ORIGINAL ARTICLE

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Bu yazı "Analyzing the Effect of Individually Structured Trunk Training on Trunk, Upper and Lower Limb Motor Function in Children with Spastic Cerebral Palsy" adı ile 29th Annual Meeting of the European Academy of Childhood Disability (May 17 – 20 2017, Amsterdam The Netherlands) konferansında sunulmuştur.

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Effects of Trunk Training on Trunk, Upper and Lower Limb Motor Functions in Children with Spastic Cerebral Palsy: A Stratified Randomized Controlled Trial

ABSTRACT
Objective: The aim of this study was to investigate the effects of trunk training on the trunk, upper and lower limb motor functions of children with bilateral spastic Cerebral Palsy.
Methods: Thirty-six children were recruited for this study; 19 children were included in the trunk training group and 17 children were included in the control group. Motor functions of the children were assessed by the Trunk Control Measurement Scale, Gross Motor Function Measurement, Quality of Upper Extremity Skills Test, Pediatric Balance Scale, Gillette Functional Assessment Scale, and Impact on Family Scale at baseline and after an 8 week of intervention period.
Results: The Trunk Control Measurement Scale (p=0.008), Gross Motor Function Measurement (p=0.047), Quality of Upper Extremity Skills Test (p=0.032), Pediatric Balance Scale (p=0.006), and Gillette Functional Assessment Scale (p=0.011) scores improved in favor of the trunk training group (p<0.05).
Conclusions: Individually structured trunk training is a promising method to improve trunk, upper and lower extremity motor functions and activity levels of children with bilateral spastic Cerebral Palsy.

Keywords: Cerebral Palsy, Physiotherapy, Strength Training, Trunk

Spastik Serebral Palsili Çocuklarda Gövde Eğitiminin Gövde, Üst ve Alt Ekstremite Motor Fonksiyonları Üzerine Etkisi: Tabakalı Randomize Kontrollü Çalışma

ÖZET
Amaç: Bu çalışmanın amacı, bilateral spastik Serebral Palsili çocuklarda gövde eğitiminin gövde, üst ve alt ekstremite motor fonksiyonları üzerindeki etkilerini araştırmaktır.
Gereç ve Yöntem: Bu çalışmaya 36 çocuk alındı; çocuklardan 19'u gövde eğitimi grubuna, 17'si ise kontrol grubuna dâhil edildi. Çocukların motor fonksiyonları; Gövde Kontrol Ölçüm Ölçeği, Kaba Motor Fonksiyon Ölçümü, Üst Ekstremite Becerileri Kalitesi Testi, Pediatrik Denge Ölçeği, Gillette Fonksiyonel Değerlendirme Ölçeği ve Aile Etkilenimi Ölçeği ile başlangıçta ve sekiz hafta süren müdahale sonrasında değerlendirildi.
Bulgular: Gövde eğitim grubunda; Gövde Kontrol Ölçüm Ölçeği (p = 0.008), Kaba Motor Fonksiyon Ölçümü (p = 0.047), Üst Ekstremite Becerileri Kalitesi Testi (p = 0.032), Pediatrik Denge Ölçeği (p = 0.006) ve Gillette Fonksiyonel Değerlendirme Ölçeği (p. = 0.011) puanları gelişme gösterdi (p <0,05).
Sonuç: Bireysel olarak yapılandırılmış gövde eğitimi, bilateral spastik Serebral Palsili çocukların gövde, üst ve alt ekstremite motor fonksiyonlarını ve aktivite düzeylerini geliştirmek için ümit vaat eden bir yöntemdir.

