Araştırma Makalesi (Research Article)

The Impact of Cervical Sagittal Slope on Postural Oscillation and Balance

Servikal Sagital Eğimin Postüral Salınım ve Denge Üzerine Etkisi

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Özet

Amaç: Statik denge ve postüral salınım farklı hastalıklardan etkilenebilir. Bu çalışmanın amacı; servikal lordoz kaybı ya da servikal kifoz olan bireylerde klinik testler ve stabilometrik ölçümler ile denge bozukluğunu araştırmak ve denge durumunu servikal lordozu olan bireylerle karşılaştırmaktır.

Gereç ve Yöntemler: Çalışmamızda son 6 ay içinde Fiziksel Tıp ve Rehabilitasyon polikliniğine başvuran, servikal lateral grafisi çekilmiş olan ve araştırmaya alınma kriterlerine uyan 102 hasta değerlendirildi. Hastalar Cobb metoduna göre hesaplanan servikal sagittal eğim açılarına göre 4 gruba ayrıldı. Hastaların 8 farklı pozisyonda stabilometrik ölçümleri yapıldı. Ayrıca Berg denge skalası (BDS) ve aktiviteye özgü denge güvenlik skalası (AÖDGS) skorları hesaplanıp, zamanlı ayağa kalkma yürüme testi (ZAKYT), dört kare adımlama testi (DKAT) ve fonksiyonel uzanma testi (FUT) yapıldı. İstatistiksel tüm değerlendirmelerde anlamlılık düzeyi $p<0.05$ olarak kabul edildi.

Bulgular: Çalışmaya katılan hastaların stabilometrik ölçümlerinden NC (Natural head-Nötral baş pozisyonu) mediolateral salınım hızı, NC mediolateral toplam salınım miktarı, NC anteroposterior salınım hızı, NC anteroposterior toplam salınım miktarı, NC vektöriyel maximum salınım miktarı, NC vektöriyel toplam salınım miktarı, HR anteroposterior maksimum salınım miktarı, HR (Head Right-Baş sağ rotasyonda) anteroposterior salınım hızı, HR anteroposterior toplam salınım miktarı ve PC (Nötral baş pozisyonu) anteroposterior maksimum salınım miktarı bakımından istatistiksel olarak anlamlı fark saptandı. BDT skoru, AÖDGS skoru, ZAKYT ve DKAT süresi ve FUT açısından ise gruplar arasında anlamlı fark yoktu.

Sonuç: Bu çalışmanın sonuçlarına göre servikal sagittal eğim açılarına göre gruplandırılan hastalar arasında bazı postürografik parametreler açısından anlamlı farklar tespit edilirken, bazıları açısından gruplar arasında fark bulunamamıştır. Bu sonuç servikal sagittal eğimin lordozdan kifoza doğru gittikçe postüral performansın bazı komponentlerini olumsuz yönde etkilediğini ancak tüm komponentlerini etkilemediğini düşündürmektedir.

Anahtar kelimeler: Denge, Servikal sagittal eğim, Stabilometri

Abstract

Aim: Static balance and postural oscillation can be affected by different diseases. The aim of this study was to investigate balance disorders with clinical tests and stabilometric measurements in individuals with cervical lordosis loss or cervical kyphosis and to compare the balance state with cervical lordosis individuals.

Material and methods: In our study, 102 patients, with cervical lateral x-ray imagings and met criteria for inclusion into the study, who applied to the physical medicine and rehabilitation polyclinic within the last 6 months were evaluated. Patients were divided into 4 groups according to the cervical sagittal slope angles calculated based on the Cobb method. Stabilometric measurements of the patients were performed in 8 different positions. In addition, the berg balance scale (BBS) and the activity-specific balance confidence scale (ABC) scores were calculated and the timed up and go test (TUG), the four square step test (FSST) and the functional reach test (FRT) were performed. Statistical significance was accepted as $p<0.05$ in all statistical evaluations.

