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ORIGINAL ARTICLE

Investigation of gait symmetry, cervical joint position sense, cervical range of motion and functional disability in individuals with chronic idiopathic neck pain

Kronik idiopatik boyun ağrılı bireylerde yürüyüş simetrisi, servikal eklem pozisyon hissi, servikal hareket açıklığı ve fonksiyonel yeti yitiminin araştırılması

Hatice AYAN[1,2], Bilge KARA[3], Reşat Serhat ERBAYRAKTAR[4]

Abstract

Purpose: Gait asymmetry has not been adequately clarified in Chronic Idiopathic Neck Pain (CINP). Cervical position sense is important to maintain gait function. However, the association between gait symmetry and cervical position sense is unknown. The first aim is to evaluate gait symmetry, cervical joint position error (JPE), cervical range of motion (ROM), and functionality in persons with CINP and compare them with healthy controls (HC). The second aim is to investigate the relationship between gait symmetry and cervical JPE, ROM, and functional disability in CINP.

Methods: 35 persons with CINP (27 females, eight males, mean age 25.48 ± 8.69 years) and 34 HC (25 females, nine males, mean age 25.76±7.96 years) were included. Gait symmetry was assessed with a wearable sensor gait device. Cervical JPE and ROM were evaluated with the Cervical Range of Motion (CROM) device. Neck Disability Index (NDI) was used for functional disability.

Results: Persons with CINP had significantly worse gait symmetry, cervical JPE, and lower cervical range of motion in all directions ($p<0.01$). In the CINP group, gait symmetry had significant, negative weak and moderate correlations with the cervical JPE (flexion, extension, right lateral flexion, $r=-0.387$, -0.459, -0.443, $p<0.05$) and NDI ($r=-0.493$, $p<0.05$).

Conclusion: This study showed that gait symmetry, cervical position sense, and range of motion were negatively affected in individuals with CINP compared to the healthy controls, and that the decrease in gait symmetry was associated with the increase in cervical joint position error and functional disability. Improving cervical position sense may be effective in increasing gait symmetry in persons with chronic idiopathic neck pain.

Keywords: Neck pain, Gait, Position sense.

Öz

Amaç: *Kronik idiopatik boyun ağrısında (KİBA) yürüyüş asimetrisi yeterince aydınlatılmamıştır. Yürüyüş fonksiyonunun sürdürülmesinde servikal pozisyon duyusu önemlidir. Ancak KİBA'da yürüyüş simetrisi ile servikal pozisyon duyusu arasındaki ilişki bilinmemektedir. Çalışmamızın ilk amacı KİBA'lı bireylerde yürüyüş simetrisini, eklem pozisyon hatasını (JPE), servikal hareket açıklığını (ROM) ve fonksiyonel yeti yitimini değerlendirmek ve bunları sağlıklı kontrollerle (HC) karşılaştırmaktı. İkinci amacımız ise KİBA'lı bireylerde yürüyüş simetrisi ile servikal JPE, ROM ve fonksiyonel yeti yitimi arasındaki ilişkiyi araştırmaktı.*

Yöntem: *35 KİBA'lı birey (27 kadın, 8 erkek, ortalama yaş 25,48 ± 8,69 yıl) ve 34 HC (25 kadın, 9 erkek, ortalama yaş 25,76 ± 7,96 yıl) çalışmaya dahil edildi. Yürüme simetrisi, giyilebilir sensörlü yürüyüş cihazı ile değerlendirildi. Servikal pozisyon hissi ve ROM, Servikal Hareket Açıklığı (CROM) cihazı ile değerlendirildi. Fonksiyonel yeti yitimi için Boyun Özürlülük İndeksi (BÖİ) kullanıldı.*

