ORİJİNAL ARAŞTIRMA ORIGINAL RESEARCH

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The Effects of Supervised Intensive Exercises Programme on Activity Performance Following Tendon Transfers in Brachial Plexus Birth Injury: Randomized Controlled Trial

Doğumsal Brakiyal Pleksus Yaralanmalarında Tendon Transferi Sonrası Supervize Yoğun Egzersiz Programının Aktivite Performansı Üzerine Etkisi: Randomize Kontrollü Çalışma

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ABSTRACT Objective: The purpose of this study was to determine the effect of intensive exercise therapy program on the activity performance in children ages 4 to 8 with brachial plexus birth injury (BPBI) who were applied modified Hoffer technique for improving abduction and external rotation of the shoulder. **Material and Methods:** The inclusion criteria consisted of age: between 4-8 years, postoperative status: at least one year. Exclusion criteria covered patients with the previous microsurgery in the early stages of brachial plexus renovation. Forty-three children with BPBI were included in the study. The mean age of Group 1 was 5.98±1.25 years, and the mean age of Group 2 was 6.36±1.39 years, Group 1 consisted of 22 children who received one hour supervised intensive exercise therapy (SIET) program daily for five days a week, while Group 2 consisted of 21 children who received an individualized home exercise program. Range of motion and functionality were evaluated. Functional assessments were performed by using the Mallet Scale, Quality of Upper Extremity Skill Test (QUEST), Pediatric Evaluation of Disability Inventory (PEDI) and Canadian Occupational Performance Measure (COMP). **Results:** A significant difference was found in pre-treatment and post-treatment of Mallet, QUEST independent movements, PEDI functional activities, COMP scores in both groups ($p<0.05$). Although the changes were observed in both groups, pre-treatment and post-treatment differences were more in Group 1 than in Group 2 ($p<0.05$). **Conclusion:** Supervised intensive exercises and individual home exercise programs are effective in children with BPBI. SIET group was more efficient, and adding supervised exercises to these children's physiotherapy protocol was important because there was an increase in the functionality of the upper extremity.

Keywords: Brachial plexus; birth injury; exercise; functional activity; shoulder tendon transfer

ÖZET Amaç: Çalışmanın amacı, 4-8 yaş arasında omuz abdüksiyon ve eksternal rotasyonunu artırmak için modifiye Hoffer tekniği uygulanan doğumsal brakiyal pleksus yaralanmalı (DBPY) çocuklarda denetimli yoğun egzersiz tedavisinin aktivite performansı üzerine etkisini belirlemekti. **Gereç ve Yöntemler:** Tendon transferi sonrası en az 1 yıl geçmiş olgular çalışmaya dâhil edilirken erken dönemde sinir cerrahisi geçiren olgular çalışmaya dâhil edilmedi. DBPY'li 43 çocuk çalışmaya dâhil edildi. Yirmi iki olgudan oluşan Grup 1'e haftada 5 gün 1 saatlik denetimli yoğun egzersiz programı verilirken 21 olgudan oluşan Grup 2'ye bireyselleştirilmiş ev egzersiz programı verildi. Grup 1'in yaş ortalaması 5,98±1,25 yıl, Grup 2'nin yaş ortalaması 6,36±1,39 yıl idi. Olguların, eklem hareket açıklığı ve fonksiyonel değerlendirmeleri yapıldı. Fonksiyonel değerlendirmeler için Mallet Skalası, Üst Ekstremite Beceri Kalitesi Testi bağımsız hareketler alt skoru, Pediatrik Özürlülük Envanterinin fonksiyonel aktiviteler skorları ve Kanada Rol Performans ölçümü kullanıldı. **Bulgular:** Her iki grupta da tedavi öncesi ve sonrası Mallet Skalası, Üst Ekstremite Beceri Kalitesi testi bağımsız hareketler alt skoru, Pediatrik Özürlülük Envanteri Fonksiyonel aktiviteler alt skoru ve Kanada Rol Performans Ölçümü skorları arasında anlamlı farklılık bulunurken tedavi öncesi ve sonrası farklar Grup 1'de daha fazla idi ($p<0,05$). **Sonuç:** Denetimli yoğun egzersiz ve ev egzersiz programı gruplarının her ikisinin de tedavi öncesi ve sonrası skorlarda anlamlı farklılık bulunsa da denetimli yoğun egzersizler üst ekstremite fonksiyonelliği üzerinde daha etkili idi. DBPY'li çocuklarda fizyoterapi programlarına denetimli yoğun egzersiz programlarının eklenmesinin üst ekstremite fonksiyonlarının artırılması için önemli olduğu görüşündeyiz.