Findings: Statistically significant differences were found in the NC mediolateral oscillation rate, NC (Natural head position)mediolateral total oscillation amount, NC anteroposterior oscillation rate, NC anteroposterior total oscillation amount, NC vectorial maximum oscillation amount, NC vectorial total oscillation amount, HR anteroposterior maximum oscillation amount, HR (Head right rotation) anteroposterior oscillation rate, HR anteroposterior total oscillation amount and PC (Natural Head position) anteroposterior maximum oscillation amount from the stabilometric measurements of the patients participating in the study. There was no significant difference between the groups in terms of BBS score, ABC score, TUG and FSST score and FRT.

Conclusion: According to the results of this study, while there were significant differences in terms of some posturographic parameters among the patients grouped according to the cervical sagittal slope angles, there was no difference between the groups in terms of some parameters. This result suggests that cervical sagittal slope gradually affects some components of postural performance from lordosis to kyphosis, however, not all components were affected by that.

Key Words: Balance, Cervical sagittal slope, Stabilometry

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INTRODUCTION

The natural slope of the cervical spine maintains its lordotic shape due to the need to compensate for the kyphotic slope of the thoracic spine and due to the wedge shape of the cervical vertebrae. This thoracic kyphosis allows expanded lung volumes at normal intervals. Deviations in the slope of the cervical lordosis, such as loss of lordosis or development of cervical kyphosis, are associated with pain and disability (1). The lordotic slope is generally regarded as the "normal" or "ideal" state for the cervical spine. It has been reported that between 20 and 35 degrees are normal in C2-C7 measurements (2).

People with cervical region problems may experience dizziness and subjective balance disorder (3). In diseases affecting the cervical region, it has been noted that vestibulo-spinal reflex may be affected and the balance may be disrupted (4). For instance, in whiplash injured people, balance control problems can be seen as well as neck pain and limitation of movement (5,6). Some authors describe vertigo that accompany cervical disease as "cervical vertigo" (7). Transition of the head from any position to previous first position is related to the cervicocephalic kinesthetic stability. The movement of the head relative to the body includes information from the cervical proprioceptive structures and the vestibular system. (8,9). Impaired cervicocephalic kinesthetic sensitivity have been accused at functional instability and susceptibility to trauma of joints, chronic pain and even in degenerative diseases.

Posturographic measurements are used in peripheral and central vestibular system disorders, movement system disorders, metabolic diseases and determining drug side effects, as well as to evaluate age-related balance deficits (10,11). In a previous study, balance and postural performance with a computerized static posturography device was investigated in patients with cervical radiculopathy, and the drop index in the group of radiculopathies was found to be high (12). However, there are no studies investigating balance status in individuals with loss of cervical lordosis or with growing cervical kyphosis.

The purpose of our work is to investigate the balance disorder in patients with loss of cervical lordosis or with cervical kyphosis by clinical tests and stabilometric measurements, and to compare the balance with individuals that have normal cervical lordosis.

MATERIALS AND METHODS

In this study, 102 patients between the ages of 20-50, who applied to the physical medicine and rehabilitation polyclinic within the last 6 months, with cervical lateral x-ray imaging were evaluated. The lateral cervical x-ray imaging of all patients taken in neutral position were evaluated. Patients who did not enter the C7 vertebral lower tip plateau imaging area on the direct x-ray imaging, patients with no visible C7 lower tip plateau due to structural reasons and those not drawn in the neutral position of the cervical lateral x-ray imaging were not included in the study. With the Cobb method, the cervical sagittal slope angles were measured using software from the (Picture Archiving and Communication Systems) system. In the Cobb method, the angle between the C2 vertebrae bottom end plateau and the C7 vertebrae bottom end plateau was calculated. Those with orthopedic disorders such as muscle weakness, visual disturbances, vestibular and / or cerebellar disease, amputation and joint replacement and neurological diseases and muscle diseases (parkinson, Multple Sclerosis, myopathy) causing balance and dysfunction disorders, and drug use that could make hypothyroidism, peripheral neuropathy and balance disorder were not included in the study. Patients were divided into 4 groups according to the cervical sagittal slope angles calculated according to the Cobb method: cervical sagittal angle of inclination between +10° and +1° (Group 1), 0° (Group 2), between -1° and -10° (Group 3) and between -11° and -20° (Group 4). In evaluating patients' balances, the berg balance scale (BBS), the functional reach test (FRT), the timed up and go test (TUG), the four square step test (FSST), the activity-specific balance confidence scale (ABC) and measurements performed in stabilometry devise were used. The berg balance test is a simple and safe test that aims to measure the ability of a person to maintain their balance while doing functional test such as standing up while sitting, standing without support, picking up objects from the ground, standing on one foot. BBC consist of 14 parameters, each scored between 0 and 4. The maximum score is 56, and if the score is 45 and above, the balance is considered to be good. In the functional reach test, the maximum distance that the individual can reach forward in the horizontal plane while maintaining his stability on the support surface in standing position is measured. This measurement is repeated 3 times and averaged. Values of 15 cm and above indicate that the risk of falling increases significantly, values between 15-25 cm indicate that there is a moderate risk of falling. In the TUG, the person is asked to stand up from the chair, walk 3 meters forward, turn 180 degrees in place and walk towards to chair. The time is measured with the stopwatch while the person performs this task. There is a significant relationship between the time elapsed while completing the test and the functional mobility level. For the FSST, the patients were placed on a flat ground to create 4 squares and numbered all the squares. The standing subjects were told to step into each square as quickly as possible in a consecutive order (1-2-3-4-4-3-2-1), without touching the boards, and that both feet should touch the ground in each square. The time to complete the order was recorded as score. Values above fifteen seconds were considered a high risk of falling. In the ABC, participants were asked 16 questions evaluating how confidently they performed the movements during daily life and they were asked to score between 0 and

