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RELATIONSHIP BETWEEN SITTING POSTURE, SITTING BALANCE AND UPPER EXTREMITY FUNCTIONS IN CHILDREN WITH SPINA BIFIDA

ORIGINAL ARTICLE

ABSTRACT

Purpose: To evaluate the relationship between the sitting posture, sitting balance and upper extremity functions of children with Spina Bifida (SB).

Methods: Thirty-one children with SB, and aged 5-18 years, were included the study. Their physical and clinical characteristics were recorded. Seated Postural Control Measure (SPCM), Pedalo® Balance Measurement System, Sitting Assessment for Children with Neuromotor Dysfunction (SACND), Modified Functional Reach Test (MFRT) and Jebsen-Taylor Hand Function Test (JTHFT) were used.

Results: There was a significant correlation between JTHFT results and the other test results, i.e. Pedalo® ($r = -0.478$, $p=0.007$), SACND ($r=0.399$, $p=0.026$) and MFRT ($r = -0.598$, $p<0.01$). There was no correlation between JTHFT and SPCM ($p>0.05$). In Pedalo®, MFRT, SACND, SPCM scores, significant differences were observed between the levels of lumbar and sacral lesions.

Conclusion: In children with SB, upper extremity functions and functional independence can be increased by improving sitting postures and sitting balance starting from the early period. We believe that studies searching for sitting mechanisms and exercises that may improve the sitting abilities and hand functions of children with SB are needed.

Key Words: Balance, Hand, Posture, Sitting Position, Spinal Dysraphism.

SPİNA BİFİDALI ÇOCUKLARDA OTURMA POSTÜRÜ, OTURMA DENGESİ VE ÜST EKSTREMİTE FONKSİYONLARI ARASINDAKİ İLİŞKİ

ARAŞTIRMA MAKALESİ

ÖZ

Amaç: Spina Bifida (SB)'lı çocukların oturma postürü, oturma dengesi ve üst ekstremite fonksiyonları arasındaki ilişkiyi değerlendirmek.

Yöntem: Çalışmaya 5-18 yaş arası 31 SB'li çocuk dahil edildi. Fiziksel ve klinik özellikler kaydedildi. Oturarak Postüral Kontrol Ölçümü (SPCM), Pedalo® Denge Ölçüm Sistemi, Nöromotor Disfonksiyonlu Çocuklarda Oturma Değerlendirme (SACND), Modifiye Fonksiyonel Uzanma Testi (MFRT) ve Jebsen-Taylor El Fonksiyon Testi (JTHFT) kullanıldı.

Sonuçlar: Pedalo ($r =-0,478$; $p=0,007$), SACND ($r = 0,399$; $p = 0,026$) ve MFRT ($r =-0,598$; $p<0,01$) ile JTHFT arasında anlamlı bir korelasyon vardı. JTHFT ile SPCM arasında bir ilişki yoktu ($p>0,05$). Pedalo®, MFRT, SACND ve SPCM skorlarında, lumbal ve sakral lezyon seviyeleri arasında anlamlı farklılık gözlendi.

Tartışma: SB'li çocuklarda erken dönemden başlayarak oturma postürleri ve oturma dengesi iyileştirerek üst ekstremite fonksiyonları ve fonksiyonel bağımsızlık arttırılabilir. SB'li çocukların oturma becerilerini ve el fonksiyonlarını geliştirebilecek oturma mekanizmalarını ve egzersizlerini araştıran çalışmalara ihtiyaç olduğu kanaatindeyiz.

Anahtar Kelimeler: Denge, El, Postür, Oturma Pozisyonu, Spinal Disrafizm.

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INTRODUCTION

Spina bifida (SB) is a disease that causes structural dysfunction in the body, and restrics participation in activities and daily life, depending on the type and level of lesions affecting the spine and lower extremities. Additionally, joint contractures are very common in SB. Muscle weakness, congenital malformations, and limitation of motion of the joints that accompany the neurological disorder can lead to the formation and progression of these deformities (1).