Anahtar Kelimeler: Serebral Palsi, Fizyoterapi, Kuvvetlendirme, Gövde

INTRODUCTION

Cerebral Palsy (CP) defines permanent disorders that lead to motor, sensory, cognitive problems and activity limitations. These disorders are associated with non-progressive impairments, lesions or anomalies occurring in early stages of brain development (1, 2). Trunk impairment is very common but an underscored feature of spastic CP that affects the upper and lower extremity motor functions as well. Impairments associated with the trunk seen in children with CP include but are not limited with decreased stability of the head and trunk, shoulder protraction, spinal curve deviations, and trunk muscle weakness (3, 4). Inadequate control of trunk muscles leads to compensation of other muscles to maintain the upright posture. Inability of proximal stabilization and increased activation of extremity muscles during postural adjustments reduces their functionality during extremity movements (5, 6).

Researches and the interventions used in clinics for CP are generally targeting extremities, and trunk impairment is disregarded. Only a few studies have focused on trunk training in CP population. These studies commonly used serious games and virtual reality for training the trunk (7-9). Due to this gap in the literature; in current study we aimed to focus on training the trunk, and we used The Neuro-development Treatment (NDT) which contains many exercises and activities targeting the trunk muscles (10, 11). The purpose of this study was to investigate the effects of individually structured functional trunk training on motor functions of the trunk, upper and lower extremities.

MATERIAL AND METHODS

Children at the ages of 4-18 diagnosed with spastic CP by a pediatric neurologist and had a bilateral impairment, and who are able to follow verbal instructions, and whose family approved their participation were included in this study. Children who had an orthopedic surgery or Botulinum Toxin A (BoNT-A) injection during the last 6 months or had seizures during the last one year were excluded from the study.

The design of this study was a single-blind stratified randomized controlled trial. Hacettepe University Non-interventional Clinical Research Ethics Board received permission for this study (Permisson Number: GO 14/135). The children, who consulted to Bolu Abant İzzet Baysal University, Physical Therapy and Rehabilitation Department and the children who were attending to physiotherapy program at the special education centers in Bolu city were included in the study. The parents of the children were informed about the interventions and benefits of the study and their written informed consents were received. Some of the children recruited for this study were living in government's care centers for disabled children. Permission was received for these children from the concerned ministry.

The children were divided into two groups according to their Gross Motor Function Classification System (GMFCS) levels by using the stratified random sampling. Stratified randomization performed by using XLSTAT (XLSTAT, Addinsoft, Paris, France) software. Patient recruitment carried out between January 2014- October 2015. This study has been registered in the ClinicalTrials.gov under the title; "Analyzing the Effect of Trunk Training on Limbs in Children with Spastic Cerebral Palsy" and the number: ID NCT02643160.

A physiotherapy program planned for the children included in trunk training group (TTG) consist of exercises and activities focusing on the activation of the trunk muscles, pelvic control and proximal stabilization according to the NDT principles, and these were combined with the trunk and gluteal muscle strengthening exercises. The trunk elongation activities, the facilitation of spinal extension, weight shifting and weight-bearing activities are frequently used. The children in the TTG received 45-75-minute of physiotherapy twice a week for 8 weeks at Bolu Abant İzzet Baysal University in addition to a regular physiotherapy (twice a week for 45 minutes) at the special education centers. The exercises were individually structured based on the gross motor function levels, performances, cognitive abilities and fatigue level of the children. The children who were recruited for the control group (CG) were asked to continue their routine physiotherapy program (45 minutes in session, twice a week, during 8 weeks at the special education centers).

Measurements: All of the data obtained from children on their age (year), height (cm), body mass (kg), gender, method of delivery, birth week, birth weight (gr), oral medications, orthotics, surgeries, BoNT-A applications were recorded. Trunk control was assessed by the Trunk Control Measurement Scale (TCMS) (12). The children sat at the edge of a treatment table without the back, arm or feet-support. Each item was performed three times, and the best performance was taken into account for scoring. The Static Sitting Balance, Dynamic Sitting Balance and Dynamic Reaching domain scores and total score were calculated. Gross motor function was assessed by the Gross

