynamic plate test, three children out of 14 did not participate because they were unable to stand upright without moving, due to either low mental capacity or accompanying autistic features that did not allow them to follow instructions. Also, three children did not participate, as they had no ability to stand in an upright position, even while supported, due to neuromuscular weakness. Thus, the sample, in this measurement, was limited to eight children.

Table 5 shows the measurements before and after the intervention. In most of the measurements, there was no statistically significant difference. Only the mean pressure (P) of the right foot, statistically significant decreased in mean values (standard error) 29.54 (9.48) units ($p=0.017$).

Pediatric Balance Scale

Three children did not participate because they had no ability to stand in upright position, not even while supported, due to neuromuscular weakness. Thus, the sample, in this measurement, consisted of 11 children.

Table 6 shows the average values and standard deviations of the PBS range for all time points and table 7 shows the changes in PBS for each GMFCS category. It was observed that PBS levels changed based on GMFCS. At

Table 1. Demographic data for GMFM, GMPM, Ashworth and PBS and per GMFCS level.

	GMFM, GMPM and modified Ashworth Scale				
Characteristic	**Total (n=14) Mean (SD)**	**GMFCS II (n=1) Mean (SD)**	**GMFCS III (n=5) Mean (SD)**	**GMFCS IV (n=3) Mean (SD)**	**GMFCS V (n=5) Mean (SD)**
Age	11.93 (4.58)	18 (-)	12.6 (4.45)	10 (5.29)	11.2 (4.6)
Weight	34.29 (16.35)	60 (-)	39 (18.84)	31.33 (16.29)	26.2 (9.98)
Height	1.28 (0.27)	1.67 (-)	1.33 (0.15)	1.2 (0.4)	1.21 (0.27)
Characteristic	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**
Gender					
Male	11 (78.57)	1 (100)	3 (60)	3 (100)	4 (80)
Female	3 (21.43)	0 (0)	2 (40)	0 (0)	1 (20)
WISC III					
Normal	2 (14.29)	1 (100)	1 (20)	0 (0)	0 (0)
Low average	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Mild	1 (7.14)	0 (0)	1 (20)	0 (0)	0 (0)
Moderate	1 (7.14)	0 (0)	0 (0)	1 (33.3)	0 (0)
Sever	6 (42.86)	0 (0)	1 (20)	0 (0)	5 (100)
Profound	4 (28.57)	0 (0)	2 (40)	2 (66.67)	0 (0)
	PBS				
Characteristic	**Total (n=11) Mean (SD)**	**GMFCS II (n=1) Mean (SD)**	**GMFCS III (n=5) Mean (SD)**	**GMFCS IV (n=3) Mean (SD)**	**GMFCS V (n=2) Mean (SD)**
Age	12.73 (4.65)	18 (-)	12.6 (4.45)	10 (5.29)	14.5 (4.95)
Weight	37.36 (16.43)	60 (-)	39 (18.84)	31.33 (16.29)	32.5 (3.54)
Height	1.35 (0.25)	1.67 (-)	1.33 (0.15)	1.2 (0.4)	1.48 (0.11)
Characteristic	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**
Gender					
Male	9 (81.82)	1 (100)	3 (60)	3 (100)	2 (100)
Female	2 (18.18)	0 (0)	2 (40)	0 (0)	0 (0)
WISC III					
Normal	2 (18.18)	1 (100)	1 (20)	0 (0)	0 (0)
Low average	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Mild	1 (9.09)	0 (0)	1 (20)	0 (0)	0 (0)
Moderate	1 (0.09)	0 (0)	0 (0)	1 (33.3)	0 (0)
Sever	3 (27.27)	0 (0)	1 (20)	0 (0)	2 (100)
Profound	4 (36.36)	0 (0)	2 (40)	2 (66.7)	0 (0)

GMFM: Gross Motor Function Measure, GMPM: Gross Motor Performance Measure, GMFCS: Gross Motor Function Classification System, PBS: Pediatric Balance Scale, SD: Standard deviation, WISC: Wechsler Intelligence Scale for Children

all-time points there was a statistically significant increase in the mean value of the total PBS relative to the 1st assessment ($p<0.001$).

