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SPATIOTEMPORAL GAIT PARAMETERS, PELVIC MOVEMENTS AND PELVIC SYMMETRY DURING WALKING WITH SINGLE AND DUAL-TASKS IN INDIVIDUALS WITH CHRONIC IDIOPATHIC NECK PAIN

ORIGINAL ARTICLE

ABSTRACT

Purpose: Neck pain is associated with gait disturbances. The first aim of this study was to examine spatiotemporal gait parameters, pelvic movements and pelvic symmetry during single and dual task conditions in persons with Chronic Idiopathic Neck Pain (CINP) compared to healthy subjects (HS). The second aim was to investigate the relationship between disability and gait in persons with CINP.

Methods: Thirty-one individuals with CINP (mean age 22.06±1.38 years, range 18-56 years) and 24 HS (mean age 22.60±1.51 years, range 18-43 years) participated in the study. CINP group completed Neck Disability Index. All participants performed 10-meter walking test in two conditions: (1) walking with head straight at usual speed, (2) walking with head straight at usual speed while carrying a tray. The BTS G-Walk wearable sensor was used to assess spatiotemporal parameters (speed, cadence, step length), pelvic movements (tilt, obliquity, rotation), and pelvic symmetry.

Results: During single task gait, the CINP group had significantly lower walking speed, shorter stride length and worse pelvic tilt symmetry (p<0.05), but pelvic movements did not differ significantly according to the HS (p<0.05). During dual task condition, the CINP group had significantly lower cadence, gait speed and stride length, significantly increased pelvic movements and significantly worse pelvic rotation symmetry compared to HS (p<0.05).

Conclusion: Patients with CINP had a slower gait, lower stride length, decreased pelvic symmetry and increased pelvic movements compared to HS. Differences in gait and pelvic movements between the two groups were more pronounced during the dual task gait than single task gait.

Keywords: Chronic Idiopathic Neck Pain, Dual Task, Gait, Pelvic Movement

KRONİK İDİYOPATİK BOYUN AĞRILI BİREYLERDE TEK VE ÇİFT GÖREV YÜRÜYÜŞÜ SIRASINDA SPASYOTEMPORAL YÜRÜME PARAMETRELERİ, PELVİK HAREKETLER VE PELVİK SİMETRİ

ARAŞTIRMA MAKALESİ

ÖZ

Amaç: Boyun ağrısı yürüme bozuklukları ile ilişkilidir. Bu çalışmanın ilk amacı, Kronik İdiyopatik Boyun Ağrısı (CINP) olan kişilerde tekli ve ikili görev durumunda spasyotemporal yürüme parametrelerini, pelvik hareketleri ve pelvik simetriyi incelemek ve bunları sağlıklı bireylerle (HS) karşılaştırmaktır. Çalışmanın ikinci amacı ise CINP'li kişilerde yeti yitimi ve yürüyüş arasındaki ilişkiyi incelemektir.

Yöntem: Çalışmaya 31 CINP'li birey (ortalama yaş 22,06±1,38 yıl, 18-56 yaş aralığında) ve 24 sağlıklı birey (ortalama yaş 22,60±1,51 yıl, 18-43 yaş aralığında) katıldı. CINP grubu Boyun Özürlülük İndeksi'ni tamamladı. Tüm katılımcılar 10 m'lik bir mesafeyi iki farklı şekilde yürüdüler ve başlangıç noktasına geri döndüler: (1) İlk olarak başları düz, normal yürüyüş hızında, (2) ikinci olarak ise başları düz, normal yürüyüş hızında, ellerinde bir tepsi taşıyarak. Spasyotemporal parametreleri (hız, kadans, adım uzunluğu), pelvik hareketleri (tilt, oblikite, rotasyon) ve pelvik simetriyi değerlendirmek için giyilebilir hareket analiz sistemi BTS G-Walk kullanıldı.