Anahtar Kelimeler: Brakiyal pleksus; doğum yaralanması; egzersiz; fonksiyonel aktivite; omuz tendon transferi

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Brachial plexus birth injury (BPBI) describes the group of clinical conditions caused by a traction injury in the brachial plexus during birth that includes shoulder area muscle weaknesses, soft tissue contractures, and progressive glenohumeral joint deformity or instability.[1-3] In BPBI, the clinical symptoms and prognosis differ according to the mechanism of injury, involvement, affected area, and applied treatment. Children and adolescents with BPBI frequently exhibit a wide range of limitations in functionality in the affected arm and a high risk for permanent disability with middle (C5-C7) and total (C5-T1) plexus injuries.[4-7]

In addition, structural deformities seen in the upper extremity in BPBI limit the performance of activities of daily living (ADLs) and participation in both school and social activities.[8] With sustained BPBI, children are at risk for progressive increases in participation restrictions.[9] Although conservative and surgical treatment approaches are complementary, they are not alternatives for each other. Therefore, the purpose of both conservative and surgical treatments is to provide the maximum functional enhancement of performance and enrichment in quality of life.[10-13] Although the purpose of all treatment is to achieve functionality in the affected extremity, very few studies have been reported that describe postoperative exercise program.[14] The modified Hoffer technique is one of the most commonly performed surgeries to restore external rotation and abduction in BPBI. This technique with significant improvement in postoperative shoulder abduction, external rotation, and functional outcome measures.[15,16] Postoperatively, patients were immobilized in a "Statue of Liberty" brace. The patient is braced at 90° of shoulder abduction and full external rotation over the succeeding 12 weeks.

The purpose of our study is to determine the effect of a supervised intensive exercises therapy (SIET) program on activity performance using the modified Hoffer technique for shoulder tendon transfers in BPBI

MATERIAL AND METHODS

In this study, records were analyzed on BPBI patients who underwent tendon transfers to increase shoulder abduction and external rotation using the modified Hoffer technique and followed-up at the Division of Hand Surgery, Department of Plastic, Reconstructive, and Aesthetic Surgery, İstanbul University Medical Faculty in İstanbul, Turkey. This study was approved by the Clinical Research Ethics Board dated 23.12.2011 and numbered 2011/2103-891 with the number of files and made in accordance with the Helsinki Declaration.

The study was designed as a single-blind randomized parallel-group trial. Patients attending our clinic were assessed secondary for the inclusion criteria and were accepted to the study accordingly. All patient data collection was conducted by physiotherapists. Microsoft Excel "RAND (USA)" function was utilized for randomization. One of the researchers (ARÖ) had knowledge of the function used but did not participate in any of the assessments. The second researcher (ET) was completely blinded to the process and had knowledge of only a standard set of assessments to conducted. Third researcher (ZH) carried out the intervention without any knowledge of the assessments.

The study included a purposive sample of 54 patients selected according to eligibility criteria from 60 potential postoperative candidates. Six cases were excluded due to inclusion criteria. The inclusion criteria consisted of age: between 4-8 years, postoperative status: minimum one year because and no plans for a new operation in the near future, and psychological status: the absence of cooperation problems that could preclude understanding exercises. Exclusion criteria covered patients with the previous microsurgery in early stages of brachial plexus renovation, having a postoperative status in less than one year and noncompliance with a treatment plan, including follow up care. Patients were excluded from the study if they had primer microsurgery, that cause limitation of shoulder range of motion (ROM) and muscle strength was less than 3/5.