Children with SB can achieve various ambulation abilities based on their lesion levels but in the adolescent period, ambulation could be lost due to obesity and patients may become wheelchair-bound. Therefore, maintaining the sitting posture and spine alignment becomes even more important in this period (2).

It is emphasized that the disorder in upper extremity functions of children with SB is caused by such problems as upper extremity weakness, lack of coordination, spasticity, lack of body control and scoliosis (2). A progressive scoliosis deformity can bring a child from walking to sitting or limit bilateral hand use (3). Children with SB have been shown to have weak hand muscles and difficulty in writing (4).

Rehabilitation of postural impairment caused by muscle weakness and spinal deformities in children with SB is crucial to improve the effectiveness of using hands. Since these children are generally wheelchair-bound, increasing the sitting balance and alignment, improving upper extremity functions and increasing independence in daily living activities should be aimed (5).

There is no study in the literature that evaluates the sitting ability, body control and upper extremity functions of children with SB as a whole with objective data. Our study was performed to determine the relationship between upper extremity functions, sitting balance and sitting posture of children with SB. This study evaluates the sitting balance by providing objective data through Pedalo® balance test and also measures the sitting ability with different scales. We believe that this study will contribute to the literature in these aspects.

METHODS

This study was conducted between March 2016 and March 2017 in Istanbul. The participants were contacted via Turkey Spina Bifida Association and the evaluations were conducted in their home environment. Children with SB, aged between 5 and 18 years, and with independent sitting ability and mental capacity to understand instructions were included in the study (n=31). Children with mental and behavioral problems that impede perceiving the command were excluded from the study. Written consent was obtained from the participants' parents. The permission was obtained from Marmara University Ethics Committee for the study (22.02.2016-23).

The participants' socio-demographic characteristics, lesion levels, extremity involvement, whether they used assistive devices and an accompanying orthopedic/neurological disease was present were recorded (Table 1).

Pedalo® balance board is a system that records the centre of pressure sway to give information about body balance, response time and possible imbalances. A person can improve his/her performance by trying to achieve motor coordination on Pedalo®, and the progress achieved with therapy is documented by numerical results. In our study, the patients who could sit unsupported were seated on the platform of Pedalo® balance assessment device and the centre of pressure sway was recorded by asking the subjects to maintain their balance for one minute (6).

Seated Postural Control Measure (SPCM) is a test used in children and adults. This measurement evaluates postural impairment and the effect of sitting on postural control. SPCM consists of; a) personal information (diagnosis, age, date of birth, etc.), b) alignment section, c) upper limb function. The test evaluates the sitting posture by grading deviations from the base posture (from 1-severe impairment to 4-normal) (7, 8). In our study, the alignment section of SPCM test was used to evaluate the sitting posture.

The sitting ability of the cases were evaluated with Sitting Assessment for Children with Neuromotor Dysfunction (SACND), which is a scale that evaluates the quality of independent seating under four sub-headings: a) proximal stability, b) postural tonus, c) postural alignment and d) equilibrium. The lowest possible score was-8 and the highest one was 32 points, and a low score indicates a high sitting ability (9).

The dynamic sitting balance of the cases was evaluated with Modified Functional Reach Test (MFRT). In MFRT, the arm is extended parallel to the wall while in the sitting position. First, the tip of the middle finger is marked on the wall, then the forearm reaches forward as far as possible and the tip of the fingertip is marked for a second time. The distance between the two points is recorded in cm using a tape measure (10).

Jebsen-Taylor Hand Function Test (JTHFT) was used to evaluate upper extremity and hand functions. JTHFT is one of the most frequently used objective and standardized tests to evaluate functional hand use. The test includes seven subtests designed to investigate various hand activities: 1) copy a sentence, 2) turn index cards, 3) pick up small objects and place them in a can, 4) pick up beans with a spoon and place them in a can, 5) stack checkers, 6) move empty cans onto a board, and 7) move 1-pound cans onto a board (11). All these subtests were used except for the first one, which includes writing, in our study to evaluate the hand functions of the cases.

