TORASİK HİPERKİFOZLU YAŞLILARDA SPİNOMED ORTEZİNİN DENGE VE YÜRÜME PERFORMANSINA ETKİSİ

Sefa ELDEMİR[1], Kader ELDEMİR[2], Çağla ÖZKUL[1], Arzu GÜÇLÜ GÜNDÜZ[1]

[1]Gazi Üniversitesi, Sağlık Bilimleri Fakültesi, Fizyoterapi ve Rehabilitasyon Bölümü, Ankara, Türkiye
0000-0002-2122-5706, 000-0001-9367-9910, 0000-0001-9367-9910
[2]Ordu Üniversitesi, Sağlık Bilimleri Fakültesi, Fizyoterapi ve Rehabilitasyon Bölümü, Ordu, Türkiye
0000-0002-1167-8971

ÖZ

Torasik hiperkifoz, yaşlılarda denge ve yürüme bozukluklarına neden olan yaygın problemlerden biridir. Spinomed ortezi hiperkifozun önlenmesinde kullanılan etkili bir tedavi yaklaşımıdır, ancak ne yazıkki torasik hiperkifozlu yaşlılarda denge ve yürüme parametreleri üzerine etkisini gösteren çok az kanıt bulunmaktadır. Bu çalışma, Spinomed ortezinin denge ve yürüme parametreleri üzerindeki etkisini kapsamlı bir şekilde araştırmak için planlandı. Çalışmaya torasik kifozu 40°'den fazla olan 34 gönüllü yaşlı birey dahil edildi. Tüm katılımcılardan Spinomed ortezine alışmaları için 1,5 saat boyunca ortezi takmaları istendi. Postural stabilite, stabilite limiti ve modifiye-duyu organizasyonu klinik testi Biodex Balance System ile değerlendirildi. Yürüme parametreleri ise G-Walk yürüme sistemi kullanılarak değerlendirildi. Tüm ölçümler ortezli ve ortezsiz olmak üzere rastgele sırayla ölçüldü. Spinomed ortezi kullanımı sonrası yapılan değerlendirmelerde tüm denge parametrelerinde anlamlı iyileşmeler oldu ($p<0.05$). Ek olarak, hız, kadans, dominant olmayan taraf yürüme döngü süresi ve çift destek fazında ($p<0.05$) pozitif yönde anlamlı gelişmeler oldu. Ancak diğer yürüme parametrelerinde anlamlı bir gelişme olmadı ($p>0.05$). Çalışma sonuçları, torasik hiperkifozlu yaşlı bireylerde Spinomed ortezi kullanımının denge ve yürümenin bazı parametrelerini iyileştirmede etkili bir yöntem olabileceğini göstermiştir. Bu nedenle Spinomed ortez kullanımı, etkili bir ameliyatsız tedavi seçeneği olarak düşünülebilir.

Anahtar kelimeler: Ortez, Kifoz, Denge, Yürüme, Yaşlı

EFFECTS OF SPINOMED ORTHOSIS ON BALANCE AND WALKING PERFORMANCE IN ELDERLY PEOPLE WITH THORACIC HYPERKYPHOSIS

ABSTRACT

Thoracic hyperkyphosis is one of the common conditions that cause balance and walking impairments in the elderly. The use of Spinomed orthosis is an effective treatment approach for hyperkyphosis, but unfortunately, there is little evidence to support its effect on the balance and walking parameters of elderly people with thoracic hyperkyphosis. This study was planned to investigate the effect of the Spinomed orthosis on balance and walking parameters comprehensively. Thirty-four volunteer elderly people with thoracic kyphosis greater than 40° were recruited for this study. All participants were asked to wear the Spinomed orthosis for 1.5 h to get used to them. Postural stability, limits of stability, and modified clinical test of the sensory organization were evaluated by the Biodex Balance System. The walking parameters were evaluated by the G-Walk System. All outcome measures were measured with and without the orthosis in random order. There was a significant improvement in all balance parameters with Spinomed orthosis ($p<0.05$). Additionally, the Spinomed orthosis had a significant positive effect on speed, cadence, non-dominant side gait cycle duration, and first double support phase ($p<0.05$) but not other walking parameters ($p>0.05$). The results showed that Spinomed orthosis may be an effective treatment approach for improving balance and walking parameters in elderly people with thoracic hyperkyphosis.