After informed consent was obtained from the patient's parents, study participants were randomly assigned to two groups: supervised intensive exercises therapy group [SIET-group] (n=27) and home exercise therapy group [HET-group] (n=27). Five patients were removed from the SIET-group, and six patients have dropped from the HET-group for one of

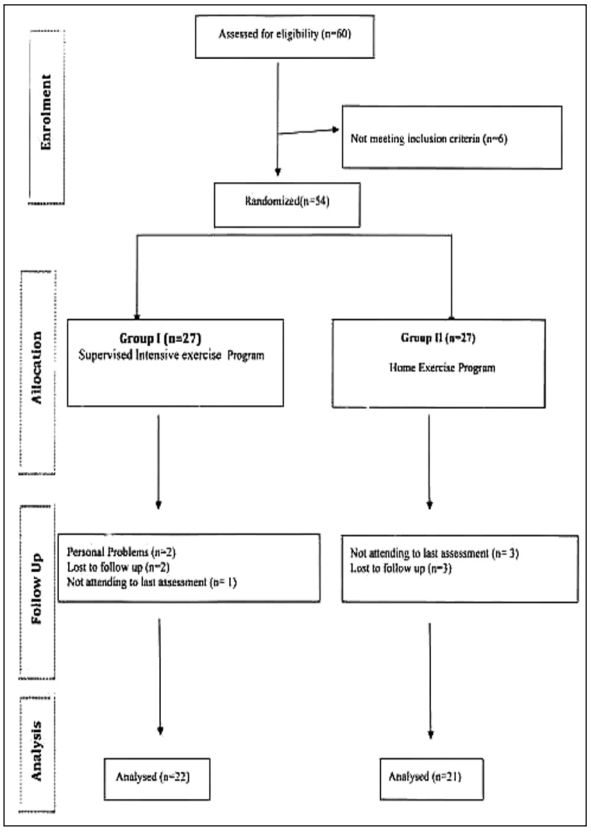

FIGURE 1: Progress of study participants.

three possible causes: participation in a new exercise program, personal problems, or failure to attend the second assessment. As a result of the final screening, 22 patients remained in the SIET-group and 21 patients in the HET-group. All 43 remaining patients completed the study (Figure 1).

OUTCOME MEASUREMENTS

ROM, Mallet classification Pediatric Evaluation of Disability Inventory (PEDI), Quality of Upper Extremity Skill Test (QUEST), and Canadian Occupational Performance Measure (COPM) were used to assess upper extremity function. All assessments were performed before treatment and repeated after 12 weeks.

RANGE OF MOTION

Active ROM was evaluated objectively with universal goniometer. Shoulder abduction, and flexion measurements were performed with the patient standing in order to prevent compensatory movements. Stabilization of the scapula for measurement of external and internal shoulder rotations was achieved by laying the patient on an examination table in the prone position.[17,18] Other ROM measurements were performed using standard techniques associated with the test. According to the sequence of measurement proceeded from the healthy side to the affected extremity.

THE MALLET CLASSIFICATION

The Mallet classification was used to measure the global movement of the extremity and to analyze the movement patterns for function and defect. This classification evaluates five movements: shoulder abduction, external rotation, taking the hand to the head, taking the hand to the back, and taking the hand to the mouth. Every parameter is graded from 1 to 5, according to the below assessment schema for each parameter.[18,19] A total Mallet score is calculated from the scores gained in the performance of the former tasks with a grading scale of I to V giving a maximum score of 25.[19]

PEDIATRIC EVALUATION OF DISABILITY INVENTORY

PEDI consists of 3 subsections as functional abilities:

1. Patients were in need of caregiver help and modifications.

2. Patients with BPBI did not need caregiver help and modifications

3. The functional abilities section of the cases was evaluated for BPBI cases.

A total of 197 items were scored by giving 1 point to each of the items that the participant successfully completed and assigning 0 points for the items they did not complete.[20]