Statistical Analysis

Statistical analysis was performed using SPSS 11.5 (Statistical Package for Social Sciences Inc. Chicago, IL, ABD). The significance level was accepted as $p < 0.05$. Percentage values were used for the variables determined by analysing the demographic information of the cases and mean ± standard deviation values were calculated for the variables determined through measurement. During the data analysis process, One-Sample Kolmogorov-Smirnov test was performed in order to select the appropriate statistical tests, and it revealed that the data was normally distributed. The factors associated with upper extremity functions were analyzed with Pearson's Correlation Test because the data was normally distributed and in compliance with parametric conditions. If an r value of 1 is considered perfect, then 1 ⊠ r ≥ 0.8 is very strong, 0.8 ⊠ r ≥ 0.6 is moderate, 0.6 ⊠ r ≥ 0.3 is fair and 0.3 ⊠ r ≥ 0.1 is poor (12). The difference between the variables was investigated via Kruskal-Wallis Test. Differentiating groups were determined using Post-hoc Tamhane's Test (13).

RESULTS

The study included 31 children with SB who fulfilled the inclusion criteria. Of the participants, 18 (58%) were male and 13 (42%) were female and the mean age was 10.25±4.10 (Table 1). Ten of the patients had the ability to walk. Eight children had

Table 1: Demographic Characteristics of Participants.

Characteristics	Mean (SD)
Age (year)	10.25 (4.10)
BMI (kg/m²)	20.46 (4.91)
	n (%)
Gender **Male** **Female**	 18 (58) 13 (42)
Lesion level **Cervical-toracal** **Upper Lumbal** **Lower Lumbal** **Sacral**	 0 (0) 11 (35.48) 13 (41.93) 7 (22.58)
Mobility devices **Walks independently** **Walks with assistance** **Uses a wheelchair**	 7 (22.58) 3 (9.67) 21 (67.74)

SD: Standart Deviation, BMI: Body Mass Index

Table 2: Functional assessment results of children with spina bifida according to levels.

Tests	Lesion Levels	Mean (SD)
Seated Postural Control Measure	Upper Lumbar	54.36 (4.41)
	Lower Lumbar	58.61 (5.36)
	Sacral	61.42 (5.15)
	Total	57.74 (5.56)
Sitting Assessment for Children with Neuromotor Dysfunction	Upper Lumbar	17.54 (2.69)
	Lower Lumbar	12.61 (3.81)
	Sacral	8.57 (1.51)
	Total	13.77 (5.06)
Modified Functional Reach Test (cm)	Upper Lumbar	12.31 (8.51)
	Lower Lumbar	20.69 (9.86)
	Sacral	28.5 (5.86)
	Total	19.48 (10.41)
PEDALO® (%)	Upper Lumbar	94.81 (2.56)
	Lower Lumbar	96.92 (2.05)
	Sacral	98 (1.41)
	Total	96.41 (2.43)
Jebsen-Taylor Hand Function Test (sec)	Upper Lumbar	81.09 (36.17)
	Lower Lumbar	58.31 (36.99)
	Sacral	51.22 (16.7)
	Total	64.79 (34.61)

PEDALO®: Pedalo Balance Measurement System, SD: Standart Deviation.

a sacral and two children had a lumbar level lesion.

SPCM, SACND, MFRT (cm), Pedalo® (%), JTHFT (sec) test results are given in Table 2.

There was a negative fair correlation between JTHFT results and those of Pedalo® (r=-0.478, p=0.007) and MFRT (r=-0.598, p<0.01) and a positive fair correlation between JTHFT and SACND (r=0.399, p=0.026) (Table 3). Besides, there was a poor correlation between JTHFT and SPCM (r=-0.334, p=0.066) (Table 3).