Key words: Orthosis, Kyphosis, Balance, Walking, Elderly

İletişim/Correspondence
Sefa ELDEMİR
Gazi Üniversitesi, Sağlık Bilimleri Fakültesi
Fizyoterapi ve Rehabilitasyon Bölümü, Ankara, Türkiye

E-posta: sefa.eldemir@gmail.com
Geliş tarihi/Received: 05.11.2022
Kabul tarihi/Accepted: 01.12.2022
DOI: 10.52881/gsbdergi.1199930

INTRODUCTION

Thoracic hyperkyphosis, affecting 20-40% of elderly people, is defined as the excessive forward curvature of the thoracic spine and is referred to as the angle of kyphosis beyond 40° (1). Vertebral factors, degenerative disc disease, decreased mobility, poor posture, proprioceptive deficits, and weakness of spinal extensor muscle strength and endurance are risk factors for the development and progression of hyperkyphosis (2). Increased kyphosis is directly or indirectly related to impaired balance and walking performance (3). These impairments increase the risk of falling and lead to decreased physical function, quality of life, and ability to perform daily activities (2, 4, 5). Therefore, it is important to evaluate and treat hyperkyphosis in elderly people.

Spinal orthoses have been used in the management of hyperkyphosis (6). Spinomed orthosis is one of the frequently recommended orthotic recommendations for hyperkyphosis in the elderly (7-9). Spinomed orthosis contributes to the improvement of balance and walking performance as well as correcting posture (6-9). Previous studies have demonstrated that Spinomed orthosis may be beneficial to improving the balance and walking ability in elderly people by decreasing postural sway, improving proprioception, correcting skeletal alignment, and correcting the spinal vertebrae (6, 7, 9). One of the studies was conducted on women with postmenopausal osteoporosis (6). In other studies, it is seen that functional tests were used to evaluate only balance by using Berg balance scale (7) and walking speed (9). However, all parameters of balance or walking were not examined comprehensively.

To our knowledge, little evidence exists regarding the effect of Spinomed orthosis on improving all balance parameters and spatiotemporal walking parameters in elderly people with thoracic hyperkyphosis. Therefore, this study was planned to enable an investigation of the effect of Spinomed orthosis on balance and spatiotemporal walking parameters comprehensively in the elderly people with thorocic hyperkyphosis.

METHOD

Subjects

A total of 34 elderly subjects (18 females, 16 males) participated in this cross-sectional study, which was conducted at the neurorehabilitation outpatient clinic, Department of Physiotherapy and Rehabilitation. Subjects with thoracic hyperkyphosis were recruited as volunteers from the caregivers or relatives of the patients who came for treatment at the same neurorehabilitation outpatient clinic and through public announcements.

Subject inclusion criteria are as follows: (a) having an age of 60 years or above, (b) the ability to walk at least 10 meters independently (c) thoracic hyperkyphosis angle above 40 degrees (1). The exclusion criteria are as follows: (a) having fractures or surgery on the spine or lower limbs within the last 12 months (b) having degenerative impairment in the spine, such as scoliosis and osteoarthritis, and (c) having any neurological and cognitive impairment.

The thoracic kyphosis was evaluated in elderly people using a valid (ICC: 0.81) and reliable (ICC: 0.92-97) dual digital inclinometer (J-Tech Medical, Midvale, USA) (10). One sensor of the inclinometer with 2 sensors was placed in spinous process of the 1st thoracic vertebra (T1) and the second sensor was placed in spinal process of the 12th thoracic vertebrae (T12) during the standing position. The kyphosis

angle was then measured by the inclinometer.