Bulgular: *KİBA'lı bireylerde anlamlı derecede daha kötü yürüyüş simetrisi, daha kötü servikal JPE ve tüm yönlerde daha az servikal hareket açıklığı vardı ($p<0.01$). CINP grubunda yürüyüş simetrisi, servikal JPE (fleksiyon, ekstansiyon, sağ lateral fleksiyon, $r=-0,387$, $-0,459$, $-0,443$, $p<0,05$) ve BÖİ ($r=-0,493$, $p<0,05$) ile anlamlı, zayıf ve orta düzeyde negatif korelasyona sahipti.*

Sonuç: *Bu çalışma, KİBA'lı bireylerde, yürüyüş simetrisinin, servikal pozisyon hissinin ve eklem hareket açıklığının, sağlıklı bireylere göre olumsuz yönde etkilendiğini, yürüyüş simetrisindeki azalmanın, servikal eklem pozisyon hatasındaki ve fonksiyonel yeti yitimindeki artışla ilişkili olduğunu gösterdi. Kronik idyopatik boyun ağrısı olan bireylerde servikal pozisyon hissinin iyileştirilmesi, yürüyüş simetrisinin arttırılmasında etkili olabilir.*

Anahtar kelimeler: *Boyun ağrısı, Yürüyüş, Pozisyon hissi.*

1: Dokuz Eylul University, Institute of Health Sciences, Izmir, Türkiye
2: Izmir Katip Çelebi University, Vocational School of Health Services, Physiotherapy Program, Izmir, Türkiye
3: Dokuz Eylul University, Faculty of Physical Therapy and Rehabilitation, Izmir, Türkiye
4: Dokuz Eylul University, Faculty of Medicine, Department of Neurosurgery, Izmir, Türkiye
Corresponding author: Hatice Ayan: hatice_010188@hotmail.com
ORCID IDs (order of authors): 0000-0002-6641-3540; 0000-0003-4503-5074; 0000-0002-2938-578X
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INTRODUCTION

Chronic neck pain, one of the most common musculoskeletal problems in society, causes negative effects on individuals' disability, quality of life, work efficiency and health expenditures.[1] Chronic idiopathic neck pain is defined as cervical pain that is not due to any neurological, orthopedic or systemic origin and persists for more than three months.[1] The basic mechanism that causes chronic idiopathic neck pain is still unknown. Still, a sedentary lifestyle, working conditions, postural disorders, changes in muscle control and psychosocial conditions are stated to be risk factors.[2] Recent studies have shown that chronic neck pain increases among young adults due to inappropriate use of screen-related devices.[3]

Gait is an important determinant of functional level and quality of life.[4] In recent years, gait-related functional impairments have been reported in people with chronic idiopathic neck pain (CINP).[5] They have gait disturbances compared to healthy individuals, such as slower walking speed, smaller stride length, and greater alteration during dual-task.[6,7] Gait consists of cyclic movements of the lower extremities, and the symmetry of these movements is very important for an efficient gait.[8] However, there are not enough studies on whether gait asymmetry exist in persons with CINP. In the literature, gait symmetry was defined as perfect harmony between movements of lower extremities. It was stated that the term 'gait symmetry' can be used when there is no statistical difference in the parameters measured bilaterally.[8]

Joint position sense is an important component of proprioception. It provides the ability to sense and reproduce a predetermined position or range of motion. The error that occurs when producing predetermined motion is defined as joint position error (JPE).[9]

Cervical proprioception contributes to the adjustment of the position of the head and neck in space through the complex interaction between afferent and efferent lines. Afferent information from the cervical proprioception is also combined with head movement information from the visual and vestibular systems,[10] related to locomotor function. Previous studies showed that impairments in proprioceptive information obtained from the cervical region may negatively affect sensory-motor integration in patients with CINP.[11]

Awareness of the body segments in space is essential for eliciting quality motor movement.[12] Therefore, the deterioration in the cervical joint position sense may cause damage to the feedback information received from neck region, which is a key area for positioning the head and gaze. In addition, if awareness of the position and movement of body segments is decreased during walking, the joints and body may not be prepared for movement effectively.[13]

Therefore, impaired cervical proprioception may negatively affect gait function and gait symmetry in individuals with neck pain. However, the association between gait symmetry and cervical proprioception in CINP is unknown.