Sonuçlar: Tek görev yürüyüşü sırasında, CINP grubu sağlıklı gruba göre anlamlı olarak daha düşük yürüme hızına, daha kısa adım uzunluğuna ve daha kötü pelvik tilt simetrisine sahipti (p<0,05), ancak gruplar arasında pelvik hareketlerde anlamlı farklılık yoktu (p<0,05). İkili görev sırasında, CINP grubu sağlıklı gruba göre anlamlı ölçüde daha düşük kadans, yürüme hızı ve adım uzunluğuna, anlamlı olarak artmış pelvik hareketlere (tilt, oblikite, rotasyon) ve anlamlı olarak daha kötü pelvik rotasyon simetrisine sahipti (p<0,05).

Tartışma: CINP'li kişilerde sağlıklı bireylere kıyasla daha yavaş yürüyüş, daha düşük adım uzunluğu, azalmış pelvik simetri ve artmış pelvik hareketler vardı. İki grup arasındaki yürüyüş ve pelvik hareketlerdeki farklılıklar, ikili görev yürüyüşü sırasında, tekli görev yürüyüşüne göre daha belirgindi.

Anahtar kelimeler: Kronik İdiyopatik Boyun Ağrısı, İkili Görev, Yürüyüş, Pelvik Hareket

INTRODUCTION

Chronic neck pain is one of the most common musculoskeletal diseases, causing disability and economic burden (1). Idiopathic neck pain (non-specific neck pain) is defined as having no underlying identifiable neurological and orthopedic disease or anatomical disorder. There is no specific disease can be identified as the cause of the complaints in persons with chronic idiopathic neck pain and this group constitutes the majority of neck pain cases (2).

Gait performance is an informative indicator of health status and functional independence (3). In the literature, there is some evidence that neck pain can lead to a variety of functional problems, including gait disturbances (4–6). Uthaikhup et al. reported that persons with chronic neck pain had slower walking speed, shorter step length and narrower step width when walking with head turns and at maximum gait speed (6). Individuals with chronic idiopathic neck pain (CINP) were also found to have more asymmetrical gait and slower walking speed compared to healthy subjects (HS) (5).

The capability to perform two concurrent tasks is very important in daily function. People often execute a secondary task while walking, such as carrying a glass or talking (dual tasking) (7,8). Dual tasks reflect daily life activities and are frequently used in walking research, giving important clues related to gait changes (9–11). In a recent study, it was reported that patients with neck pain had reduced trunk rotation and gait speed compared to the HS (12). Moreover, this reduction in trunk rotation was more pronounced during walking with the dual task (13). While walking, the pelvis performs different movements: anterior and posterior tilt in the sagittal plane, rotation forward and backward in the transverse plane, and pelvic hike and drop movements in the frontal plane (14). The amount of pelvic movement is related to walking speed and more movement occurs during fast walking (15). These pelvic motions provide an effective gait with minimal energy use, by optimizing the movement of the center of gravity (14). It remains unknown whether persons with CINP have altered pelvic movements. It is clinically important to investigate the effect of neck pain on the gait characteristics and pelvic movements. Therefore, the first aim of this study was to examine spatiotemporal gait parameters, pelvic movements and pelvic symmetry in patients with CINP during single and dual task gait and compare them with HS. Any difference between the two groups was expected to be more apparent in the case of dual task. The second aim was to investigate the relationship between disability related to neck pain and gait parameters.

METHODS

Study Design

The study was carried out at the Dokuz Eylul University School of Physical Therapy and Rehabilitation between January and February 2020. This study was approved by the Ethics Committee of Dokuz Eylul University (Approval Date: 17.07.2019 and Approval Number: 2019/18-04). The written informed consents were obtained from all participants. All procedures were conducted according to the Helsinki Declaration.