Table 1. Defining of the stabilometric measurement positions

Position	Head of position	Eyes	Floor	Purpose
NO	Natural	Open	On the platform	Assessment of static posture
NC	Natural	Closed	On the platform	Elimination of the visual system
PO	Natural	Open	On the sponge placed on the platform	Elimination of the somatosensorial system
PC	Natural	Closed	On the sponge placed on the platform	Elimination visual and somatosensorial system
HR	Right rotation	Closed	On the platform	Elimination of the visual system and vestibular stress
HL	Left rotation	Closed	On the platform	Elimination of the visual system and vestibular stress
HB	Extension	Closed	On the platform	Elimination of the visual system and vestibular and cervical stress
HF	Anteflexion	Closed	On the platform	Elimination of the visual system and vestibular and cervical stress

100. Then the arithmetic mean of the total score was obtained. Accordingly, it was accepted that those who score less than 67 have increased fall risk.

Stabilometric measurements were made on the platform in dimensions of 60 x 60 cm. The data from the weight sensors on all four corners of the platform were sampled at 25 Hz and transferred to the computer via USB. This data was collected by Prof. Dr. Vedat Nacitarhan transformed it into x and y coordinate system with 1 mm resolution through the program written in Visualbasic 6.0. Measurements were made in 8 different positions, each took 30 seconds, and recorded on a computer **(Table 1)**. Then, some variables were obtained for each of these 8 positions depending on the displacement of the center of gravity.

These variables are;

- Mediolateral maximum oscillation (mm)
- Mediolateral total oscillation (mm)
- Mediolateral oscillation rate (mm/s)
- Anteroposterior maximum oscillation (mm)
- Anteroposterior total oscillation (mm)
- Anteroposterior oscillation rate (mm/s)
- Vectorial maximum oscillation (mm)
- Vectorial total oscillation (mm)
- Vectorial oscillation rate (mm/s)

Ethical approval was obtained from the ethics committee of Kahramanmaras Sutcu Imam University on 30.11.2015 in the session numbered 2015-16 with protocol number 218 and decision number 10. Written informed consent was obtained from all patients.

Statistical Evaluation

Analysis of the data was done in the SPSS for Windows 22.0 package program. Two-way variance analysis (ANOVA, Post Hoc, Tukey) was performed to assess differences between groups. The relationship between stabilometric measurements made at 8 different positions with cervical slope angle, the four square step test (FSST), the timed up and go test (TUG), the functional reach test (FRT), the berg balance scale (BBS) and the activity-specific balance confidence scale (ABC) was assessed by Pearson correlation analysis and the coefficient of "r". The results were considered statistically significant for $p<0.05$.