It has been reported that cervical proprioception may be affected by factors such as muscle strength, joint range of motion, deterioration in the length-tension relationship of the muscles, muscle fatigue, and spinal degeneration due to age.[14] Therefore, evaluating these factors, which may also be effective in gait symmetry, is important for determining the necessary rehabilitation strategies.

This study aims to investigate the relationship of gait symmetry with cervical joint position error, cervical range of motion and functional disability in individuals with CINP and compare them with healthy individuals.

METHODS

The study was conducted in Dokuz Eylül University Faculty of Physical Therapy and Rehabilitation between November 2019 - February 2020.

Participants

The study included 35 persons with CINP (27 females, 8 males, mean age 25.48 ± 8.69 years) and 34 healthy controls (25 females, 9 males, mean age 25.76 ± 7.96 years). Sample size was calculated as 34 persons for each group according to the effect size = 0.80, power = 0. 90, alpha error value = 0 .05 with G* Power software (version 3.1.9.4, Düsseldorf University, Germany) based on the similar studies investigating gait parameters in persons with chronic neck pain.[6,15] Demographic information was obtained from all participants. Inclusion criteria for individuals with CINP were

diagnosis of idiopathic neck pain for at least 3 months and an NDI score of at least 5 out of 50. Individuals who had congenital cervical anomalies, structural scoliosis, vertebrobasilar artery insufficiency, thoracic outlet syndrome, trauma, surgery, orthopedic, rheumatic, neurological or vestibular disease and received physiotherapy and medication except simple analgesics related to neck pain in the last 6 months were excluded from the study.

Measurements

Gait Symmetry

Gait symmetry was evaluated with BTS G-Walk (BTS Bioengineering S.p.A., Garbagnate Milanese, Italy), a portable sensor device with Bluetooth®3.0 connection (G-Studio®software). The device provides real-time data transfer in determining gait symmetry and allows the patient to move freely without laboratory conditions with its wireless sensor feature. It is a valid and reliable method for measuring gait parameters and gait symmetry.[16,17] It is placed at the L5 level with its elastic belt. The device compares the right and left spatiotemporal parameters of gait and the movements of the pelvis to measure gait symmetry (Figure 1). This device acquired data based on the participant's height, weight, and foot size.

Cervical Proprioception (Joint Position Error)

Joint position error (JPE) was assessed for cervical proprioceptive ability. The cervical JPE (flexion, extension, lateral flexion, rotation) was evaluated with an easy-to-use device (Cervical Range of Motion; CROM) containing 3 head-mounted inclinometers.

For the assessment of JPE, participants were asked to sit upright and comfortably in a chair and look ahead. They sat on the chair with their hips and knees at 90 degrees, feet flat on the ground, and their hands on their legs. The CROM inclinometer apparatus was placed on the head, and a magnetic collar of the CROM device was placed on the shoulders to consider any trunk rotation. Participants closed their eyes throughout the test. First, three teaching tests were performed. The head was turned passively towards the one side as slowly as 65% of the maximum range of motion and held for 3 seconds for teaching test. The subjects were asked to remember this position as the target point, and the head was returned to the neutral position passively. After that, the participant was asked to move his head to that target point. The absolute angular difference between the endpoint and the target point was recorded as the Joint Position Error, and the test was repeated 3 times (Figure 2). The average was taken as the score. The JPE assessments were performed for cervical flexion, extension, right-left lateral flexion and right-left rotation. The reliability of this test in 6 directions has been proven.[18]