MFRT, which gives dynamic sitting balance results, was fairly negatively correlated with lesion level (r=-0.579, p=0.001) and JTHFT (r=-0.598, p<0.01), moderately negatively correlated with SACND (r=-0.653, p<0.01); moderately positively correlated with SPCM (r=0.655, p<0.01) and Pedalo® (r=0.638, p<0.01) (Table 3).

Table 3: Correlations of parameters.

Parameters	Lesion level	SPCM	SACND	MFRT	PEDALO®	JTHFT
Lesion level	r=1 p<0.01*	r= -0.465 p=0.008*	r=0.747 p<0.01*	r=-0.579 p=0.001*	r=-0.503 p=0.004*	r=0.323 p=0.076
SPCM	r= -0.465 p=0.008*	r=1 p<0.01*	r=-0.739 p=0.01	r=0.655 p<0.01*	r=0.363 p=0.045*	r=-0.334 p=0.066
SACND	r=0.747 p<0.01*	r=-0.739 p<0.01*	r=1 p<0.01*	r=-0.653 p<0.01*	r=-0.593 p<0.01*	r= 0.399 p= 0.026*
MFRT	r=-0.579 p=0.001*	r=0.655 p<0.01*	r=-0.653 p<0.01*	r=1 p<0.01*	r=0.638 p<0.01*	r= -0.598 p < 0.01*
PEDALO®	r=-0.503 p=0.004*	r=0.363* p=0.045*	r=-0.593 p<0.01*	r=0.638 p<0.01*	r=1 p<0.01*	r= -0.478 p= 0.007*
JTHFT	r=0.323 p=0.076	r=-0.334 p=0.066	r= 0.399 p= 0.026*	r= -0.598 p<0.01*	r= -0.478 p= 0.007*	r=1 p<0.01*

SPCM: Seated Postural Control Measure, SACND: Sitting Assessment for Children with Neuromotor Dysfunction, MFRT: Modified Functional Reach Test, PEDALO®: Pedalo Balance Measurement System, JTHFT: Jebsen Taylor Hand Function Test

Pedalo® results were fairly negatively correlated with lesion level (r=0.503, p=0.004), SACND (r=-0.593, p<0.01) and JTHFT (r=-0.478, p=0.007); fairly positively correlated with SPCM (r=0.363, p=0.045) and moderately positively correlated with MFRT (r=0.638, p<0.01) (Table 3).

Evaluating sitting ability, SACND was moderately positively correlated with lesion level (r=0.747, p<0.01) and- fairly positively correlated with JTHFT (r=0.399, p=0.026); moderately negatively correlated with SPCM (r=-0.739, p<0.01) and MFRT (r=-0.653, p<0.01), fairly negatively correlated with Pedalo® (r=-0.593, p<0.01) (Table 3).

SPCM, which evaluates sitting posture, was fairly negatively correlated with lesion level (r=-0.465, p=0.008), moderately negatively correlated with SACND (r=-0.739, p<0.01); fairly positively correlated with Pedalo® (r=0.363, p=0.045), moderately positively correlated with MFRT (r=0.655, p<0.01) (Table 3).

There were significant differences between each level of lesion (sacral, lower lumbar and upper lumbar) in terms of SACND scores (p<0.05) (Table 4). SPCM, Pedalo® and MFRT results differed significantly between the upper lumbar and sacral regions (p<0.05) (Table 4). There was no significant difference between the sacral and lumbar levels in terms of JTHFT scores (p>0.05) (Table 4).

DISCUSSION

The ambulation level and independence of a child with weak upper extremities who cannot use mobility aids may decrease. This can disrupt daily functioning and affect overall activity levels (4). Sitting balance is an important factor for upper extremity skills (2). When sitting balance is disturbed, upper extremity skill development is negatively affected as the upper extremity is used for support. Spinal lesion level is closely related to sitting ability. As the lesion level increases, ambulation worsens and sitting balance deteriorates (14). Therefore, in order to evaluate the factors affecting the upper extremity and hand functions of children with SB and the relationship between their sitting posture, sitting balance and upper extremity functions, we evaluated 31 children aged 5-18 years. In our study, it was found that upper extremity functions are associated with sitting ability and balance in children with SB.