QUALITY OF UPPER EXTREMITY SKILL TEST

This assessment cluster is applied in order to evaluate handcraft and movement quality. QUEST consists of 6 subsections, including independent movements, grasp, weight-bearing, protective extension, hand function proportion, and cooperation proportion. Every activity is illustrated in the test, and at the same time, the normal criteria of the activity are written near the activity that will be measured. The results taken from all sections of the test were scored as 1 point for each of

the items that the participant completed and assigning 0 points for the items they did not complete.[21]

CANADIAN OCCUPATIONAL PERFORMANCE MEASURE

COPM is a client-centred, occupation-focused outcome measure for the detection of a change in perceived occupational performance over time. It is a generic measure suitable for all clients with perceived problems in daily activities (self-care, work and/or leisure activities). The COPM results in two main scores as performance and satisfaction, each out of a total of 10. The patient prioritizes up to five problems she/he deems that are the most urgent or important and rates the problems on an ordinary 10-point scale regarding performance (1 = not able to do at all and 10 = able to do extremely well) and satisfaction (1 = not satisfied at all and 10 = extremely satisfied). Performance and satisfaction scores of 5 activities were summed up and divided by the number of activities, resulting in total performance and satisfaction scores. COPM is a reliable, valid, and responsive instrument and change scores of 1.4 for performance and 1.9 for satisfaction are considered clinically important.[22]

INTERVENTIONS

Twenty-two patients participated in the SIET-group and received an intensive exercise program. Conversely, twenty-one patients included in the HET-group received individualized home exercise (IHE) program. The patients and parents were informed about the study, and written informed consent was obtained from the parents.

The treatment intervention was applied to the SIET-group five times per week for 60 min over the course of 12 weeks. Strengthening exercises for shoulder abduction, flexion, external rotation and extension, and stretching exercises for shoulder internal rotation were prescribed as three sets and ten repetitions. For daily life activities, button fastening, hair combing, zipper pulling activities and skill cube were practised with the physiotherapist. This program focused on daily living activities, bimanual task activities, as well as ROM and stretching exercises. In addiction, home exercises were given other day of the week.

On the other hand, although the HET-group received a professionally planned, IHE program consisted of ROM of the shoulder, elbow, forearm with flexion, extension, and rotation and stretching exercises. The exercises were performed daily by the patient under observation with family. All patients in the HET-group were provided with a written instructional plan to follow for their home exercises. They also were asked to document the exercises in a daily activity diary. In addition, they were followed up by telephone once per week. The level of intensity and difficulty for the exercises was increased gradually for both groups, and all participants were provided with the same instructions and programming activities for home exercises. The exercise programs for each group is provided below in Table 1.

STATISTICAL ANALYSIS

Statistical analysis was assisted by SPSS (v21) software. The significance threshold was set at 0.05 (2-tailed). Power analysis was done by a Raosoft web service (raosoft.com).

Shapiro-Wilks test verified the normality of the baseline data ($p>0.05$). Parametric tests were applied to all groups. Mean +- SD format was used to report descriptive statistical data. Differences in demographic and/or baseline variables were tested both for categorical (chi-square test) and continuous variables (independent t-test). Independent t-test was also used to report on changes in score between groups, and the paired t-test to report changes within the groups in a similar manner.

TABLE 1: Exercise program.

1. Shoulder abduction exercise
2. Shoulder flexion exercise
3. Shoulder external rotation
4. Shoulder internal rotation
5. Shoulder internal rotation stretching exercise
6. Elbow extension
7. Forearm pronation-supination exercise
Daily vital activities determined according to the child's requirements
Study with ADL purposeful ability cube
Study with resistant grasp kit
Supination-pronation activity

ADL: Activities of daily living.

RESULTS

The demographic characteristics for both groups are shown in Table 2. Sixteen patients had C5-C6 lesions, while 27 had C5-C6-C7 lesions according to Narakas classification. A mean of 22.68±6.83 was calculated for participants who had been operated on 12-48 months prior to the study for the SIET-group, while a mean of 23.49±5.72 for the HET-group. There were no statistically significant differences between the groups based on post-surgical months (p>0.05). Demographic data of patients are given in Table 2.