Cervical Range of Motion

The cervical range of motion (flexion, extension, lateral flexion, rotation) was evaluated in all directions. Evaluation of the range of motion was also performed with the 3 head-mounted inclinometers CROM device.[18] Participants were asked to sit with their hips and knees at 90 degrees with their feet flat on the ground. The hands were held in a resting position on the legs. Participants were asked to perform the cervical movement slowly, and verbal warnings were used to prevent shifts in other directions while performing the movement. Flexion-extension, right-left rotation and lateral neck flexion were measured, and the results were recorded. There was a 5-10 second rest period between measurements. The validity of this device in measuring the range of motion has been demonstrated.[19]

Neck Disability Index

Neck Disability Index (NDI) is a 10-item self-rated scale used to evaluate the functional impact associated with neck pain during activities of daily living.[20] The minimum and maximum scores obtained from NDI are 0 and 50, respectively (0=no disability, 50=maximum functional disability). Individuals with chronic neck pain who have a disability of 5 or more, according to NDI, were included in the study. Turkish version of NDI has validity and reliability.[21]

Test Procedure

During the measurements, the participants were asked to wear comfortable clothes. To assess gait symmetry, individuals wore standard type, flat-soled, normal ankle height, lace-up sneakers. They walked a 10-meter away and turned back to the starting point with straight heads at the usual walking speed. A trial gait symmetry measurement was performed before the assessment. Cervical range of motion and proprioception were evaluated in a sitting position in a standard

Figure 1. Gait symmetry assessment with G-Walk Sensor device.

Figure 2. Cervical joint position error assessment with CROM device.

chair. The tests were done randomly, with a 5-minute rest period between each test.

Statistical analysis

The SPSS Statistics for Windows (version 21.0; SPSS Inc., Chicago, USA) was used to analyse the data. Normal distribution of the data was examined with the Shapiro-Wilk test. Gait symmetry, range of motion, JPE and NDI data were not normally distributed. So Mann-Whitney U test was used to compare two groups, and correlation between the variables was examined using Spearman's correlation coefficient. The statistical significance level was $p<0.05$.

Correlation coefficients was interpreted as (0.00-0.10) negligible; (0.10-0.39) weak; (0.40-0.69) moderate; (0.70-0.89) strong and (0.90-1.00) very strong correlation.[22]

RESULTS

There was no significant difference between the CINP group and the HC in terms of demographic data (sex, age, height, weight) (Table 1).

Persons with CINP had significantly worse gait symmetry than HC ($p<0.001$). There were significant differences between the CINP and HC in all cervical JPE directions and cervical range of motion ($p<0.01$). In the CINP group, gait symmetry had weak and moderate correlations with the cervical JPE (flexion, extension, right lateral flexion, $r=-0.387$, -0.459, -0.443, $p<0.05$) and NDI ($r=-0.493$, $p<0.05$). There was no significant correlation between gait symmetry and cervical ROM except right lateral flexion ($r=-0.355$, $p<0.05$). No significant correlation was found between JPE, cervical ROM and NDI ($p>0.05$).

DISCUSSION

This study showed that persons with CINP had significantly worse gait symmetry, decreased cervical proprioception, and cervical joint limitation compared to the healthy controls. It has also been demonstrated in the current study that gait symmetry was related to cervical JPE (flexion, extension, right lateral flexion), ROM of right lateral flexion and functional disability in CINP.

The literature states that the spatio- temporal

gait parameters differ between persons with and without neck pain significantly, and negative differences occur in walking speed, stride length and stride width,[6,15,23] in persons with chronic neck pain. Uthaikhup et al. examined the effects of head movement and walking speed on gait parameters in CINP, and reported gait disturbances during walking with head movements and walking at maximum speed in CINP, and they concluded that the observed gait disturbances might be a strategy to compensate for gait instability resulting from cervical proprioceptive deficits.[6] In a previous study, Lee et al. also showed that symmetry in hip movements was worse in CINP than in healthy controls. Similarly, in another study, individuals with CINP had different gait pattern than healthy controls under different walking speed conditions.[15] But in these previous studies, gait symmetry did not investigate. Our study, showed that gait symmetry was worse in the CINP than in the healthy controls under normal walking speed condition.