It is observed that the greater improvement was in the 3rd assessment, i.e. at 12 weeks of intervention with an increase in the PBS score on average (typical error) 4.69 (0.76) units ($p<0.001$). Also, a statistically significant difference between 6th and 12th week with an increase of 2.45 (0.76) units and $p<0.001$ was observed. Within two months, the balance capacity was reduced by an average of -0.81 (0.79) without statistical significance ($p=0.301$) compared to the last session (12th week). On the other hand, compared to the 1st evaluation (before the EAI sessions) the children had better balance with statistical significant results ($p<0.001$).

Table 2. Demographic data for dynamic plate and per GMFCS level.

Dynamic plate Characteristic	Mean (SD)
Age	14.13 (4.16)
Height	1.4 (0.2)
Weight	41.13 (17.61)
	Total n=8 (%)
Gender	
Male	6 (75)
Female	2 (25)
WISC III	
Normal	2 (25)
Low average	1 (12.5)
Mild	1 (12.5)
Moderate	2 (25)
Severe	2 (25)
GMFCS	
II	1 (12.5)
III	4 (50)
IV	2 (25)
V	1 (12.5)

SD: Standard deviation, WISC: Wechsler Intelligence Scale for Children, GMFCS: Gross Motor Function Classification System

Modified Ashworth Scale

No statistically significant difference (p-value=0.581) in Ashworth Scale values throughout the EAI was noticed according to Fisher's exact test criterion.

Minimal clinically important differences

Minimal clinically important differences (MCID) provided the threshold determining if clinically important differences take place before and after an intervention.[22] According to the literature,[23] important clinical improvement was observed (average low value differential >1.29 and high value >3.99) in GMFM between the timings of initial assessment and of the 12 week assessment (10.11). The same was observed between the initial and that of the final assessment, the latter referring to the eight weeks after the intervention had been completed (7.48). Accordingly, for the PBS[24] children showed also clinical significant improvement (average low value differential >1.80 and high value >3.66) based on MCID (4.69).

Adverse events

There were no adverse events related to the EAI. None of the participants suffered any injury or other complications during the study.

DISCUSSION

The aim of this study was to evaluate the efficacy of EAI in children with spastic quadriplegia. Children presented statistically significant improvement in gross motor function, performance and in static and dynamic balance. Especially for GMFM and PBS, results were clinically important, too. Regarding spasticity, results showed that children had improved but without reaching statistical significance.

In a study[25] where the participants were children with spastic quadriplegia, a statistical significant improvement was only observed in the total score of GMFM and its D and E subcategories. In the present study, a statistical significant improvement was observed in total score and in all subcategories of GMFM. In addition, they compared the improvement of children of I and II classification with children of III and IV classification in GMFCS and the results

Table 3. Comparison of the GMFM between the different time-points.

Characteristic	n	Total (n) Mean value (SD)	Mean difference (SE*)	p-value Univariate model	Multivariate model**
GMFM, total					
Before the intervention	14	38.09 (25.19)	0	–	–
6 weeks after the start of the intervention	14	43.88 (27.21)	5.80 (1.04)	<0.001	<0.001
At 12 weeks (at the end of the intervention)	14	48.2 (29.19)	10.11 (1.04)	<0.001	<0.001
8 weeks after the end of intervention	12	45.64 (28.06)	7.48 (1.10)	<0.001	<0.001

* Compared to pre-intervention value, ** The multivariate model has been weighted for gender, age, level of WISC III and GMFCS level

SD: Standard deviation, SE: Standard error, GMFM: Gross Motor Function Measure, WISC: Wechsler Intelligence Scale for Children, GMFCS: Gross Motor Function Classification System

Table 4. Distribution across GMPM scale and its subcategories, as well as per GMFCS level.