No statistically significant differences were detected between the age and birth weight averages, pre-treatment, ROM, and functional assessments scores of the groups (p>0.05).

A pre- and post-treatment comparison for alteration in values of flexion, forearm rotation, internal rotation, elbow flexion-extension, shoulder abduc-

TABLE 2: Demographic characteristics of the patients.

	Group 1 (SIET)	Group 2 (HET)	p value
Gender (M/F)	12/10	5/16	
Age (year)	5.98±1.25	6.36±1.39	
Time of surgery (month)	22.68±6.83	23.49±5.72	0.774
Affected side			
Right n (%)	10 (45.5)	13 (61.9)	
Left n (%)	12 (54.5)	8 (38.1)	
Involvement type			
C5-6 n (%)	8 (36.4)	8 (38.1)	
C5-6-7 n (%)	14 (63.6)	13 (61.9)	
Birth weight	4295±597	4168±372	0.086
Delivery method			
Normal	22	21	
Cesarean section	-	-	
Birth place			
Private hospital	2 (9.1)	3 (14.3)	
Public hospital	20 (90.9)	18 (85.7)	

SIET: Supervised intensive exercise therapy; HET: Home exercise therapy.

TABLE 3: Comparison of pre-treatment, post-treatment, and value changes of ROM.

ROM (Degree)		Pre-T $\bar{X}$±SD	Post-T $\bar{X}$±SD	p value	Difference $\bar{X}$±SD	Difference p value
Shoulder abduction	Group I	123.77±23.49	139.77±21.12	**0.001**	16.01±17.21	0.052
	Group II	130.29±26.17	137.04±25.47	0.165	6.76±18.04	
Shoulder flexion	Group I	124.18±28.66	135.90±25.80	**0.003**	11.72±15.02	0.148
	Group II	129.29±22.37	134.90±24.97	0.121	5.61±14.44	
Shoulder external rotation	Group I	69.50±12.21	79.54±11.64	**0.005**	3.90±18.84	0.273
	Group II	69.43±20.20	73.33±13.26	0.377	10.04±14.97	
Shoulder internal rotation	Group I	1.45±20.29	10.90±15.40	**0.002**	9.45±11.72	**0.001**
	Group II	-0.71±15.10	-1.90±14.18	0.474	1.19±18.36	
Elbow flexion	Group I	126.59±14.67	130.00±12.63	0.173	3.40±14.25	0.950
	Group II	122.86±19.27	128.57±14.06	0.057	5.71±12.87	
Elbow extension	Group I	-15.23±12.00	-11.81±11.60	**0.037**	3.40±6.79	0.149
	Group II	-11.90±8.72	-11.42±8.68	0.746	0.47±4.71	
Pronation	Group I	46.59±39.92	54.31±36.22	**0.005**	7.72±11.82	0.309
	Group II	48.10±41.30	51.19±40.89	0.567	3.09±19.33	
Supination	Group I	56.36±28.62	68.86±16.03	**0.006**	12.66±23.31	0.951
	Group II	58.29±29.53	70.95±13.19	**0.006**	12.50±21.58	
Wrist extension	Group I	62.50±35.81	69.31±28.12	**0.004**	6.81±21.57	0.682
	Group II	64.29±24.61	69.52±17.67	0.081	5.23±12.29	
Wrist flexion	Group I	46.59±18.15	51.36±17.19	0.082	4.77±11.90	0.200
	Group II	42.95±18.01	52.38±15.13	**0.003**	9.42±11.99	

ROM: Range of motion; SD: Standard deviation; Pre-T: Pre-treatment; Post-T: Post-treatment.

TABLE 4: The comparison of pre-treatment, post-treatment and value changes of functional tests between the groups.