Table 1. Characteristics of the Groups.

	CINP Group (N=35)	Healthy Controls (N=34)	
	Mean±SD	Mean±SD	p
Gender (female/male), n	27/8	25/9	0.728[a]
Age (years)	25.48±8.69	25.76±7.96	0.890[b]
Height (cm)	168.68±10.23	168.20±8.26	0.831[b]
Body weight (kg)	65.02±12.98	61.88±10.88	0.280[b]
Body mass Index	22.80±3.86	21.75±2.41	0.178[b]
Neck Disability Index	14.08±4.46	-	-
Pain duration (month)	33.94±22.00	-	-

CINP: Chronic Idiopathic Neck Pain. HC: Healthy Controls.

Table 2. Comparison of gait symmetry, joint position error, and range of motion.

	CINP Group (N=35)	Healthy Controls (N=34)	
	Median (interquartile range)	Median (interquartile range)	p
Gait symmetry (%)	94.90 (93.30-96.10)	97.60 (97.00-98.00)	<0.001
Joint position error (°)			
Flexion	5.0 (3.3-10.0)	1.0 (0.0-3.0)	<0.001
Extension	5.0 (4.0-8.0)	1.0 (0.0-2.0)	<0.001
Lateral flexion- Right	6.5 (5.0-10.0)	1.5 (0.0-3.0)	<0.001
Lateral flexion-Left	7.0 (5.0-8.5)	1.25 (0.0-3.0)	<0.001
Rotation-Right	8.0 (3.3-10.0)	1.5 (0.0-2.0)	<0.001
Rotation-Left	7.0 (3.3-12.0)	1.75 (0.0-2.25)	<0.001
Range of motion (°)			
Flexion	45 (40.0-50.0)	60 (50.0-70.0)	<0.001
Extension	50 (40.0-60.0)	80 (70.0-90.0)	<0.001
Lateral flexion- Right	40 (35.0-50.0)	53.5 (50.0-60.0)	<0.001
Lateral flexion-Left	40 (30.0-45.0)	52.5 (50.0-60.0)	<0.001
Rotation-Right	60 (50.0-70.0)	70 (70.0-80.0)	<0.001
Rotation-Left	60 (50.0-60.0)	72 (70.0-80.0)	<0.001

CINP: Chronic Idiopathic Neck Pain. HC: Healthy Controls.

Table 3. Correlations between gait symmetry with joint position error, range of motion, and Neck Disability Index in the Chronic Idiopathic Neck Pain Group.

	Gait symmetry	
	rho	p
Joint position error		
Flexion	-0.387*	0.022*
Extension	-0.459*	0.006*
Lateral flexion- Right	-0.443*	0.008*
Lateral flexion-Left	-0.237	0.171
Rotation-Right	-0.187	0.281
Rotation-Left	-0.102	0.561
Range of motion		
Flexion	-0.081	0.643
Extension	-0.053	0.762
Lateral flexion- Right	-0.355*	0.036*
Lateral flexion-Left	-0.175	0.314
Rotation-Right	-0.265	0.125
Rotation-Left	-0.284	0.098
Neck Disability Index	-0.493*	0.003*

* p<0.05. rho: Spearman's correlation coefficient.

Riskowski et al. examined the relationship between proprioceptive sense and gait kinematics. They stated that the proprioceptive sense changes the rate of load on the joints and is a factor that affects the gait of individuals.[13] When previous studies in the literature were examined, Özgören et al. stated that the deterioration in the joint position sense was available in all cervical movements except left lateral flexion in individuals with chronic neck pain.[24] In another study, Chen and Treleaven reported that persons with neck pain had significantly worse JPE in cervical rotation than healthy controls.[25] In another study, statistically significant JPE was found only in flexion test movements in patients with non-traumatic chronic neck pain. Still, no significant difference was found in other directions (rotation, extension, lateral flexion) compared to healthy controls.[26] For cervical joint position errors in all directions, there are different results that cervical JPE can discriminate between individuals with and without neck pain.[26,27] The reason for the differences in these studies may be that they have different age and disability levels for groups and different evaluation methods. In addition, many studies have small sample sizes. In our research, in parallel with the literature,[28] joint position error was able to differentiate between individuals with and without chronic idiopathic neck pain. Similarly, a systematic review of eleven studies concluded that JPE tests had a significant intermediate effect estimate for the flexion, extension, and rotation subgroups, such that subjects with chronic neck pain had significantly worse joint position sense than healthy controls.[12]