The sample size was calculated using G*Power software 3.0.1 (Franz Faul, University of Kiel, Kiel, Germany). The sample size calculation was based on the balance score stated in a similar study (8). Because of the analysis, the number of individuals was determined as a minimum of 26 (α:0.05 and power: 80%). A total of 34 patients were included, based on the estimation of 15% drop in the evaluations.

All participants who met the inclusion criteria signed a written consent form before participation. This research was approved by the Gazi University Ethics Committee (24.05.2022, No: 2022 - 699) before the recruitment began.

Interventions

The Spinomed orthosis consists of an anterior pad, a flexible metal in the wrapping pad that can be shaped to the shape of the spine and shoulder, pelvic, and waist straps (8). The wearing of the orthosis was performed by a person who experienced it. Based on the patient's spinal shape, the part of the metal was manually shaped for each patient. The shoulder, pelvic, and waist straps were also adjusted to fit the patient (Figure 1).

Figure 1. Spinomed orthosis used in this study.

Recruited all subjects were evaluated both with and without the Spinomed orthosis. The sequence of measures in this configuration was random in order to limit the effect of learning and fatigue. The randomization procedure was performed by tossing a coin. A rest period of approximately 1 h was considered into account between the evaluations with and without the orthosis. All subjects wore a Spinomed® IV orthosis (Medi-Bayreuth, Bayreuth, Germany). All subjects were asked to wear the orthoses for 1.5 h to get used to the orthosis. During this time, individuals sat and did some walking. Previous studies noted that Spinomed orthosis must be worn approximately 1.5 h/day and therefore, in this study, 1.5 h was considered as a suitable orthotic adaptation time (8, 9).

Outcomes

Balance: Biodex Balance System-BioSway™ was used to evaluate the balance. Three different balance tests were used in the current study: Postural Stability Test (PST), Limits of Stability (LOS) test, and modified Clinical Test of Sensory Organization on Balance (m-CTSIB) (11).

The PST includes the overall stability index, the anterior/posterior (AP), and the medial/lateral (ML) stability scores. The test was repeated twice and the participitans were asked to stand on both feet for 30 seconds. LOS was obtained from nine targets that required the individuals to shift their weight. The test duration reflected the total amount of time completed by each individual. The overall percentage reflected the individual's degree of directional control accuracy. The higher percentage reflected better performance. Two trials were completed for each participant, and the average results were recorded. The m-CTSIB evaluates the relationship of balance with the various senses. The test included four conditions: (1) Eyes open-firm surface, (2) Eyes closed-firm surface, (3) Eyes open-foam surface, and (4) Eyes closed-foam surface. The participants were asked to stand on both feet for 30 seconds, and each condition was repeated twice, and the average results were recorded.

Walking Performance: Walking performance was assessed using a G-Walk sensor system (BTS G-Walk BTS Bioengineering Company, Italy). This test consisted of walking at a preferred speed for a distance of 10 m marked at both ends. Each participant completed passes with a G-Walk sensor with 3 axes, located at spinal segment of the 5th lumbar vertebra (L5), using an elastic belt (12). The used setting was the following: Accelerometer; with16 bit/axes with multiple sensitivity (±2, ±4, ±8, ±16 g), a magnetometer; with 13 bit (±1200 μT), and, gyroscope; with 16 bit/axes with multiple sensitivity levels (±250, ±500, ±1000, ±2000°/s). Before the test started, the age, height, weight, and shoe size of the person were recorded in the system. Walking assessments began with the participant standing still in a standing position and ended when they walked a distance of 10 m. The parameters for evaluation were the following: Speed (m/s), cadence (steps/min), stride length (m), stride duration (s), stance duration (% of the gait cycle), swing duration (% of the gait cycle), double support (% of the gait cycle), single support (% of the gait cycle), elaborated steps (number of strides), gait cycle symmetry index, and pelvic angles during gait (degrees).

