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ORIGINAL ARTICLE

Immediate effect of elastic trunk orthosis on trunk positioning sense and balance in post-stroke individuals

Şebnem AVCI[1], Ramazan KURUL[1], Hatice ÇANKAYA[2], Serkan SEVİM[1]

Purpose: Stroke; causing sensory, perception, motor loss, affects balance, postural stability and mobility. Position sense of trunk and its stability are important in terms of limb functions. Various methods are used in physiotherapy and rehabilitation, including orthotic devices to increase trunk control. This study aimed to investigate the immediate effect of elastic trunk orthosis on trunk repositioning sense and balance in post-stroke individuals.
Methods: A total of 56, 28 with stroke and 28 age matched healthy individuals, were included into study. Repositioning sense and balance were evaluated with and without a trunk orthosis, using the HUMAC NORM isokinetic device, Trunk Impairment Scale, Postural Assessment Scale for Stroke Patients, and Functional Reach Tests.
Results: There was no significant difference within and between groups on trunk repositioning sense with and without corset use ($p>0.05$). Postural Assessment Scale for Stroke Patients scores did not show significant change ($p>0.05$). There was a significant difference in favour of corset use in both study and control groups in functional reach test ($p=0.013$ and $p<0.001$ respectively). Study group showed significant change with and without corset scores in Trunk Impairment Scale ($p=0.003$). Mean differences on Functional Reach Test and Trunk Repositioning Test showed no significant difference in both groups ($p>0.05$).
Conclusion: The use of trunk orthosis has an immediate effect in some functional tests, but not in terms of repositioning sense were concluded. We propose to examine the factors affecting the repositioning sense in individuals with stroke and to investigate the effectiveness of new physiotherapy applications accordingly.
Keywords: Orthosis, Position sense, Postural balance, Proprioception, Stroke.

İnme sonrası bireylerde elastik gövde ortezi kullanımının gövde pozisyon hissi ve denge üzerine anlık etkisi

Amaç: Duyu, algı, motor kayıplarına yol açan inme; denge, postüral stabilite ve mobiliteyi etkilemektedir. Gövde pozisyon hissi ve stabilitesi ekstremite fonksiyonları açısından önemlidir. Fizyoterapi ve rehabilitasyonda ortotik cihazlar da dahil olmak üzere, gövde kontrolünün arttırılmasına yönelik çeşitli yöntemler kullanılmaktadır. Bu çalışma, inme sonrası bireylerde elastik gövde ortezinin gövde repozisyon hissi ve denge üzerindeki anlık etkisini araştırmayı amaçladı.
Yöntem: Çalışmaya 28 inme geçirmiş, aynı yaş grubunda 28 sağlıklı, toplam 56 birey dahil edildi. Repozisyon hissi ve denge, gövde ortezli ve ortezsiz olarak, HUMAC NORM izokinetik cihazı, Gövde Bozukluk Ölçeği, İnme Hastaları İçin Postüral Değerlendirme Ölçeği ve Fonksiyonel Uzanma Testleriyle değerlendirildi.
Bulgular: Grup içi ve gruplar arasında gövde korseli ve korsesiz olarak repozisyon hissi bakımından anlamlı farklılık bulunmadı ($p>0,05$). İnme Hastaları İçin Postüral Değerlendirme Ölçeği skorları anlamlı değişiklik göstermedi ($p>0,05$). Fonksiyonel Uzanma Testinde korse kullanımı lehine hem çalışma hem kontrol grubunda anlamlı farklılık bulundu (sırasıyla $p=0,013$ and $p<0,001$). Çalışma grubu Gövde Bozukluk Skalasında korseli ve korsesiz anlamlı değişiklik gösterdi ($p=0,003$). Fonksiyonel Uzanma ve Gövde Repozisyon Testi ortalama farkları iki grupta da anlamlı farklılık göstermedi ($p>0,05$).
Sonuç: Bu çalışmada, elastik gövde ortezi kullanımının bazı fonksiyonel testlerde anlık etkisinin olduğu fakat repozisyon hissi bakımından etkili olmadığı sonucuna varıldı. İnmeli bireylerde repozisyon hissini etkileyen faktörlerin incelenmesini ve bu doğrultuda yeni fizyoterapi uygulamalarının etkinliğinin araştırılmasını önermekteyiz.
Anahtar Kelimeler: Ortez, Pozisyon hissi, Postüral denge, Propriyosepsiyon, İnme.