Decreased range of motion is a common problem seen in individuals with chronic neck pain.[29] Studies have shown that cervical joint range of motion is reduced in individuals with chronic neck pain.[24] In our study, in accordance with the literature, the cervical range of motion was more limited in individuals with neck pain than in healthy individuals.[30] However, there was no significant relationship between range of motion and gait symmetry, except for right lateral flexion. This showed that gait asymmetry was more associated with the decrease in cervical joint position sense than the cervical range of motion. Therefore, in addition

to range of motion, which is frequently evaluated in the clinic, considering, and evaluating proprioceptive sense in individuals with chronic neck pain may be useful in terms of improving gait symmetry.

The maintenance of locomotion is achieved by integrating sensory information from the proprioceptive, visual, vestibular and somatosensory systems.[31] Proprioceptive input from the cervical region can also induce persistent influences on the self-perception of motion and body schema. Cervical proprioception also has a powerful effect on body orientation during locomotion.[32] In a study examining the relationship between proprioceptive input and gait, it was reported that neck muscle vibration improved postural control and walking speed in participants with neck pain, and these results supported the importance of cervical proprioceptive sense for balance and gait.[31] Therefore head position and motor movement change due to deterioration in cervical proprioception may lead to gait asymmetry. In support of this view, the results of our study support that the decrease in cervical proprioceptive sense seen in individuals with CINP negatively affects gait symmetry.

Functional status is adversely affected by chronic neck pain. Symptoms related to neck pain can negatively affect the individual's abilities, such as concentration, sleep, lifting, driving and leisure activities. It is thought that structural changes in soft tissue and limitation of movement in neck muscles may impair daily functions.[33]

The level of disability is an important parameter for both clinic perspective and public health. Studies have shown that there is a moderate or high correlation between neck pain and functional disability.[34] The deterioration in functional status due to neck pain restricts daily living activities and causes job loss.[35] Simsek et al. stated that neck awareness and pain intensity are the main factors that determine functional level in individuals with neck pain.[34] In our study, the relationship between walking, which is an important parameter for health indicators, and the functional disability caused by neck pain was examined. We evaluated gait symmetry with a wearable sensor gait device as an objective method, and we observed that functional disability decreased in direct proportion to the level of gait symmetry in persons with CINP. Therefore, our results suggest that determining rehabilitation strategies to improve gait symmetry in individuals with chronic idiopathic neck pain may be effective in improving functional disability.

Limitations

This study has some limitations. Firstly, the individuals were young and middle-aged with mild to moderate disability in our study. In future studies, individuals with different age and disability levels should be investigated. We could also assess gait symmetry only at normal gait speed at the usual pattern. Further studies should examine the relationship between gait symmetry and proprioception at different gait patterns and speeds.

Conclusion

In conclusion, the results of this study showed that gait symmetry, cervical joint position sense and cervical range of motion were negatively affected in individuals with CINP. Gait symmetry should also be taken into consideration when evaluating gait disorders in chronic neck pain. Additionally, the results showed that the decrease in gait symmetry was associated with an increase in cervical joint position error and functional disability. Therefore, programs to evaluate and improve cervical proprioceptive sense may be useful to increase gait symmetry in individuals with CINP. Determining proprioceptive sensory and motor disorders and developing appropriate rehabilitation approaches may be effective for the progression of the disease with CINP.

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