Functional tests		Pre-T $\bar{X}$±SD	Post-T $\bar{X}$±SD	p value	Difference $\bar{X}$±SD	Difference p value
MALLET	Group I	17.00±1.19	17.68±0.94	**0.002**	0.68±0.83	**0.025**
	Group II	17.47±1.12	17.66±1.06	**0.046**	0.19±0.40	
QUEST IM	Group I	69.91±8.80	72.45±8.20	**0.028**	2.54±5.34	0.133
	Group II	71.38±7.61	72.33±8.47	0.180	0.95±3.55	
QUEST TOTAL	Group I	80.12±8.60	82.16±7.39	**0.003**	2.05±3.77	0.130
	Group II	80.76±10.91	82.11±11.34	**0.043**	1.35±3.80	
PEDI	Group I	178.73±10.15	190.04±6.55	**0.000**	11.31±7.32	**0.000**
	Group II	181.43±12.74	185.61±12.19	**0.000**	4.19±3.69	
COPMP	Group I	3.19±1.83	5.50±2.24	**0.000**	2.31±1.59	**0.032**
	Group II	2.30±1.86	4.15±1.69	**0.000**	1.39±1.27	
COPMS	Group I	3.40±5.36	6.08±3.27	**0.002**	2.68±6.02	**0.045**
	Group II	2.76±1.65	4.21±2.56	**0.001**	1.91±1.94	

Pre-T: Pre-treatment; Post-T: Post-treatment; SD: Standard deviation; QUEST: Quality of upper extremity skills test; IM: Independent movements; PEDI: Pediatric evaluation of disability inventory; COPMP: Canadian occupational performance measure performance; COPMS: Canadian occupational performance measure satisfaction.

tion, forearm pronation-supination, wrist flexion-extension ROM values are shown in Table 3.

Post-treatment measurements were significantly higher than pre-treatment values of shoulder abduction, flexion, external rotation, elbow extension, and wrist flexion in SIET-group ($p<0.05$). Although there was an increase in the values of shoulder abduction, flexion, external rotation, elbow extension, wrist flexion in SIET-group compared to the HET-group, this difference was not statistically significant ($p>0.05$). A significant increase in shoulder internal rotation values was observed in SIET-group ($p<0.05$), and also the differences between groups were also statistically significant ($p<0.05$).

The between-group comparison of pre- and post-treatment results for the alteration of functional tests is shown in Table 4. A significant difference was also found in pre- and post-treatment scores for Mallet, QUEST independent movements, PEDI functional activities, and COPMS scores in both groups ($p<0.05$). The group differences for these tests were also significant ($p<0.05$). Likewise, a significant difference was found in the pre- and post-treatment values of QUEST total score in both groups ($p<0.05$); however, the between-group difference for this test was not statistically significant ($p>0.05$).

DISCUSSION

The aim of this study was to investigate the impact of late exercise programs on the upper extremity functions in BPBI. At the end of the study, patients from both groups benefited from the treatment. Although the changes were observed in both groups, the changes in the SIET group was better for the children's regular participation and compliance to exercise. The evaluations in BPBI are gathered in 4 groups, including classification, diagnostics, physical examination and functional outcome.[6,10,23] Evaluation of all parameters beginning from the earliest period of BPBI is relatively important for determining the functional level and treatment options of the child.[10]

Measurement parameter for BPBI cases is ROM measurement. One of the safest methods for measuring ROM is goniometry measurement. Russel and colleagues evaluated the everyday life use of goniometer measurements and upper extremity in the first year after the shoulder tendon transfer. They stated that there was a high correlation between especially the increase in shoulder abduction and external rotation and the everyday life use of extremity.[8]

In our study, we achieved an increase, especially in shoulder abduction, flexion and external rotation, elbow extension, forearm supination and wrist flexion, and ROM in the SIET-group. One of the interesting results of the study is the further increase in wrist extension in the control group. We consider this as a random consequence.