RESULTS

16 and 86 of the patients were male and female, respectively. The mean age of the patients was 38.13±8.16. The mean BMI (Body Mass Index) of the participants was 29.31±5.94. After the analyzes performed, it was determined that 24 (23.5%) of 102 subjects were kyphotic (group 1) with cervical sagittal angle of +10° to +1°, 22 (22.4%) of them were found to have 0° cervical lordosis (group 2), 34 (34.68%) of 102 patients were found to have lordotic (group 3) between -1° and -10° and 22 (22.4%) lordotic group between -11° and -20° (group 4). There was no significant difference between the groups when we assessed in terms of age, gender and BMI ($p> 0.05$).

A statistically significant difference was found in the NC mediolateral oscillation rate ($p=0.035$), NC mediolateral total oscillation rate amount ($p=0.036$), NC anteroposterior oscillation rate ($p=0.016$), NC anteroposterior total oscillation rate amount ($p=0.016$), NC vectorial maximum oscillation rate ($p=0.024$), NC vectorial total oscillation rate ($p=0.014$), HR anteroposterior maximum oscillation rate ($p=0.046$), HR anteroposterior oscillation rate ($p=0.047$), HR anteroposterior total oscillation amount ($p=0.047$) and PC anteroposterior maximum oscillation amount ($p=0.025$) when the distribution of the results of the statistical stabilometric measurements was analyzed **(Table 2)**.

Table 2. Stabilometric measurement parameters with significant differences between groups

	p
NC mediolateral oscillation rate	0.035
NC mediolateral total oscillation	0.036
NC anteroposterior oscillation rate	0.016
NC anteroposterior total oscillation	0.016
NC vectorial maximum oscillation	0.024
NC vectorial total oscillation	0.014
HR anteroposterior maximum oscillation	0.046
HR anteroposterior oscillation rate	0.047
HR anteroposterior total oscillation	0.047
PC anteroposterior maximum oscillation	0.025

There was no significant difference between groups in terms of BBS score, ABC score, TUG and FSST durations and FRT used in the evaluation of the balance (p>0.05) **(Table 3)**.

DISCUSSION

Sagittal imbalance results in increased muscular effort and energy expenditure, causing pain, fatigue, and disability (13). The natural curvature of the cervical spine is lordotic due to the need to compensate for the kyphotic curvature of the thoracic spine, allowing large lung volumes, and the wedge shape of the cervical vertebrae. Deviations in the cervical lordosis slope such as loss of lordosis or development of cervical kyphosis are associated with pain and disability (1).

According to the results of our study, there was a significant difference in terms of some of the stabilometric measurements among the patients grouped according to the cervical sagittal slope angles, but there was no difference between the groups in terms of some of them. This result suggests that the cervical sagittal slope gradually affects some components of the postural oscillation from the lordosis to the kyphosis, but not all the components were affected.

Proprioceptive input originating from the cervical region is important in maintaining balance. It has been reported that proprioceptive information from the vestibular, visual and neck region is important in subjective body orientation and perception of space (14). In some animal experiments, local anesthetic injection into the cervical deep tissues resulted in ataxia and nystagmus (15).

Disruption of proprioceptive information originating from the cervical region for various reasons may affect postural performance, causing dizziness or drowsiness (16). According to Paulus et al., Patients with persistent neck pain show proprioceptive disorder even during their painless periods. According to them, this may be due to the change in the interpretation of propriseptive signals (17). Spasm in the neck area often limits neck movements. Altered signals from proprioceptors in painful and spasm neck muscles may contribute to impaired postural performance (12). For this reason, we think that the change in the cervical sagittal slope from lordosis to kyphosis causes spasm and neck pain in the neck muscles and the change in the signals coming from the proprioceptors in the neck muscles adversely affects the postural performance.

Cervical vertigo is a term used to describe dizziness and misbalance in walking caused by neck disorders. Since cervical spondylosis (CS) is a common disease, especially among the elderly, development of vertigo in CS patients is important. In a study conducted in patients with cervical spondylosis, 50% of patients had vertigo, while another reported 65% of elderly patients having dizziness (18). Some researchers have found that vertebral artery (VA) blood flow is impaired during vertigo with neck rotation and are associated with CS. Machaly et al. (19) investigated VA blood flow rates in patients with CS patients who complained dizziness and