Hoffer et al. suggested that patients with meningomyelocele (MMS) should be examined under four groups, i. e. thoracic, upper lumbar, lower lumbar and sacral (15). Therefore, concordantly, we divided

Table 4: Comparison of mean differences of functional test results between lesion levels.

Tests	Lesion Levels	MD (SE)	X^2	p*	p**
SPCM	Sacral-Lower Lumbar	2.81 (2.45)	7.486	0.024*	0.615
	Sacral-Upper Lumbar	7.06 (2.36)			0.035*
	Lower Lumbar-Upper Lumbar	4.25 (1.99)			0.128
SACND	Sacral-Lower Lumbar	-4.04 (1.2)	18.312	<0.001*	0.011**
	Sacral-Upper Lumbar	-9.88 (1.23)			<0.001**
	Lower Lumbar-Upper Lumbar	-5.83 (1.52)			0.003**
MFRT	Sacral-Lower Lumbar	7.8 (3.52)	10.837	0.004*	0.115
	Sacral-Upper Lumbar	16.18 (3.39)			0.001**
	Lower Lumbar-Upper Lumbar	8.37 (3.75)			0.105
PEDALO®	Sacral-Lower Lumbar	1.07 (0.78)	8.805	0.012*	0.462
	Sacral-Upper Lumbar	3.18 (0.93)			0.011**
	Lower Lumbar-Upper Lumbar	2.1 (0.96)			0.118
JTHFT	Sacral-Lower Lumbar	-7.08 (12.04)	3.931	0.14	0.917
	Sacral-Upper Lumbar	-29.86 (12.6)			0.092
	Lower Lumbar-Upper Lumbar	-22.77 (14.97)			0.37

Kruskal-Wallis Test: *p <0.05, Tamhane Test: p**<0,05, MD: Mean Difference, SE: Standard error, PEDALO®: Pedalo Balance Measurement System, MFRT: Modified Functional Reach Test, SACND: Sitting Assessment for Children with Neuromotor Dysfunction, SPCM: Seated Postural Control Measure, JTHFT: Jebsen Taylor Hand Function Test the lesion level of the cases into four corresponding groups in our study. In the literature, it is reported that MMS is the most common in lumbosacral region (16). Similarly, in our study, all of the cases had lumbar and sacral region lesions. Because of the clinical status of children with upper-level lesions with SB, it could be argued that they may have problems in attending to special education and rehabilitation institutions, and therefore, these patients are not frequently encountered in institutions.

A statistically significant difference was found between the levels of sacral and upper lumbar lesions in terms of sitting balance and sitting posture. There was no difference between the lower lumbar and sacral regions in terms of these variables. However, sitting ability (SACND) was found different at each lesion level. In SACND, any unwanted abnormal postural responses such as involuntary movements which take place during each module (rest and reach) and their duration are recorded (17). Since it is a method that evaluates not only the sitting ability but also the quality of sitting, we think that it differs across all lesion levels. In the present study, upper extremity functions did not differ between sacral, lower lumbar and upper lumbar levels. When the literature is examined, it is seen that the level of the lesion affects the upper extremity functions negatively (4). However, in our study, the participants had only lumbar and sacral lesions, and their upper extremity functions were not affected at these levels.

Improvement of sitting posture in children with SB is aimed to increase sitting tolerance, ensure appropriate pelvic-vertebral-head alignment and increase the level of functional independence (18). In our study, sitting balance and sitting ability improved with the increase in sitting posture (SPCM) results. With the increase in the level of the lesion, the sitting posture was disrupted. Thomson et al. emphasized that sitting posture is related to the level of lesion and ambulation level, which is similar to the results of our study (18). Glard et al. indicated that the level of lesion was a determinant factor in spinal deformities. They stated that spinal deformity was not expected at L5 and below, but expected at L2 and above, also indicated that T12 and higher levels are prognostic in the development of kyphosis (19). Mummareddy et al., Dunn et al., Sibinski et al. stated that scoliosis had a negative effect on sitting balance (20-22). In the present study, no relationship was found between sitting posture and hand functions. The alignment section of the SPCM test was used to evaluate the sitting posture. The test was performed while the children were in a static state. However, evaluation of hand functions is related to dynamic posture. It was an expected result that hand functions were associated with dynamic sitting ability rather than a static sitting posture.