Scale	Before the intervention	After the intervention	Mean difference (SE)	t-test paired	Multivariate model*
Dissociated movement	25.86 (18.61)	33.53 (18.89)	7.67 (2.35)	0.0067	0.0007
Coordination	33.81 (14.44)	41.42 (20.25)	7.62 (3.28)	0.0384	0.0155
Alignment	35.75 (6.49)	38.74 (8.65)	2.99 (1.47)	0.0644	0.034
Weight shift	26.66 (8.09)	31.28 (10.97)	4.62 (2.07)	0.0455	0.0202
Stability	36.98 (11.23)	46.4 (12.43)	9.42 (2.63)	0.0038	0.0002
Total	31.81 (10.57)	38.12 (11.33)	6.31 (1.49)	0.0012	<0.001

* The multivariate model has been weighted for gender, age, level of WISC III and GMFCS level

GMPM: Gross Motor Performance Measure, GMFCS: Gross Motor Function Classification System, SE: Standard error

Table 5. Results in dynamic plate.

Parameter	Before the intervention		After the intervention		Difference	p-value
	n	Mean (SD)	n	Mean (SD)	Mean difference (SE)	Univariate model
Weight distribution, left	8	53.05 (18.26)	8	49.42 (9.07)	-3.63 (5.52)	0.53
Weight distribution, right	8	46.95 (18.26)	8	50.58 (9.07)	3.63 (5.52)	0.53
Weight distribution, left front	8	28.96 (25.7)	8	23.06 (14.88)	-5.9 (8.61)	0.515
Weight distribution, left back	8	24.1 (18.42)	8	26.36 (12.63)	2.26 (9.46)	0.818
Weight distribution, right front	8	32.81 (25.49)	8	28.52 (14.99)	-4.29 (7.56)	0.589
Weight distribution, right back	8	14.18 (18.5)	8	22.03 (15.29)	7.85 (7.89)	0.353
Oscillation center of gravity front	8	19.56 (23.64)	8	24.6 (29.87)	5.034 (13.02)	0.71
Oscillation center of gravity back	8	31.23 (39.48)	8	27.97 (41.25)	-3.26 (19.64)	0.873
Oscillation center of gravity left	8	45.31 (55.91)	8	25.02 (26.36)	-20.29 (21.93)	0.386
Oscillation center of gravity right	8	47.6 (46.03)	8	33.71 (33.65)	-13.89 (21.38)	0.537
P mean left	8	65.89 (43.1)	8	42.06 (30.74)	-23.83 (16.7)	0.197
P mean right	8	69.2 (35.83)	8	39.66 (18.65)	-29.54 (9.48)	0.017

SD: Standard deviation, SE: Standard error

Table 6. Results in PBS.

Characteristic PBS	Total (n=11) Mean (SD)	Mean difference (SE)	p-value Univariate model
Before the intervention	16.58 (15.52)	0	–
Six weeks after the start of the intervention	18.82 (17.66)	2.24 (0.76)	0.003
At 12 weeks (at the end of the intervention)	21.27 (18.26)	4.69 (0.76)	<0.001
Eight weeks after the end of intervention	18.2 (16.71)	3.88 (0.87)	<0.001

PBS: Pediatric Balance Scale, SD: Standard deviation, SE: Standard error

were that children with classification III and IV had a better improvement than others in total score of GMFM and C, D and E subcategories.

The results of the present study agreed with several studies in international literature that EAI improve the motor performance of children with CP.[26–33] Children with CP have difficulties in dissociated movement, due to presence of spasticity, weakness of the muscles and or the reduced muscle control by the CNS.[34] According to the results of the present study, treatment favors the separate mobility of the pelvis and trunk, which promotes postural correction and patient's balance responses.[8,35–37] Moreover, there is

Table 7. Results in PBS for each GMFCS category.

Characteristic PBS	GMFCS II Total (n=1) Mean (SD)	GMFCS III (n=5) Mean (SD)	GMFCS IV (n=3) Mean (SD)	GMFCS V (n=2) Mean (SD)
Before the intervention	42.67 (-)	18.53 (10.85)	14.78 (19.54)	1.33 (0.47)
Six weeks after the start of the intervention	50 (-)	20.4 (12.38)	17.33 (21.36)	1.5 (0.71)
At 12 weeks (at the end of the intervention)	52 (-)	24 (13.71)	19.33 (20.55)	2 (1.41)
Eight weeks after the end of intervention	51 (-)	17.25 (4.65)	19 (20.88)	2.5 (0.71)

PBS: Pediatric Balance Scale, GMFCS: Gross Motor Function Classification System, SD: Standard deviation

poor body alignment and abnormal weight shifting due to contracture development from pelvic asymmetry and spasticity.[34] A possible explanation for the improvement in body alignment, which was also noted in the present study, is that EAI stimulates trunk muscles. This improves hypotonia, reduces spasticity and increases the range of motion of various joints.