Participants

Thirty-one pateints with CINP (24 female and 7 male; mean 22.06±1.38, range 18-56 years) and 24 HS (15 female and 9 male; mean 22.60±1.51, range 18-43 years) participated in the study. Demographic data (sex, age, height, weight) were recorded for all participants. Inclusion criteria for individuals with CINP were the presence of idiopathic neck pain for least 3 months, and NDI scores higher than 10/100. HS were selected to approximately match the age range and gender balance of the CINP group, and the inclusion criterion was absence of neck pain for the past year. Exclusion criteria for all participants were a history of trauma and surgery in the neck area, diagnosed with orthopedic, neurological or vestibular disease, and receiving physiotherapy due to neck pain in the last 6 months.

G* Power software (version 3.1.9.4, Düsseldorf University, Germany) was used to calculate sample size. In a similar study (6), when the step length of individuals with chronic neck pain and HS was examined, it was found to be 57.9±7.9 cm in patients with neck pain and 67.1±14.5 cm in HS, and the effect size was calculated as 0.787. For power=0.80, alpha error value=0.05 and effect size=0.787. The sample size was calculated as 21 for each group; however, we were able to exceed this number.

Measurements

Neck Disability Index

The Neck Disability Index is a widely used, self-rated scale measuring disability caused by neck pain. It contains ten questions about daily living activities (neck pain severity, dressing-cleaning, lifting, reading, working, headache, concentration, driving, sleeping, free time activities). Each question is scored minimum 0 and maximum 5. Higher scores represent greater disability. The score obtained from each question was summed up and multiplied by 2 to calculate a percentage score out of 100 (16). Turkish version of Neck Disability Index was completed by the CINP group. The validity and reliability of the Turkish version of NDI was conducted by Aslan (16).

Gait Analysis

The BTS G-Walk (BTS Bioengineering S.p.A., GarbagnateMilanese, Italy), a wearable sensor device, was used to assess spatiotemporal parameters (speed (m/sec), cadence (steps/min), stride length (m), step length (% stride length)), pelvic movements (tilt (°), obliquity (°), rotation (°)) and pelvic symmetry (%) during gait through a Bluetooth®3.0 connection (G-Studio®software). The BTS G-Walk is an inertial sensor consisting of a triaxle accelerometer, a triaxle magnetometer, a triaxle gyroscope and a global positioning system receiver. This system is portable, cost-effective and uncomplicated to measure gait and jump parameters (17). It is also considered a valid and reliable measure of gait (18–20). BTS G-Walk device was attached to the participants' body with an elastic belt at the level of the fifth lumbar vertebra. Spina iliaca posterior superior was referenced to place the device at L5 level. Individuals were required to wear comfortable clothes and the elastic belt was put on the clothes. The elastic belt adjusted to optimal tightness not to slip during walking. The BTS G-Walk enables to examine the spatiotemporal characteristics of gait, the pelvic symmetry index, the 3-dimensional kinematics of the pelvis (anterior-posterior tilt, intra-extra rotation, up-down obliquity) and spine, with the help of a transport transmitted by bluetooth. The device compare the right and left movement range of pelvis to measure pelvic symmetry index. This device obtained the data based on the participant's height, weight and foot size.

Test Procedure

Evaluations were made in both single and dual task situations. All participants were instructed to walk a 10 m walkway and come back to the start point under two different conditions: (1) walking with head straight at usual speed, (2) walking with head straight at usual speed while holding a tray. There were three empty paper cups on the tray and the aim was not to overturn these cups during walking. The randomized order was used for each condition. After a trial performance for each condition, the actual tests were performed. The average of the two performance was considered for statistical analysis. 60 seconds rest was given between each walking trial. The participants wore comfortable clothes and size-matched standard sport shoes which are suitable for daily life. These sport shoes had rubber sole, leather material, flat sole type and normal ankle length laced up.

Statistical Analysis

There were no missing data. The data were analyzed using the SPSS Statistics for Windows (version 21.0; SPSS Inc., Chicago, USA). Shapiro-Wilk test was used to assess normal distribution of the data. Groups were compared with independent groups t-test if the data had normal distribution (spatiotemporal parameters, pelvic symmetry index and pelvic angles), and if not, with Mann-Whitney U test. Gait parameters and pelvic movement data were normally distributed. NDI data did not show normal distribution. So correlation between the variables was calculated using Spearman's correlation coefficient. The statistical significance level was established at $p<0.05$.