Motor Functions Measurement (GMFM) (13). The GMFM total score and 5 domain scores were calculated. The upper extremity functions were assessed by using the Quality of Upper Extremity Skills Test (QUEST) (14) which assessed the quality of upper extremity functions under 4 domains as the Dissociated Movement (19 items), Grasp (6 item), Weight Bearing (5 item) and Protective Extension (3 items). The Pediatric Balance Scale (PBS) (15) was used to assess the balance. The gait-related outcomes of the children were assessed by using Turkish version of the Gillette Functional Assessment Questionnaire (Gillette FAQ) which consisted of the "Gillette FAQ Walking Scale" classifying the ambulatory function in 10 levels and the "Gillette FAQ Skills Test" assessing the functional locomotor activity by 22 items (16). The impact on family was assessed by using Turkish version of the Impact on Family Scale (17). All of the assessments were performed at baseline and after an 8-week intervention by an experienced pediatric physical therapist.

Statistical analyses: The Statistical Package for the Social Sciences PASW 18 (Chicago: SPSS Inc, USA) was used for statistical analyses. Descriptive analyses were presented as means and standard deviations for the continuous variables, and as numbers and percentages for the categorical variables (gender, topographic distribution). The differences in demographic characteristics between the groups were analyzed by using the Chi-square Test for the categorical variables (gender, topographic distribution, delivery method, prematurity, birth-weight classification), and the Mann–Whitney U test was used for the continuous variables (age, height, weight). The Wilcoxon Signed-rank Test was used to compare the differences between the baseline and post intervention scores within the groups. The Mann–Whitney U test was used to compare the differences between the groups. The level of significance was set at $p<0.05$.

RESULTS

For this study 65 children with spastic CP were contacted. 27 of them didn't meet inclusion criteria or their families who did not approve to participate. Overall 38 children (10 girls, 28 boys, mean age 9.61±4.12) with spastic CP were included in this study.

One child from the TTG had a seizure during the intervention period and one of the children from the CG went to BoNT-A injection so this two children were dropped from the study. The demographic characteristic of the children are shown in Table 1.

Table 1. Demographic characteristic of the children and group comparison

Characteristic		**TTG (n=19)**		**CG (n=17)**			
						Mann-Whitney U	
Numeric		X± SD		X± SD		z	p
Age (year)		8.8±3.9		10.4±4.6		-0.910	0.377
Height (cm)		121.1±19.5		131.2±26.6		-1.097	0.273
Body mass (kg)		26.1±12.6		35.4±19.7		-0.775	0.438
Categorical						**Pearson X^2**	
		Number	%	Number	%	x^2	p
Gender	**Girl**	4	20	6	33.3		
	Boy	16	80	12	66.7	0.869	0.351
Topographic distribution	**Diparetic**	11	55	12	66.7		
	Quadriparetic	9	45	6	33.3	0.540	0.463
Birth week	**<37 weeks**	12	60	10	62.5		
	37-40 weeks	8	40	6	37.5	0.23	0.878
Method of delivery	**Natural**	4	24	7	43.8		
	Cesarean	13	76	9	56.2	1.517	0.218
Birth weight (gr)	**<1500 gr**	8	47	8	50.0		
	>1500 gr	9	53	8	50.0	0.029	0.866
Use of Oral Myorelaxant	**Yes**	13	65	13	72.2		
	No	7	35	5	27.8	0,229	0.632

TTG: Trunk Training Group, CG: Control Group, X: mean, SD: Standard Deviation, p: statistical significance

At the baseline; Dynamic Sitting Balance scores of the TCMS were better at the CG. There weren't statistically significant differences in other values of the TTG and CG. A comparison of the baseline scores are presented in Table 2. After an 8 week-intervention, the TTG improved in comparison to the baseline in terms of the TCMS total score and 3 domain scores, GMFM total score, QUEST Weight Bearing domain score, PBS score, Gillette FAQ Skills Test scores ($p<0.005$). There

wasn't a significant difference in other measurements of the TTG (p>0.05). In control group, there was an improvement in the GMFM scores however they were not significant (p>0.05). When we compared the groups for the differences due to the interventions; the TCMS Static Sitting Balance score, Dynamic Reaching Score, total score, GMFM Dimension A score, total score, QUEST total score, PBS score and Gillette FAQ Skill Test scores improved in the TTG in comparison to the CG (p<0.05). There was no difference in the other measurements (p>0.05). The comparisons between the groups are shown in Table 3-4.