According to the literature, there is no tool that can assess all the dimensions of balance.[38] In our study, for better accuracy of our results, we chose two methods; the dynamic plate to assess static balance, and the PBS to assess functional balance. In children with CP, compared to typical developing children, stance was more laterally displaced than anteroposteriorly.[39,40] This finding was also confirmed in our study. Improvement was noted after intervention in posterior, left and right displacement but without statistical significance. Another parameter that can be measured by a dynamic plate is the plantar contact area, which can be useful in various pathological situations.[41] In our study this parameter of the plantar surface which comes in contact with the ground was been measured.

One study[42] showed statistically significant improvement with the use of a dynamic plate in the range of anterior-posterior oscillation after an equine-assisted therapy in elderly people. Another study,[43] after comparing exercises in treadmill with hippotherapy, found improvement in elderly people after hippotherapy in anterior-posterior and lateral displacement. In addition, a study[44] evaluating static balance following a horse simulator exercise showed positive results. One study compared the total mean and maximum range of oscillation of center of gravity in children with intellectual disability, who received hippotherapy. The result was an improvement during the one leg stance.[45] Several researches have shown that the reduction of the plantar contact area is associated with a higher load per unit area in the anterior and posterior parts of the foot, which may be a risk factor for injuries and overload of the lower limbs.[46] In contrast, when there is a larger plantar contact area there is better re-distribution of pressure in all areas of the foot,[47] and especially in those receiving the largest loads, i.e. heel and heads of metatarsals.[41] As the weight of children did not change during this study, we concluded that the plantar area that came into contact with the child's foot increased, which showed an improvement in the balance of children participating in the intervention. Another possible explanation was that the pressures in plantar region are normalized in terms of alignment. This results in fewer and smaller maximum pressure values. Additionally, as a result of balance improvement, there isn't large fluctuation in pressure from the loss and regaining of the center of gravity position.

Various studies using PBS to assess children that participated in a EAI reported positive results.[11,48] The results of this study were consistent with those of Kwon et al.[48] In their study, there is a statistically significant improvement to all children of all levels of GMFCS. The only difference in contrast to the present study is that this particular study did not include level V children, where they existed. A correspondingly similar to the present study is that in one study[25] regarding the follow-up of children at different times, two months before, immediately before and after the end of the intervention. Their results showed statistically significant improvement in children's balance. In our study, there was a statistically significant improvement in all children at all times of the intervention, with a better improvement at the end, i.e. after the completion of 12 weeks, with a statistically significant increase in the PBS score. The benefits in static and dynamic balance remain at least for two months after the end of the intervention.

The information on the normalization of muscle tone with neurodevelopmental treatment appears to be limited.[49] Both our work as previously noticed by other,[50] acknowledge the positive effect of EAI on muscle tone. Additionally, neurodevelopmental treatment, EAI, hydrotherapy sometimes are preferred for the treatment of spasticity, as medication can cause serious side effects such as drowsiness and generalized weakness, which have a negative impact on the rehabilitation of patients.[51]

According to our results, after intervention at least for six weeks, children showed clinical significant improvements both in their balance and in their gross motor function based MCID.

Our study confirmed, not only the statistical but also the clinical significance of the change in balance PBS and gross motor function of children.

The major limitation of our study was the small sample size. A major confounding factor was that, due to ethical reasons, participants were not requested to discontinue other therapeutic interventions or activities. The simultaneous implementation of other therapeutic modalities did not allow us to credit only the EAI for the positive results. Nevertheless, in order to counteract this effect, we asked from the parents to keep these therapies or activities stable throughout the whole intervention. We designed our study, based on the protocol that is widely accepted and implemented by others.[17,30,52] We used the same children cohort as control group before and after the intervention. Initially, this may be seen as a study limitation, but in reality it may also be a sensitive way of detecting even the slightest individual improvement[52] since the development of each child suffering from a neurological-muscular disorder may vary.