RESULTS

There were no significant differences between the groups in terms of age, height, weight or gender ($p>0.05$). The characteristics of the groups were shown in Table 1.

Table 2 showed the spatiotemporal parameters of single and dual task gait. During single task, the

Table 1. Characteristics of the Groups

	CINP (Mean ± SD)	HS (Mean ± SD)
Sex (female/male), n	24/7	18/6
Age (years)	22.06 ± 1.38	22.6 ± 1.51
Height (cm)	169.74 ± 1.85	170.37 ± 1.73
Weight (kg)	64.54 ± 3.04	62.91 ± 2.51
NDI	14.41 ± 4.48	-

CINP: Chronic Idiopathic Neck Pain, HS: Healty Subjects, NDI: Neck Disability Index (%)

CINP group had significantly lower scores in terms of speed (p=0.002), left stride length (p=0.021) and right stride length (p=0.025) compared to the HS. Pelvic movements did not differ between the groups, however, pelvic tilt was significantly more asymmetric in CINP group compared to the HS (p=0.046) (Table 3). During dual task walking condition, cadence, gait speed and stride length significantly differed between the CINP and HS groups (Table 2). Different from the single task condition, in the dual task walking condition there were significant differences between the groups in pelvic tilt range, pelvic obliquity range, pelvic rotation symmetry and right pelvic rotation range (p<0.05) (Table 3). There were significant correlations between NDI and step length in both walking conditions (p<0.05) (Table 4). There was no significant relationship between NDI, pelvic movements and pelvic symmetry (p>0.05)

DISCUSSION

This study is the first to examine the variability of gait parameters, pelvic movements and pelvic symmetry in persons with CINP during single and dual task gait conditions. The results indicate altered spatiotemporal gait parameters, pelvic movements and pelvic symmetry in persons with CINP. In the single task condition, persons with CINP have lower speed and stride length. In the dual task condition, they have reduced speed, stride length and cadence according to the HS. Similarly, a previous study found that, patients with neck pain had lower walking speed, step length and narrower step width while walking at maximum speed compared to asymptomatic controls (6). Chronic neck pain is related to alteration in neuromuscular function (13). These alterations are sensorimotor disorders including proprioceptive deficits (21), postural instability (22), vestibular impairment (23), slower

Table 2. Comparison of the Spatiotemporal Parameters during the Single and Dual Task Walking

		CINP (Mean ± SD)	HS (Mean± SD)	p
Cadence (steps/min)	Single task	110.02 ± 6.60	113.66 ± 7.64	0.064
	Dual task	108.36 ± 6.02	112.84 ± 9.19	0.034*
Speed (m/sec)	Single task	1.18 ± 0.19	1.36 ± 0.22	0.002*
	Dual task	1.10 ± 0.17	1.28 ± 0.22	0.002*
Stride length- left (m)	Single task	1.29 ± 0.18	1.41 ± 0.19	0.021*
	Dual task	1.23 ± 0.17	1.37 ± 0.18	0.008*
Stride length-right (m)	Single task	1.29 ± 0.19	1.41 ± 0.18	0.025*
	Dual task	1.23 ± 0.17	1.37 ± 0.19	0.006*
Step length-left (% stride length)	Single task	49.61 ± 2.59	50.25 ± 2.20	0.337
	Dual task	49.61 ± 2.18	50.62 ± 2.39	0.110
Step length-right (% stride length)	Single task	50.35 ± 2.57	49.82 ± 2.21	0.429
	Dual task	50.15 ± 2.13	49.86 ± 2.39	0.636

Independent sample t-test, p< 0.05, CINP: Chronic Idiopathic Neck Pain, HS: Healty Subjects.