In BPBI, functional tests are used in order to evaluate surgical or rehabilitative efficiency. We used Mallet classification as one of the scales while evaluating the functional outcomes of the patients. Mallet classification is a test used especially after 3-4 years and evaluates shoulder functionality and global movement patterns. It has been used in numerous studies for evaluating the efficacies of both conservative and surgical treatments in BPBI. In the literature, when Mallet score is over 18, the shoulder is defined as functional or useful. In our opinion, scores of 18 and over should be defined as functional because of variability in the scores across applied treatments and age groups.[19,24,25]

Van der Sluijs et al. investigated the reliability of Mallet scale inter-observers and found that the shoulder abduction was more reliable than the external rotation. There was a significant difference in Mallet scores between the pre-treatment and post-treatment in both groups, and also the difference between the groups was statistically significant.[26]

In future studies, evaluating the subgroups of Mallet classification would be more valuable for the separate assessment of upper extremity functionality. The Mallet score was 17 in both groups before treatment and increased significantly afterwards. Although our patients' scores from the SIET-group remained under 18 after the treatment, the increase was found to be statistically significant, and shoulder functions also improved.

QUEST is a test developed for cerebral palsy; validity studies have not been found in the literature for Turkish. However, because of its high correlation with Melbourne and active hand assisting tests, which are used frequently in BPBI, we argued for its usefulness in evaluating lower and total score values for independent movements in BPBI as well and used these tests in our study. We based our decision on the evidence of "very high correlation coefficients have been calculated between the Melbourne assessment and self-care [0.939] and mobility domains [0.783] of the PEDI and the overall functional skills section of the PEDI [0.718]".[27,28] In addition, the Melbourne assessment has demonstrated excellent construct validity for upper limb functioning.[29] Our results yielded significant differences between pre- and post-treatment scores in QUEST independent movements, but between-group differences did not reflect significance. We think that QUEST results for the SIET-group were better because of increases that ROM provided. There were significant differences between pre- and post-treatment values for both the SIET-group and home exercise program group in the QUEST total score. Furthermore, the differences between the groups were statistically significant. We think that the increase in the lower score of independent movements created an increase in the total score.

Thorley et al. suggested that QUEST should be calculated independently for each area and each extremity when assessing children with cerebral palsy.[27] They recommended that the posture sub-items of the grasp sub-group should be removed because its relationship with the total score is minimal. Our study was not affected by these sub-items because our children did not have problems with posture. We applied QUEST independent movements to the evaluation of hand functions only in the grasp sub-group, while the evaluation of protective extension and weight-bearing sub-groups was achieved through the level of the body functions. QUEST is insufficient in evaluating fine motor and functional skills because this test does not evaluate the speed and quality of the movement.

Another test that evaluates functionality in BPBI is PEDI. Erkin et al. argued that PEDI is a detailed and useful evaluation for pediatric rehabilitation, which has attained validity and reliability for use in Turkish as well as with various physical diseases in diverse populations.[20] Although PEDI recommends the application of the whole test, self-care sub-groups can be evaluated separately for BPBI because mobility and social functions are not affected. The negative aspect of using this test is that PEDI only asserts

the absence or presence of the movements, not how the movements are made or the quality of the performance. While evaluating movement using the PEDI, one of the difficulties we encountered was that during pre-treatment, study participants performed self-care activities using the unaffected, dominant side but did not attempt to use the involved side. Likewise, the families stated that they had not observed their children, even though they had been asked to observe their children for one week. A significant difference was found between pre- and post-treatment PEDI scores in both groups, and in the between-group scores differences were similarly statistically significant.

A third test used in our study to evaluate functionality was COPM. COPM can be applied to the evaluation of child play and self-care activities, but because our study participants were aged between 4 and 8 years, their evaluations were completed with the aid of their families.[30] In the literature, COPM has been reported for evaluating childhood cancer, epilepsy, applications of botulinum toxin, and in numerous areas of pediatric rehabilitation such as with scoliosis, but especially for evaluating children suffering from cerebral palsy. We used this test in our study because of its flexibility and applicability to different clinical situations, even though Turkish validity and reliability testing were not identified in the literature.