Table 2. Baseline Values of TTG and CG

		TTG (n=19)	**CG (n=17)**	**Mann-Whitney U**	
		X± SD	**X± SD**	**z**	**p**
TCMS	Static Sitting Balance	10.8±8.0	13.8±6.5	-1.285	0.199
	Dynamic Sitting Balance	8.1±8.6	13.6±8.7	-2.027	**0.043***
	Dynamic Reaching	4.9±3.7	6.8±3.3	-1.675	0.094
	Total	23.9±19.5	34.3±17.8	-1.756	0.079
GMFM	Lying & Rolling	82.3±29.5	95.8±5.2	-0.719	0.472
	Sitting	73.0±34.2	83.3±22.5	-0.841	0.400
	Crawling & Kneeling	63.1±39.3	76.4±31.4	-1.123	0.262
	Standing	41.9±36.5	53.1±34.8	-1.069	0.285
	Walking, Running & Jumping	37.5±34.5	48.7±37.3	-1.131	0.258
	Total	59.5±32.6	70.8±25.8	-1.111	0.267
QUEST	Dissociated Movement	68.8±41.8	80.5±27.3	-0.634	0.526
	Grasp	67.0±37.8	69.2±27.9	-0.162	0.871
	Weight Bearing	69.0±42.8	68.1±33.2	-0.248	0.804
	Protective Extension	53.3±39.2	50.3±31.5	-0.242	0.809
	Total	65.6±38.5	67.0±26.4	-0.366	0.714
PBS		22.6±21.3	31.1±20.9	-1.464	0.143
IPFAM	Total	53.6±13.0	57.3±13.9	-0.874	0.397
Gillette FAS	Walking Scale	4.9±3.5	6.3±3.4	-1.111	0.266
	Skills Test	17.2±19.6	23.3±21.0	-0.806	0.420

TTG: Trunk Training Group, CG: Control Group, TCMS: Trunk Control Measurement Scale, GMFM: Gross Motor Function Measurement, QUEST: Quality of Upper Extremity Skills Test, PBS: Pediatric Balance Scale, IPFAM: Impact on Family Scale, Gillette FAS: Gillette Functional Assessment Scale, X: mean, SD: Standard Deviation, p: statistical significance

Table 3. Comparison of changes in outcomes from baseline to 8 weeks in the TTG and CG

		TTG	**CG**	**Mann-Whitney U**	
		X± SD	**X± SD**	z	*p*
TCMS	Static Sitting Balance	1.6±2.6	-0.1±2.0	-2.091	**0.036***
	Dynamic Sitting Balance	3.7±5.0	-0.9±3.5	-2.864	**0.004***
	Dynamic Reaching	1.5±1.8	0.7±2.9	-0.957	0.339
	Total	7±7.6	-0.2±5.5	-2.654	**0.008***
GMFM	Lying & Rolling	5.8±12.0	0.2±4.0	-1.982	**0.047***
	Sitting	4.0±7.9	1.4±6.0	-0.910	0.363
	Crawling & Kneeling	5.4±5.8	2.2±5.0	-1.578	0.115
	Standing	2.9±5.9	0.7±5.3	-1.096	0.273
	Walking, Running & Jumping	3.3±5.8	-0.9±4.4	-1.615	0.106
	Total	4.3±4.5	1.7±4.5	-2.456	**0.014***
QUEST	Dissociated Movement	6.8±14.9	0.7±8.2	-1.698	0.090
	Grasp	2.8±14.2	-1.3±12.1	-0.682	0.495
	Weight Bearing	8.7±16.5	3.7±20.3	-0.622	0.508
	Protective Extension	2.7±24.0	-0.5±31.8	-0.690	0.490
	Total	6.5±10.4	0.3±12.4	-2.146	**0.032***
PBS		2.5±2.5	0.1±2.0	-2.733	**0.006***
IPFAM	Total	0.9±7.9	-5.3±15	-0.849	0.396
Gillette FAS	Walking Scale	0.3±0.7	0±0.5	-1.430	0.153
	Skills Test	2.7±4.4	-0.2±6.7	-2.557	**0.011***