1: Bolu Abant Izzet Baysal University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, Bolu, Turkey.
2: Refika Baysal Public Health Center, Bolu, Turkey
Corresponding Author: Şebnem Avcı: avciseb@hotmail.com
ORCID IDs (order of authors): 0000-0003-3712-0551; 0000-0001-8605-8286; 0000-0001-8224-6423; 0000-0001-7402-2980
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The condition characterized by motor and sensory loss after stroke is a deficit called hemiplegia or hemiparesis.[1,2] In particular, it affects one half of the body muscles, the upper and lower extremity movements as well as the trunk muscles responsible for stabilizing the core, sitting balance and selective trunk movements. The basic condition for the efficiency of limb movements is trunk control and it is deteriorated after stroke.[3,4]

Postural control is a complex mechanism provided by numerous sensory-motor processes that enables body stability and orientation in the upright position. Proprioceptive system is one of these senses that have a critical role for maintaining this postural control.[5] Proprioception is described as position sense which is an awareness of the position of limbs and trunk. Kinaesthesia or movement sense on the other hand, is an awareness of the motion of the extremities and trunk. These awareness and ability are a necessity to maintain optimal muscle control, coordination and stability to accomplish daily life activities.[6] The person who can perceive the stable position and movement through a healthy proprioception can also maintain the body movements. These proprioceptive inputs are obtained from structures such as joints, ligaments, muscles and intervertebral discs and analyzed by the upper centers.[7]

Stroke patients usually suffer for inability of maintaining motor control, static posture and balance as a result of proprioception deficits.[8] Primary issue for a stroke patient is neural control centre insufficiency, but in course of time this condition negatively affects the other components. As a result; trunk muscle force and trunk proprioception decreases, trunk asymmetry occurs.[9-11] Although trunk muscles seem to provide postural stability, it will be difficult to maintain balance, mobility and daily life activities without proprioceptive sensation.[12,13] Various devices have been used to improve the trunk function of stroke patients. In these studies, the effect of trunk devices on muscle activity, balance and gait parameters were investigated. In the previous studies the rationale behind the different types of trunk orthosis like corset use can be summarized as follows: supporting the trunk, preventing excessive movements in the posture, correcting the posture through tactile feedback, optimizing the gait by supporting the lower extremities with pelvic support.[14-16] Although there are studies in the literature investigating the relationship between trunk orthoses and proprioception for various conditions, no study was found that investigating the immediate effect of the elastic corset use on proprioception and balance in stroke patients was found. The idea of examining the immediate effects of corsets on the proprioception and balance of individuals with stroke in the treatment sessions by increasing the body awareness of individuals with stroke who received a rehabilitation program, thus contributing to the literature was born. Based on this perspective, in this study, trunk proprioception, which is one of the most important parameters in postural control, was emphasized and the investigation of the instant effect of elastic trunk orthosis on trunk repositioning sense and balance was aimed.

METHODS

This research was conducted between February 2017-June 2018. Permission numbered 2015-179 was obtained from Düzce University Clinical Research Ethics Committee (issue: 2015-179 date: 07.03.2016) based on Helsinki declaration for conducting the study. The study included 28 post-stroke patients over the age of 60 who were inpatient treatment at the Physical Therapy and Rehabilitation Hospital of Abant İzzet Baysal University Medical Faculty in Bolu. The research was announced to the individuals in the 'Elderly Centre' (a form of social and physical well-being club for elderly) in the city where the research was conducted. Thus, 28 healthy age-matched individuals were randomly selected to the control group among volunteers. After obtaining participants' signed consent, study and control groups were formed.

The inclusion criteria for study group: stroke related hemiparesis on any side, being taller than 160 cm (to fit the apparatus of isokinetic device), being able to stand on both feet without showing any balance disturbance and no need for support and achieving 50 degrees of lumbar flexion.

Inclusion criteria for control group: being taller than 160 cm (to fit the apparatus of isokinetic device), being able to stand on both feet without showing any balance disturbance and no need for support. Having no diagnosed motor impairment. Achieving 50 degrees of lumbar flexion.

The exclusion criteria for study group: A Mini Mental State Examination (MMSE) score below 24, orthopaedic and neurological problems other than stroke that may prevent standing. Having lumbar flexion limitation.

The exclusion criteria for control group: Having any neurological or orthopaedic disorders. Having lumbar flexion limitation.