Table 3. Comparison of the Pelvic Movements and Pelvic Symmetry during the Single and Dual Task Walking

		CINP (Mean ± SD)	HS (Mean ± SD)	p
Tilt Symmetry Index (%)	Single task	64.87 ± 21.57	75.46 ± 15.17	0.046*
	Dual task	69.07 ± 22.42	78.25 ± 14.45	0.072
Tilt Range Left (°)	Single task	5.60 ± 1.97	4.82 ± 1.14	0.090
	Dual task	5.61 ± 2.08	4.73 ± 1.04	0.047*
Tilt Range Right (°)	Single task	5.60 ± 2.04	4.75 ± 1.17	0.077
	Dual task	5.63 ± 2.09	4.60 ± 1.13	0.024*
Obliquity Symmetry (%)	Single task	7.84 ± 1.57	98.31 ± 0.92	0.198
	Dual task	97.62 ± 1.59	97.95 ± 1.26	0.407
Obliquity Range Left (°)	Single task	10.97 ± 2.96	9.70 ± 2.65	0.107
	Dual task	10.16 ± 2.62	8.59 ± 2.37	0.026*
Obliquity Range Right (°)	Single task	10.81 ± 2.79	9.69 ± 2.70	0.142
	Dual task	10.17 ± 2.72	8.28 ± 2.92	0.017*
Rotation Symmetry (%)	Single task	98.55 ± 0.69	98.60 ± 0.67	0.775
	Dual task	97.02 ± 1.87	98.34 ± 0.85	0.003*
Rotation Range Left (°)	Single task	14.31 ± 5.84	13.62 ± 4.39	0.628
	Dual task	11.76 ± 4.30	9.71 ± 3.95	0.076
Rotation Range Right (°)	Single task	14.16 ± 5.46	13.70 ± 4.37	0.736
	Dual task	11.74 ± 4.13	9.36 ± 3.93	0.035*

Independent sample t-test, p< 0.05, CINP: Chronic Idiopathic Neck Pain, HS: Healty Subjects

response time, hand-eye incoordination (24) and reduced trunk rotation (12,13). Gait ability depends on proprioceptive, visual and vestibular systems; therefore, in patients with neck pain, disturbances in sensory information obtained from the cervical region may adversely affect sensorimotor control (25). This influence on the sensorimotor control may lead to gait disturbances.

In this study, in the single task gait, there was no difference between the two groups in the variability of pelvic movements. However, in the dual task condition, the CINP group had increased pelvic tilt, pelvic obliquity and pelvic rotation compared to the HS. The CINP group's decreased pelvic stability in sagittal, frontal and horizontal planes may contribute to altered gait parameters in the dual task condition. Attention is divided between walking and balancing the cups on the tray during the dual task gait. So, alteration in gait parameters during the dual-task might be an effort to maintain the stability as stated in a previous study (6).

As far as we know, pelvic movements during walking in individuals with CINP have not previously been compared with HS. However, similar studies

Table 4. Correlations Between NDI and Gait Parameters in the Neck Pain Group

		Correlation coefficients	p
Cadence (steps/min)	Single task	0.240	0.193
	Dual task	0.192	0.301
Speed (m/s)	Single task	0.338	0.063
	Dual task	0.276	0.133
Stride length- left (m)	Single task	0.238	0.197
	Dual task	0.276	0.133
Stride length- right (m)	Single task	0.258	0.162
	Dual task	0.276	0.133
Step length- left (% stride length)	Single task	0.528	0.002*
	Dual task	0.625	0.000*
Step length- right (% stride length)	Single task	-0.520	0.003*
	Dual task	-0.627	0.000*

Spearman's correlation coefficient, p<0.05

were conducted on individuals with chronic low back pain. In these studies, changes were found in trunk-pelvis kinematics in individuals with low back pain (26,27). It was suggested previously that these changes in gait parameters and pelvis-thorax coordination were possibly caused by increased trunk stiffness (28). According to the literature, individuals with CINP also have increased trunk stiffness similar to the persons with low back pain (12,13). In the future studies, it may be useful to research, if trunk rotation is limited during walking because of trunk stiffness in individuals with CINP.