Also, the fact that in our study final evaluations for each patient took place in a period of one to five days after the end of intervention, may hide the possible beneficial immediate effect of equine facilitated intervention on spasticity.

We recommend further research with a greater number of riders suffering from all types of CP; spastic, dystonic, mixed and of all clinical manifestations; diplegics, quadriplegics, and hemiplegics. Finally, it is necessary for new research to be based more on modern technology, so that the assessment of patients to be more reliable (gait analysis, inertial measurement units [IMUs], etc.).

In conclusion, EAI improves the motor function (qualitatively and quantitatively), and the static and dynamic balance of children with spastic quadriplegia. The improvement in motor function is also clinically important, while the benefits of the EAI remain two months after its completion.

ΠΕΡΙΛΗΨΗ

Παρέμβαση υποβοηθούμενη από άλογα σε παιδιά με σπαστική τετραπληγία: Η επίδραση στη λειτουργικότητα και στην ισορροπία. Προοπτική μελέτη

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ΣΚΟΠΟΣ Η διερεύνηση της αποτελεσματικότητας της θεραπευτικής ιππασίας σε παιδιά με σπαστική τετραπληγία. Οι παράμετροι που ελέγχθηκαν ήταν η αδρή κινητική λειτουργία και η επίδοση, η ισορροπία και η σπαστικότητα και το εάν η βελτίωση που θα προέκυπτε θα παρέμενε 2 μήνες μετά την παρέμβαση θεραπευτικής ιππασίας. **ΥΛΙΚΟ-ΜΕΘΟΔΟΣ** Δεκατέσσερα παιδιά με σπαστική τετραπληγία συμμετείχαν στη μελέτη, η οποία διήρκησε 28 εβδομάδες. Η παρέμβαση διήρκησε 12 εβδομάδες και λάμβανε χώρα με συχνότητα μία συνάντηση ανά εβδομάδα, ενώ η διάρκεια της κάθε συνάντησης ήταν 30 min. Για την αξιολόγηση της αδρής κινητικής λειτουργίας χρησιμοποιήθηκε η κλίμακα αξιολόγησης της αδρής κινητικής λειτουργίας (GMFM), της επίδοσης με την κλίμακα αξιολόγησης της αδρής κινητικής επίδοσης (GMPM), της στατικής και δυναμικής ισορροπίας με την παιδιατρική κλίμακα αξιολόγησης της ισορροπίας (PBS) και με δυναμόπλακα και, τέλος, της σπαστικότητας, με την τροποποιημένη κλίμακα κατά Ashworth (MAS). Για την αξιολόγηση του νοητικού δυναμικού χρησιμοποιήθηκε η ψυχομετρική δοκιμασία WISC III. **ΑΠΟΤΕΛΕΣΜΑΤΑ** Παρατηρήθηκε βελτίωση στην αδρή κινητική λειτουργία, καθώς και στις υποκατηγορίες της ($p<0,05$), στην ποιότητα της κίνησης ($p<0,05$) και στην ισορροπία. Τα αποτελέσματα παρέμειναν και μετά το πέρας των δύο μηνών από την ολοκλήρωση της παρέμβασης. Όσον αφορά στη σπαστικότητα, παρ' όλο που υπήρξε βελτίωση, αυτή δεν φάνηκε να είναι στατιστικά σημαντική. **ΣΥΜΠΕΡΑΣΜΑΤΑ** Η θεραπευτική ιππασία βοηθά στη λειτουργική ικανότητα, τόσο ποσοτικά όσο και ποιοτικά, καθώς και στην ισορροπία, με σημαντικά κλινικά αποτελέσματα.

Λέξεις ευρετηρίου: Αδρή κινητική λειτουργία, Θεραπεία υποβοηθούμενη από άλογα, Ισορροπία, Σπαστικότητα, Τετραπληγία

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