Data Analysis

Data analysis was performed using the SPSS software (Version 23; SPSS Inc., Chicago, IL, USA). The Shapiro-Wilk test was used to test the normality of the distribution of variables (13). Apaired t-test was used to determine the differences between the measurements with and without the orthosis. Statistical significance for all tests was determined at the $p<0.05$ level.

RESULT

In total, 34 participants with a mean age of 66.91 ± 7.03 years, height of 164.44 ± 8.33 cm, weight of 75.76 ± 14.86 kg, and kyphosis angle of 52.73° ± 8.27° participated (Table 1).

Table 1: The characteristics of the study subjects

	All participants
Number of subjects (n)	34
Age (years)	66.91±7.03
Height (cm)	164.44±8.33
Weight (kg)	75.76±14.86
BMI (kg/m^2)	27.90±4.03
Hyperkyphosis angle (degree)	52.73±8.27
Gender (n (%))	
Female	18 (52.9)
Male	16 (47.1)
Education (n (%))	
Primary school	6 (17.6)
Middle school	4 (11.8)
High school	7 (20.6)
University or higher degree	17 (50)

BMI: Body mass index.

The use of Spinomed orthosis had a significant impact on all balance parameters ($p<0.05$) (Table 2). Additionally, the Spinomed orthosis had a significant effect on speed, cadence, non-dominant side gait cycle duration, and first double support phase ($p<0.05$) but not other walking parameters ($p>0.05$) (Table 3).

Table 2: Comparison of balance parameters with and without Spinomed orthosis.

	Without orthosis Mean ± SD	Spinomed Mean ± SD	p-value
PST (score)			
Overall	0.40±0.12	0.26±0.09	**<0.001***
AP	0.28±0.10	0.19±0.07	**<0.001***
ML	0.18±0.11	0.12±0.06	**0.001***
LOS (score)	53.82±12.68	70.14±11.18	**<0.001***
m-CTSIB (score)			
Eyes open, firm surface	0.53±0.18	0.46±0.16	**0.004***
Eyes closed, firm surface	0.81±0.38	0.72±0.30	**0.049***
Eyes open, foam surface	0.94±0.35	0.81±0.23	**0.012***
Eyes closed, foam surface	2.34±0.55	1.87±0.44	**<0.001***

AP: Anterior/posterior stability score, LOS: Limit of Stability, m-CTSIB: the modified Clinical Test of Sensory Organization on Balance, ML: Medial/lateral stability score PST: Postural Stability Test, *$p<0.05$.

Table 3: Comparison of walking parameters with and without Spinomed orthosis.

		Without orthosis Mean ± SD	Spinomed Mean ± SD	p-value
Speed (m/s)		1.11±0.20	1.23±0.21	**0.007***
Cadence (steps/min)		106.91±10.63	110.41±7.14	**0.012***
Gait cycle duration (sec)	DS	1.15±0.15	1.09±0.08	0.072
	NDS	1.15±0.13	1.07±0.09	**0.049***
Stride length (m)	DS	1.30±0.20	1.32±0.17	0.300
	NDS	1.31±0.21	1.32±0.17	0.457
Stance phase (% cycle)	DS	60.84±2.72	61.02±3.57	0.704
	NDS	61.80±4.20	62.50±5.59	0.344
Swing phase (% cycle)	DS	39.15±2.72	38.97±3.57	0.704
	NDS	38.19±4.20	37.50±5.59	0.347
First double support phase (% cycle)	DS	10.69±3.28	12.37±4.27	**0.033***
	NDS	10.66±2.98	12.36±4.27	**0.024***
Single support phase (% cycle)	DS	38.35.4.04	37.97±5.39	0.577
	NDS	39.05±3.46	38.83±3.34	0.673