Greater pelvic movement during walking is an indicator of greater energy consumption (14). In our study we found that, individuals with CINP had greater pelvic movements according to the HS but we couldn't measure the energy consumption. This may also lead to future researches to investigate the relationship between pelvic movement and energy consumption in this population.

In a previous study it was stated that persons may compensate spine movement pattern because of neck pain, so this compensation may cause asymmetric hip mobility (29). Previously, CINP was also found to produce gait asymmetry at both preferred and maximum speed (5). Similar to these studies suggesting hip and gait asymmetry in patients with neck pain, our results showed more asymmetric pelvic tilt and pelvic rotation in individuals with CINP compared to HS in different gait conditions.

During the single and dual task, we found no significant relationship between NDI with pelvic movements, pelvic symmetry or gait parameters other than step length in persons with CINP. A previous study similarly found no significant correlations between NDI with gait speed and neck-trunk movements during single and dual task gait (12). Patients with neck pain participating in this study had mild to moderate neck disability (average score= 14.41/50). So this relationship should also be investigated for more severe levels of neck disability.

The difference in gait parameters between the groups was more pronounced during walking under the dual task condition. In terms of pelvic movements, there was no difference in single task condition but a significant difference was found in dual task condition. These results showed that CINP tend to increase variability in pelvic movements during the more challenging conditions, such as walking with dual task.

In dual-task studies, gait is generally investigated during straight walking, while transition movements such as turning are neglected, despite their importance in daily life (11). An advantage of the BTS G-Walk, as a wearable sensor, is its ability to measure gait and movements during the turns. In some previous researches in persons with CINP, many second tasks contain head movements (5,6,12). Differently, we used carrying a tray with cups as the second task in order to involve the upper extremity, which is the area most affected by chronic neck pain.

The results of this study are in line with previous researches showing a greater decrease in motor performance under the more challenging dual task walking conditions (10,30,31). In order to gain a greater understanding of movement changes in CINP individuals, it is important to examine the functions involving dual task that is common in daily life (12).

Increased pelvic rotation is often seen as a compensatory movement based on an effort to have longer steps. Excessive movement of the pelvis helps to move forward as well as compensates for weakness (32). Our results were in line with this suggestion that persons with CINP had lower stride length and greater pelvic rotation than HS. So increased pelvic movements seen in individuals with CINP may have occurred to compensate for the reduction in stride length.

In a recent study, it was stated that the decrease in walking speed in individuals with chronic neck pain is also associated with biomechanical limitations (33). During walking, internal and external forces act on the joints. Internal forces are caused by muscle activity, ligaments and friction in muscles and joints. External forces are caused by gravity and ground reaction forces. It is known that increased walking speed causes an increase in the momentum of the body, resulting in an increase in ground reaction forces (34). So the reason for slower walking seen in individuals with CINP may be a compensation to reduce ground reaction forces.

In this study, persons with CINP had a slower gait, lower stride length, decreased pelvic symmetry and increased pelvic movements compared to HS. These results reveal that people with CINP display changes in pelvis kinematics during gait. The dual task gait condition was better able to differentiate between persons with CINP and HS in terms of spatiotemporal gait parameters and pelvic movements alteration. Therefore, it is important that CINP studies include tasks that reflect the functional activities in daily life.

There are limitations in this study. First, the scope of the study did not include assessment of trunk movements and pelvis-thorax coordination, which can provide useful additional information. Secondly, all patients had mild to moderate disability. In further research, it is important to examine gait and pelvic movements in people with different neck disability levels in different gait conditions. Our study group was young and had normal BMI range. Neck pain is so common in workers with high body mass. This makes our results limited to this group. Finally, it was not possible to investigate whether dominant side and neck pain localization affects the gait parameters, pelvic symmetry and movements. All single and dual task measurements were performed at usual walking speed, and further research should focus on different speeds.

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