As the sitting ability of the patients increased, the sitting posture and functional reach results, and hand functions improved. The increase in lesion level negatively affected the sitting ability. SACND was also fairly correlated with Pedalo® assessment. Compared to Pedalo®, SACND can provide a more advantageous clinical evaluation method as it is an easy-to-use and inexpensive test.

The dynamic sitting balance of children with SB was measured by the Modified Functional Reach Test (MFRT). This test, which can also be used in children with neurological problems, can be applied in standing position or in sitting position when it is not possible to stand due to spinal cord injuries (10). In our study, we applied this test to all cases in sitting position. MFRT results of the patients decreased with the increase in the level of the lesion. The increase of sway on Pedalo® (forward, backward, right, left sway) was also related to the results of the modified reach test of the cases and this result was reflected in the measurements. In addition, MFRT scores increased as sitting ability, speed of hand functions, sitting posture and sitting balance improved. In addition, we found that postural stability was an important factor affecting sitting activity and upper extremity functions in children with SB.

The number of studies evaluating the sitting balance of children with SB through an objective measurement system is insufficient in the literature. In this sense, the use of Pedalo® system, which evaluates the sitting balance with numerical data, contributes to the literature. Studies investigating the balance of sitting in patients with SB are usually performed to evaluate the results of surgical interventions to correct spinal deformities such as scoliosis (23-25). In our study, we evaluated the relationship between sitting balance and upper extremity functions with Pedalo® balance test. An increase in lesion level resulted in increased sway on Pedalo® and reduction in Pedalo® performance percentage. Swank et al. discovered that the level of ambulation is related to sitting balance and stated that it is the most basic clinical finding that determines a patient's quality of life and future walking potential (26). The findings of our study also support those of this study.

It has been observed that the hand functions of children with SB who showed increased sway on Pedalo® balance board are slower. Improving the sitting ability and upper extremity functions of children with SB can improve their participation in life and their quality of life. In our study, we evaluated the sitting balance of children with SB using a method that provides objective data such as Pedalo® Balance Assessment System. Pedalo® is useful in clinical practice to evaluate the dynamic stability in a short time, as short as one minute (6, 27). However, this method of measurement is insufficient to show how the sitting balance will change during functioning. Therefore, we think it would be more appropriate to use it with other clinical balance tests. We believe that the results of our work will be guided by the development of new seating arrangements for children with SB and of rehabilitation programs to improve sitting posture, sitting balance and upper extremity functions.

Lack of power analysis for the sample size and the small number of participants are the limitations of our study.

In children with SB, upper extremity functions and functional independence can be increased by improving sitting postures and sitting balance starting from the early period. We think that studies investigating sitting mechanisms and exercises that will improve the sitting abilities and hand functions of children with SB are needed.

Source of Finance: During this study, no moral and material support was received from any pharmaceutical company that has a direct connection with the research subject, or from a company that provides or produces medical instruments and materials, which may negatively affect the evaluation process of this study.

Conflict of Interest: The authors declare no conflicts of interest.

Ethical Approval: The permission was obtained from Marmara University Ethics Committee for the study (22.02.2016-23).

Informed Consent: Consent was obtained from the participants'parents.

Author Contribution: Concept – GA1, GA2; Design – GA1, GA2; Supervision – GA2; Resources and Financial Support – GA1, GA2; Materials – GA1; Data Collection and/or Processing – GA1, GA2; Analysis and/or Interpretation – GA1, GA2; Literature Research – GA1, GA2; Writing Manuscript – GA1, GA2; Critical Review – GA1, GA2.

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