DS: Dominant side, NDS: Non-dominant side, *$p<0.05$

DISCUSSION

The results showed that the Spinomed orthosis improved postural stability, limits of stability, and sensory organization in elderly people. This study also found that Spinomed orthosis improved speed,

cadence, non-dominant side gait cycle duration, and double support period. These results showed that the Spinomed orthosis could improve balance and walking in elderly people with thoracic hyperkyphosis. In this study, the effect of the Spinomed orthosis on balance was comprehensively investigated using PST, LOS, and m-CTSIB. The results showed that the Spinomed orthosis improved postural stability, limits of stability, and sensory organization in elderly people. Pfeifer et al. showed that the Spinomed orthosis reduced body oscillation in elderly women with osteoporosis and hyperkyphosis (6, 14). Hosseinabadi et al. investigated changes in balance performance after 13 weeks of wearing a Spinomed orthosis in elderly people with thoracic hyperkyphosis (7). The researchers reported that orthosis increased balance performance in elderly people. In another study, Azadinia et al. found that Spinomed orthosis had positive effects in improving the limit of stability and sensory organization in elderly people with thoracic hyperkyphosis (8). All of previous studies supported the results of this study. In addition, the current study also showed that postural stability was improved with Spinomed orthosis. The increase in proprioceptive input occurs during the use of Spinomed orthosis. This is caused that Spinomed orthosis places muscle in optimal length and increases the activity of both the afferent receptors in the skin and also the mechanoreceptors in muscles and articular capsule. Increased awareness of spinal alignment prevents incorrect postures and reduces stress on spine, providing development in balance performance (15). The correction of forward inclination and helping the center of mass (COM) to be placed within the base of support are other mechanisms identified to improve balance performance (6, 14, 15). Throcic hyperkyphosis lead to a change the COM forward so that limits of stability decreased, and imbalance (1). Spinomed orthosis retracts the shoulders with shoulder straps. Thus, extension moments occur on the spine, the COM displace backwards, maintain within base of support, and this eventually can explain the increase in postural stability, limit of stability, and sensory organization associated with balance (14, 15).

Another aim of this study was to examine the effect of Spinomed orthosis on walking parameters. As far as we know, there is no study examining the effect of Spinomed orthosis on the spatiotemporal parameters of walking parameters in more detail using the G-Walk system. This study showed that Spinomed orthosis improved speed, cadence, non-dominant side gait cycle duration, and double support period. We think that improvement in walking performance was due to increased proprioception input and correction spinal alignment. However, there was no improvement in the dominant side gait cycle duration, stride length, stance phase, swing phase, and single support phase. Namdar et al. showed that Spinomed orthosis had positive effects on the walked distance through 2 min and walking speed (with a 10-meter walk test) (9). These findings support the results of our study. In addition, improvements were found in the cadence, gait cycle duration of the non-dominant side, and double support period in our study. However, the lack of development of other parameters such as the stance phase and swing phase in both DS and NDS, which have important roles in walking, may be due to the immediate effect of the orthosis. Participants wore the orthosis for only 1.5 h in this study.

Therefore, prolonged use of the Spinomed orthosis may better demonstrate the improvement in walking parameters.

Conclusions

The Spinomed may potentially play an effective role in improving balance and walking parameters in elderly people with thoracic hyperkyphosis, although there was no significant improvement in some walking parameters. Further studies are recommended to confirm their long-term effects on spatiotemporal effects of walking in elderly people with thoracic hyperkyphosis.

Limitations

The current study had some limitations. Firstly, The study only evaluated the immediate effect of the Spinomed orthosis on balance and walking performance, therefore long-term use of the orthosis is recommended in future studies. Second, the effect of Spinomed orthosis on activity limitation and quality of life could not be evaluated. In the future, A follow-up study of the effect of orthosis may examine these variables.

Author Contributions

SE: Study Design, Manuscript Preparation, Statistical Analysis, Providing Cases, Critical Review

KE: Data Collection, Data Interpretation, Manuscript Preparation, Literature Search

CO: Data Collection, Manuscript Preparation

AGG: Data Interpretation, Critical Review.

Conflict of interest

No potential conflict of interest was reported by the authors.

Ethical approval

This research has been approved by the Gazi University Ethics Committee (Date:24.05.2022, No: 2022 - 699).