Outcome assessments

The sensation of the trunk reposition was measured by measuring the Trunk Repositioning Error. Goldberg et al. stated that trunk repositioning error in standing position was correlated with clinical balance evaluations. Thus, this measurement was made in standing position with a trunk modular component of the HUMAC NORM (*CSMI, Stoughton, MA*) isokinetic device.[17] Before the application all participants' spinal flexion was checked. Participants stood on the body apparatus of the HUMAC NORM isokinetic device. The chest part of the body part of the device was placed to the chest of the individual. The individual was asked to flex the body to 50 degrees. In the meantime, individuals were guided by the physiotherapist who made the measurement. After reaching the trunk flexion angle of 50 degrees, individuals were asked to wait for a few seconds to perceive this position. Then the individual was brought back to the vertical position. At this point he/she was asked to close his/her eyes and try to reach the 50 degrees angle he/she had just perceived with his/her eyes closed. This measurement was repeated 3 times and the device calculated the amount of deviation from the individual's starting position to end. The mean deviation of the three measurements was determined as the amount of repositioning error.

Trunk Impairment Scale (TIS) is a test used to measure the coordination as well as dynamic and static balance of individuals after stroke in the sitting position. The test consists of 3 sections and the score of each section consists of 7, 10 and 6 points, respectively. The total score can be 23. If the individual gets zero points from the first part, he gets zero points in total. Higher scores indicate better body control.[18]

The Postural Assessment Scale for Stroke Patients (PASS) is a performance-based 12-question scale used to measure and monitor postural balance after stroke. It evaluates balance and stability of individual with stroke during postural changes. The minimum score for each question is 0 and the maximum score is 3. A total of 36 points can be scored and higher scores show better balance.[19] TIS and PASS evaluations were only conducted for the study group.

Functional Reach Test (FRT) assesses the stability of the individual by measuring the maximum range of distance while the individual reaches when he/she is in a fixed position. The individual was asked to stand close to the tape measure fixed to the wall, but not to touch it. The individual was asked to flex his/her arm up to 90 degrees, with the non-affected side standing near the wall, and to try to reach the farthest distance he/she could reach without stepping and lifting his/her heel. The starting position was standing upright. After reaching the farthest point, individual got at the ending position. The difference between starting and ending positions of the tip of the third finger of the individual was measured; the mean distance of 3 measurements was recorded.[20]

Intervention

The measurements of the individuals were performed twice, with and without elastic corset. Between the two measurements, individuals were given a 30-minute rest period. In the corset measurements, all individuals used the same, adjustable, non-underwire corset made of standard elastic material. Since this corset is produced in the same way under different brands as a medical trunk orthosis, a brand name was not specified (Figure 1). Measurements with corset were performed while the corset was worn on a thin outfit. All measurements were applied by the same physiotherapist.

Statistical analysis

According to Power analysis, to achieve $\alpha<0.05$ and $\beta=80\%$, 26 subjects were required for each group. Shapiro Wilk test was used to test normality of age, stroke onset, MMSE and outcome measurements. Normal distribution was observed on pre-test scores and demographic data. The paired sample t-test was

used for analysing changes in pre-test and post-test results for each group. The independent t-test was used to analyse the difference between the post-test and pre-test scores for both groups. A p value of less than 0.05 was considered statistically significant. All statistical analyses were performed using the SPSS for Windows version 20.0 (SPSS Inc., Chicago, IL, USA).

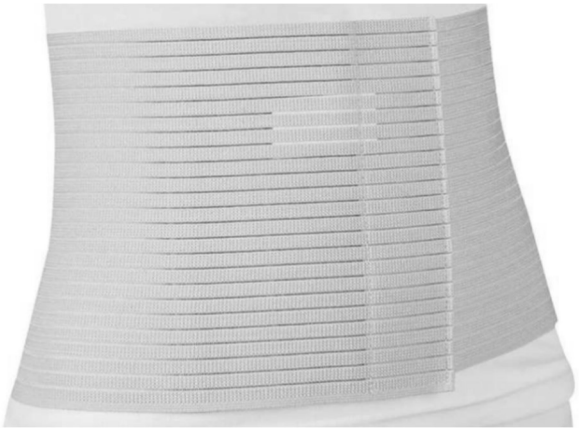

Figure 1: Standard elastic corset.

RESULTS

This study included 28 individuals after stroke with a mean age of 62.57±12.32 years as study group and 28 non-stroke subjects with a mean age of 62.64±12.97 years as controls. The gender distribution of our participants in study group was 10 female (35.7%), 18 male (64.3%) and 16 female (57.1%), 12 male (42.9%) in control group. The mean onset of stroke was 16.17±5.07 months. Mean MMSE scores of study group were 26.42±2.39 (Table 1).