TTG: Trunk Training Group, CG: Control Group, TCMS: Trunk Control Measurement Scale, GMFM: Gross Motor Function Measurement, QUEST: Quality of Upper Extremity Skills Test, PBS: Pediatric Balance Scale, IPFAM: Impact on Family Scale, Gillette FAS: Gillette Functional Assessment Scale, X: mean, SD: Standard Deviation, p: statistical significance, *p < 0.05; **p < 0.01

Table 4. Differences in groups with 8 weeks intervention

		TTG			CG		
		Before Intervention	**After Intervention**	**Wilcoxon**	**Before Intervention**	**After Intervention**	**Wilcoxon**
		X± SD	**X±SD**	***p***	**X± SD**	**X±SD**	***p***
TCMS	Static Sitting Balance	10.8±8.0	12.5±7.4	**0.012***	13.8±6.5	13.7±6.6	0.914
	Dynamic Sitting Balance	8.1±8.6	12.0±9.4	**0.006***	13.6±8.7	13.0±8.7	0.499
	Dynamic Reaching	4.9±3.7	6.5±4.0	**0.005***	6.8±3.3	7.5±3.5	0.394
	Total	23.9±19.5	31.2±20.1	**0.001***	34.3±17.8	34.2±18.0	0.711
GMFM	Lying & Rolling	82.3±29.5	87.2±25.5	**0.018***	95.8±5.2	96.0±5.0	0.109
	Sitting	73.0±34.2	76.1±32.8	**0.003***	83.3±22.5	84.7±24.9	0.108
	Crawling & Kneeling	63.1±39.3	67.8±39.9	**0.041***	76.4±31.4	78.1±31.0	0.529
	Standing	41.9±36.5	44.7±38.6	**0.037***	53.1±34.8	52.6±37.4	0.575
	Walking, Running & Jumping	37.5±34.5	41.4±37.2	**0.001***	48.7±37.3	47.1±38.4	0.711
	Total	59.5±32.6	63.4±32.1	**0.017***	70.8±25.8	71.7±25.2	0.893
QUEST	Dissociated Movement	68.8±41.8	74.4±36.8	0.066	80.5±27.3	78.6±25.6	0.674
	Grasp	67.0±37.8	69.9±35.4	0.814	69.2±27.9	67.8±28.5	0.788
	Weight Bearing	69.0±42.8	76.4±37.5	**0.051***	68.1±33.2	72.1±29.8	0.611
	Protective Extension	53.3±39.2	58.8±41.7	0.362	50.3±31.5	49.8±28.4	0.799
	Total	65.6±38.5	71.1±35.6	0.080	67.0±26.4	67.1±23.4	0.433
PBS		22.6±21.3	25.7±22.9	**0.001***	31.1±20.9	31.1±21.4	0.949
IPFAM	Total	53.6±13.0	54.3±10.4	0.711	57.3±13.9	55.4±14.3	0.700
Gillette FAS	Walking Scale	4.9±3.5	5.3±3.3	0.083	6.3±3.4	6.2±3.4	1.000
	Skills Test	17.2±19.6	20.7±21.8	**0.049***	23.3±21.0	23.1±22.3	0.572