In applying COPM to ADL for our study participants, we observed similar results that we attribute to likeness in ages, types of cases, and environmental circumstances. One of the problems we encountered during the application of COPM was the difficulty in educating the families to understand the evaluation for scoring. Self-scoring of the test by families was culturally biased. The parents consistently assessed lower scores for their child's performance, and the dissatisfaction with performance created personal distress for the parents with needing to face and assess their child's struggles. Interestingly, the families of the children with higher functional levels gave lower performance scores and satisfaction points to their children; while, the families of the children with lower levels of function gave higher points for small increases. We think that subjective evaluation presents a confounding sociocultural result that negatively impacts the validity of that aspect of study conclusions. Although pre- and post-treatment COPMS scores in both groups were increased at the end of the study, the performance and satisfaction scores were higher in the SIET-group. We believe the reason for this difference was that the children and their families who worked cooperatively directly with a physiotherapist in the SIET-group were more motivated.

The structural problems seen in upper extremity BPBI limit the performance of participation in home and society activities. Although the purpose of both conservative and surgical treatments is enhancing the child's functional level, there are few studies concerning the functional rehabilitation of BPBI in literature.[10] Exercises are critical after a peripheral nerve or central nervous system injuries and increase plasticity and functional recovery. Plasticity increases are due to the improved sensory input after exercises.[10,23] Brown et al. investigated home-based exercise in BPBI.[31] They found that home-based exercises are effective in ROM and upper extremity function, similar to our study. The difference in our study was that the patients included in the study did not undergo surgical treatment. We think that home-based exercises are beneficial in terms of upper extremity functionality both after surgery and in cases followed by conservative treatment.

In the literature, much has been published about outcomes after tendon transfers to the shoulder with the modified Hoffer technique in order to increase shoulder abduction and external rotation.[14,19,24] Although there is only one study on postoperative physiotherapy program, this study is the first research in which the effectiveness of exercise program is compared in shoulder tendon transfer in the literature.[14] The intensive exercise program has a positive impact on recovery, but there are no accurate data about the frequency, intensity, and time-planning of exercise programs.[6] Our study looked at the effects of two different exercise programs on functionality.

A few studies are available in the literature for evaluating the efficacies of different physiotherapy approaches in BPBI. In these studies, the major goal of rehabilitation is to restore the basic functional abil-

ities of their arms in children with BPPI. Improvement of upper extremity functionality usually depends on various factors such as the nature and amount of rehabilitation. Although conventional programs are shorter and less intensive to ensure optimal therapeutic results, they cannot adequately increase the motivation of the child or support activity participation.[32-34] Therefore, we think that supervised exercises will be effective in long-term physiotherapy programs after surgery in children with BPBI. There have been no randomized control trials investigating intensive exercise for BPBI after modified Hoffer technique. Our study is the first research in which the effectiveness of different exercise program is compared with modified Hoffer technique in children.

LIMITATIONS

A major limitation of this study was the absence of valid and reliable measurements in the pre-treatment evaluation phase before shoulder tendon transfer. Another limitation is that QUEST is a test developed for cerebral palsy, validity studies have not been found in the literature for Turkish.

CONCLUSION

In conclusion, supervised intensive exercises and individual home exercise programs are effective in children with BPBI. SIET group was more efficient, and adding supervised exercises to these children's physiotherapy protocol was important because the children were more motivated. There was an increase in the upper extremity functionality.

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Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Zeynep Hoşbay, Ela Tarakcı;* ***Design:*** *Ela Tarakcı, Zeynep Hoşbay;* ***Control/Supervision:*** *Arzu Razak Özdinçler;* ***Data Collection and/or Processing:*** *Zeynep Hoşbay;* ***Analysis and/or Interpretation:*** *Zeynep Hoşbay, Atakan Aydın;* ***Literature Review:*** *Zeynep Hoşbay;* ***Writing the Article:*** *Zeynep Hoşbay;* ***Critical Review:*** *Arzu Razak Özdinçler, Atakan Aydın;* ***References and Fundings:*** *Atakan Aydın, Zeynep Hoşbay;* ***Materials:*** *Atakan Aydın.*

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