There was no significant difference within and between groups on trunk repositioning sense with and without corset use ($p>0.05$) (Table 2).

Trunk impairment scale and the postural assessment scale for stroke patients' evaluations were conducted only for the study group. With and without corset scores showed significant change in TIS ($p=0.003$). PASS scores did not show significant change with or without corset use ($p>0.05$) (Table 3).

For group comparisons we found significant difference in favour of corset use in both study and control groups in functional reach test ($p=0.013$ and $p<0.001$ respectively). When we analyse the mean differences after getting pre and post test data on FRT and trunk repositioning test in both groups, we found no significant difference in either test ($p>0.005$) (Table 4).

DISCUSSION

The aim of this study was to examine the immediate effect of an elastic corset use on trunk repositioning sense and balance after stroke. The results of this study indicate that trunk repositioning error was higher in study group and it did not change with the immediate use of elastic corset in either group. In performance tests, TIS and FRT scores were better with corset in stroke survivors but FRT was also better with corset use in control group as well. PASS did not show any change in study group.

As reported by Cholewicki quoted from Calmels et al., orthoses used in the lumbar region may have a supportive effect on proprioception in low back pain patients. However, in the same study, it was also stated that the results were conflicting on corset use on proprioception. Because even healthy individuals may show greater variability in trunk repositioning sense.[21] In another study, authors concluded that there is an evidence of corset use on lumbar area as a motion restrictive device for low back pain patients.[22] When considering stroke survivors, there are several studies emphasizing the importance of trunk area.[23] Due to postural asymmetry and loss of cognition hemiplegic patients cannot perform daily life activities in a normal way and their gait and balance patterns change.[24] Thus, the use of corset as a device to affect trunk perception seemed worth to investigate.

Liao et al. used electromyography (EMG) signals to evaluate trunk repositioning sense in stroke patients and concluded that stroke patients showed higher error results than controls.[25] Ryerson et al. tested trunk repositioning sense by electromagnetic movement analysis system and stroke patients' altered trunk repositioning sense was observed.[9] Goldberg et al. concluded that balance impaired older adults – but not stroke patients- showed

Table 1: Demographic and clinical variables of the individuals.

	Study (N=28) X±SD	Control (N=28) X±SD	p
Age (year)	62.57±12.32	62.64±12.97	0.771
Stroke onset (month)	16.17±5.07	-	-
Mini Mental State Examination	26.42±2.39	-	-
Gender (Female/Male) (n (%))	10/18 (36/64)	16/12 (57/43)	

Table 2: The functional reach test and reposition angle values of the groups (N=28).

		Without corset X±SD	With corset X±SD	%95 CI	p
Study (n=28)	Functional reach test (cm)	19.51±4.23	20.50±4.74	-1.75/-0.22	0.013*
	Reposition (angle)	8.14±2.98	7.73±5.02	-1.65/2.46	0.310
Control (n=28)	Functional reach test (cm)	42.48±2.58	44.57±3.19	-2.90/-1.26	<0.001*
	Reposition (angle)	1.78±0.66	1.94±0.60	-0.49/0.18	0.763

*p<0.05. %95 CI: Confidence Interval.

Table 3: The Trunk Impairment Scale and Postural Assessment Scale for stroke values of the post stroke individuals (N=28).

	Without corset X±SD	With corset X±SD	%95 CI	p
Trunk Impairment Scale	16.03±4.51	17.57±3.22	-2.50/-.56	0.003*
Postural Assessment Scale for Stroke	29.5±5.08	30.03±4.76	-1.07/1.81	0.053

*p<0.05. %95 CI: Confidence Interval.

Table 4: Comparison of the mean differences between groups.

	Study (N=28) X±SD	Control (N=28) X±SD	%95 CI	p
Functional reach test	0.98±1.97	2.08±2.11	-0.01/2.19	0.254
Reposition	0.40±5.31	-0.15±0.86	-1.52/2.64	0.585

%95 CI: Confidence Interval.