TTG: Trunk Training Group, CG: Control Group, TCMS: Trunk Control Measurement Scale, GMFM: Gross Motor Function Measurement, QUEST: Quality of Upper Extremity Skills Test, PBS: Pediatric Balance Scale, IPFAM: Impact on Family Scale, Gillette FAS: Gillette Functional Assessment Scale, X: mean, SD: Standard Deviation, p: statistical significance, *p < 0.05; **p < 0.01

DISCUSSION

In this study we find improvements in trunk, upper and lower extremity motor functions and activity levels of children with bilateral spastic Cerebral Palsy with an individually structured trunk training.

In our study in TTG, there was an improvement in the trunk control. We also had improvement in gross motor function in both groups but it was significant in only in TTG.

In a randomized clinical trial conducted by Lee at all (18); one group received a physiotherapy program based on the NDT and the other group received a physiotherapy program consisting of the NDT+trunk and lower extremity strengthening exercises. They reported that there was an increase in the GMFM scores in the latter group when compared to only the NDT group however it was not significant.

In the literature, there are a few studies reporting their results about trunk-targeted training in children with CP. The interventions used in these studies were strengthening exercises, kinesio taping, electrical stimulation, and therapeutic horse riding/ hippo therapy methods which were generally combined with the NDT (19, 20). This was the first randomized controlled trial analyzing the effects of individually structured trunk training on the motor functions of the trunk, upper and lower limbs of children with bilateral spastic CP.

One of the hypotheses of our study was if the trunk provides a better support; the functions of the upper and lower extremities can be easier, and the motor functions of the upper and lower extremities improve by trunk training. Scarce number of studies focused on the upper extremity functions in children with bilateral CP. The TTG improved in weight-bearing sub score of the QUEST. A number of studies conducted on non-symptomatic people confirmed that scapular retraction and trunk-hip extension was synergistic (21). In the TTG, we performed numerous exercises to extend the trunk so the scapular stabilization might have been improved therefore the weight-

bearing scores improved. We didn't find an improvement in the Dissociated Movement domain scores. Selective motor control was essential for these items however the mean age of the children included in our study was higher hence the activity strategies were old, may be 8 week is not enough to change the movement strategies.

In this study we showed that balance improved in TTG. In a study conducted by Jaume-i-Capo et al, computer games that involved reaching-activities performed during 24 weeks and it is reported that balance scores improved (22). Tarakçı et al used supervised Wii FIT exercises and found an improvement in the functional balance scores (23). We have not used computer games in this study however used reaching-activities in different settings as mentioned in above studies and the position in the TTG and we also had improvement in balance scores.

According to our results, neither of the groups differed in the Gillette FAQ Walking Scale scores however the Gillette FAQ Skill Test scores of the TTG improved. The Gillette FAQ Walking Scale classifies walking ability in a ten point scale and may not be sensitive to small changes however the Gillette FAQ Skill Test evaluates different properties of gait and balance by more items therefore it could be more sensitive to differences.

In this study we could reached to a limited number of participants, but including more cases and separately analyzing the results for all GMFCS level will be efficacious to determine the patients that is more likely to benefit from trunk training.

We think that further studies are needed to determine the effects and intensity of the trunk training. Not only children with spastic CP but also children with different types of CP should be included in future studies.

CONCLUSION

According to our results, we consider that trunk training consisting of strengthening exercises and the NDT has positive effects on motor performance, activity and daily living activities when it is individually structured based on the needs, capacity and evaluation reports of the children with bilateral spastic CP.

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Author Contributions

Ayşe NUMANOĞLU AKBAŞ designed the study, assessed the patients, applied physiotherapy program to the patients in trunk training group, participated in data interpretation and revision of manuscript, and approved final version. Mintaze KEREM GÜNEL conceived paper, oversaw data collection, conducted data analysis, wrote manuscript and approved final version. The authors declare that they have no conflicts of interest.

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