REFERENCES

1. Katzman W, Cawthon P, Hicks GE, Vittinghoff E, Shepherd J, Cauley JA, Harris T, Simonsick EM, Strotmeyer E, Womack C. Association of spinal muscle composition and prevalence of hyperkyphosis in healthy community-dwelling older men and women. J Gerontol A Biol Sci Med Sci. 2012; 67(2):191-5.

2. Roghani T, Zavieh MK, Manshadi FD, King N, Katzman W. Age-related hyperkyphosis: update of its potential causes and clinical impacts—narrative review. Aging Clin Exp Res. 2017; 29(4):567-77.

3. Li W-Y, Chau PH, Dai Y, Tiwari A. The Prevalence and Negative Effects of Thoracic Hyperkyphosis on Chinese Community-Dwelling Older Adults in Wuhan, Hubei Province, China. J Nutr Health Aging. 2021; 25(1):57-63.

4. Takahashi T, Ishida K, Hirose D, Nagano Y, Okumiya K, Nishinaga M, Matsubayashi K, Tani T, Yamamoto H. Trunk deformity is associated with a reduction in outdoor activities of daily living and life satisfaction in community-dwelling older people. Osteoporos Int. 2005; 16(3):273-9.

5. Kasukawa Y, Miyakoshi N, Hongo M, Ishikawa Y, Noguchi H, Kamo K, Sasaki H, Murata K, Shimada Y. Relationships between falls, spinal curvature, spinal mobility and back extensor strength in elderly people. J Bone Miner Metab. 2010; 28(1):82-7.

6. Pfeifer M, Kohlwey L, Begerow B, Minne HW. Effects of two newly developed spinal orthoses on trunk muscle strength, posture, and quality-of-life in women with postmenopausal osteoporosis: a randomized trial. Am J Phys Med Rehabil. 2011; 90(10):805-15.

7. Hosseinabadi M, Kamyab M, Azadinia F, Sarrafzadeh J. Effect of a Spinomed orthosis on balance performance, spinal alignment, joint position sense and back muscle endurance in elderly people with hyperkyphotic posture: A randomized controlled trial. Prosthet Orthot Int. 2020; 44(4):234-44.

8. Azadinia F, Kamyab M, Behtash H, Maroufi N, Larijani B. The effects of two spinal orthoses on balance in elderly people with thoracic kyphosis. Prosthet Orthot Int. 2013; 37(5):404-10.

9. Namdar N, Arazpour M, Ahmadi Bani M. Comparison of the immediate efficacy of the Spinomed® back orthosis and posture training support on walking ability in elderly people with thoracic kyphosis. Disabil Rehabil Assist Technol. 2019; 14(3):217-20.

10. Azadinia F, Kamyab M, Behtash H, Ganjavian MS, Javaheri MR. The validity and reliability of noninvasive methods for measuring kyphosis. J Spinal Disord Tech. 2014; 27(6):E212-E218.
11. Cachupe WJ, Shifflett B, Kahanov L, Wughalter EH. Reliability of biodex balance system measures. Meas Phys Educ Exerc Sci. 2009; 5(2): 97-108.
12. De Ridder R, Lebleu J, Willems T, De Blaiser C, Detrembleur C, Roosen P. Concurrent validity of a commercial wireless trunk triaxial accelerometer system for gait analysis. J Sport Rehabil. 2019; 28(6): 295-1.
13. Portney LG, Watkins MP. Foundations of clinical research: applications to practice. 3th ed. Pearson/Prentice Hall Upper Saddle River, NJ, USA 2009, 892.
14. Pfeifer M, Begerow B, Minne HW. Effects of a new spinal orthosis on posture, trunk strength, and quality of life in women with postmenopausal osteoporosis: a randomized trial. Am J Phys Med Rehabil. 2004; 83(3):177-86.
15. Hsu JD, Michael J, Fisk J. AAOS Atlas of orthoses and assistive devices E-book. 4th ed. Philadelphia, PA: Mosby. Elsevier. 2008; 27:155-165.