more trunk repositioning error than balance unimpaired older adults or young adults.[17] The numeric results of our study showed that the study group had larger repositioning errors than our control group which revealed that post-stroke individuals' trunk repositioning sense was lower than controls as in the literature. But after the measurements with elastic corset usage the results did not show any difference between two groups. This may be due to memory deficiency of stroke individuals to recall the target trunk angle, as Cholevicki stated.[21] As a result, there are many factors that can affect this sense, and cognitive deficits that may affect the memory of hemiplegic patients may prevent them from recalling the position they sensed. Although we have included individuals with an MMT score above 24 into this study, using methods that test the memory of the participants in more detailed ways may help to

reveal the underlying reasons for this situation. Repositioning sense did not change in control group after wearing elastic corset as well. This result led us to think that there may not be an immediate effect of corset on repositioning sense. On the other hand, we assessed trunk repositioning sense in only lumbar flexion position. Similarly, Ryerson et al.[9] assessed the trunk repositioning sense in stroke survivors in flexion position and they concluded that altered trunk position sense seemed to be related balance and posture. They also stated that measuring the repositioning sense in frontal and transverse planes should be examined in the future studies. In our study we used HUMAC NORM isokinetic device and the trunk modular component of this device allowed us to measure repositioning sense in one direction. Using alternative methods or devices and movements in frontal and transverse planes to evaluate position sense may be advised.

In our study, stroke subjects showed better results with an immediate corset application for the Trunk Impairment Scale. At their study, Wee et al. investigated the immediate effect of an adjustable high-density foam trunk support on upper extremity functions in individuals with stroke. One of their main outcomes was TIS. Similar to the results of our study they found TIS scores were lower in stroke individuals and this score showed improvement after the application of trunk support.[26] Jung et al. investigated the effect of weight shift training on trunk control and trunk repositioning sense in stroke individuals. They found an improvement in repositioning sense and TIS scores and they commented as the improvement in trunk control found in their study may be caused by improved trunk proprioception.[27] Our analysis showed that both repositioning error and TIS scores positively changed based on numeric data which actually reveals the relation between trunk control and proprioception. For showing these results with a statistically significant values, number of participants may be increased.

Several studies shown total PASS scores lower than 20 for stroke inpatients, some advisory reports calculated a mean score of 31.8 for home physical therapy, 32.6 for outpatient therapy and 34.9 for no therapy at discharge.[28-30] Our mean values for PASS calculated as 29.5 and 30 without and with corset which points almost a level of home discharge for stroke patients and there was no significant difference between two evaluations. Those high mean values were not altered significantly with the application and the reason might be the functionally high starting point of our stroke patients.

Functional reach test is considered as an appropriate scale to measure the risk of fall in healthy elderly as well as post-stroke individuals.[31] It was stated that each 1 cm increase in the length of reach decreases the risk of falls in individuals with chronic stroke by 4.1%.[32] Çankaya et. al investigated the effects of 2 weeks usage of lumbar elastic corset in stroke individuals and found an improvement in FRT results. They concluded that 2 weeks of corset use improved balance of stroke individuals.[33] In our study both of our groups showed an improvement in FRT after wearing elastic corset. But we could not see this result in the isokinetic test in study group. In HUMAC NORM device there is a quite heavy chest part which could be found hard to adapt by the participants. Some of them may be afraid of falling forward with the effect of the weight of the device when performing trunk flexion. But FRT is more feasible and participants in both groups may feel more confident after wearing the corset. In addition, the fact that the repositioning sense did not show any change and the FRT gave a meaningful result may be caused by the visual input provided by performing repositioning test with eyes closed and FRT with eyes open.

Another idea at the beginning of the study was to see whether the elastic corset could be included in the applications in rehabilitation sessions and contribute to the trunk training in terms of proprioception and balance. Inexpensive, ubiquitous, easy to use elastic corsets may have contributed to the person's trunk control and positively affected the balance, although they did not affect proprioception during the rehabilitation session. This situation is recommended to be evaluated in future studies.

Limitations

The corset we used in the research was the standard elastic corset. Individuals wore this corset on a thin cloth and we did not measure the pressure. Clothing may have changed perception. Corsets giving different sensory inputs directly to skin with adjustable pressure

can be used in future studies. Since HUMAC NORM device has not a piece to constraint the hip we ignored the movement in this joint. Trunk reposition sense can be measured with devices that control the hip joint. We evaluated the sense of flexion movement since it is easier to detect and more common movement in sitting, standing and dressing. Other movements such as rotation might be evaluated in further studies. We did not apply Mini Mental Test to our control group and did not evaluate functional status of study group. We suggest paying attention to these situations in future studies.

Conclusion

In this study, immediate effect of elastic corset as an example of trunk orthoses had effect on balance but not on trunk repositioning sense. Considering that postural control and stability are very important parameters in trunk training of hemiplegic patients, we think that examining other factors that affect the sense of reposition will provide valuable data. Since the use of elastic corsets as a trunk support in rehabilitation sessions can contribute positively to balance, the effects of the corsets that are pressure adjusted and worn directly on the skin can be examined.

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