Table 3. Comparison of the clinical balance tests of the groups

	Group 1 (n:24) Mean± SD	Group 2 (n:22) Mean± SD	Group 3 (n:34) Mean± SD	Group 4 (n:22) Mean± SD	p
TUG (sec)	13.04±2.90	11.82±2.36	13.15±2.80	12.32±2.03	0.224
FRT(cm)	20.04±6.78	22.64±6.14	18.97±5.86	20.95±6.28	0.224
FSST (sec)	16.79±3.10	16.50±2.97	18.24±3.59	16.91±4.97	0.285
BBS	52.79±2.45	52.68±2.12	51.00±7.77	53.32±2.28	0.296
ABC	91.99±6.83	90.91±7.85	87.51±15.72	90.68±8.17	0.435

TUG: Timed up and go test, FRT: Functional reach test, FSST: Four square step test, BBS: Berg balance scale, ABC: Activity- specific balance confidence scale

found a decrease in VA blood flow during cervical rotation. In our study, we did not examine the vertebral artery blood flow; however, we think that as the cervical lordosis flattens towards the kyphosis in our study's patients, postural performance and balance may be adversely affected because muscle spasm around the neck increases or caused by kyphosis in the vertebral foramen causes compression in the vertebral secondary arteries.

Assessment of the balance in various diseases with computerized static posturography gained momentum at the beginning of 1990's, but primarily focused on vestibular diseases. In neurological problems such as Parkinson, ataxia, multiple sclerosis and hemiplegia, static posturography has been accompanied by classical balance assessment methods and has become an alternative to these methods. Bauer et al. in a study conducted by elderly people, static postural measurements of 30 healthy elderly people were taken for three times and averaged these values. They have demonstrated the reliability of a static posturography device in this study where they have tested the reliability of a computerized static posturography device (20). In a study on cases with Multiple Sclerosis in the Department of Physical Medicine and Rehabilitation of the Cerrahpasa Medical School, the computerized static posturography device was found to be more sensitive than the BBS score in determining the risk of falling (21). Statistically significant differences were found in the NC mediolateral oscillation rate, NC mediolateral total oscillation amount, NC anteroposterior oscillation rate, NC anteroposterior total oscillation amount, NC vectorial maximum oscillation amount, NC vectorial total oscillation amount, HR anteroposterior maximum oscillation amount, HR anteroposterior oscillation rate, HR anteroposterior total oscillation amount and PC anteroposterior maximum oscillation amount from the stabilometric measurements of the patients participating in our study. In the groups with flattening in cervical kyphosis and lordosis, high values were found indicating that the static balance was worse in these parameters. There was no significant difference between groups in terms of BBS score, ABC score, TUG and FSST durations and FRT used in the evaluation of the balance ($p>0.05$). In our study, the fact that no significant impairment was detected in the participants in the clinical tests that were mentioned above might be due to the fact that the younger age patients were evaluated compared to the other studies in the literature and it may be due to the fact that patients with additional problems (such as diabetes, drug use, hypothyroidism, postmenopausal period) that are affecting the balance state excluded from the study. As a matter of fact, in a study by Gunendi et al. (22) in which the effects on balance parameters of osteoporosis and menopausal status were assessed, the best scores were seen in women without osteoporosis in the premenopausal period as in our patient group.

Palmgren et al. (23) studied postural balance with measurements of cervicothoracic kinesthetic sensitivity and computerized static posturography in a study of patients with non-traumatic, chronic neck pain. As a result of that study, while cervicocephalic kinesthetic impairment was observed during neck flexion, no other head positions were affected. Posterior deterioration was detected in eyes closed measurements with computerized static posturography device. Karlberg et al. showed that the postural balance disorder occurs in subjects with neck and arm aches relative to healthy people with no-pain (24).

Diracoglu et al. In a study comparing the postural performance of patients with cervical radiculopathy and those with neck pain but no radiculopathy findings; found that the fall index values measured especially during cervical rotation, flexion and extension movements were higher than patients with only neck pain (12). In the same study, in patients with radiculopathy, a significant deterioration was found in the F2-4(peripheral vestibular system) frequency in the HR (eyes closed, on pillow, neck in right rotation) and HL (eyes closed, on pillow, neck in left rotation) positions compared to the control group in the measurements made with the computed static posturography device.

Postural oscillation and balance are affected by cervical proprioceptive syphilis. According to our results, the cervical sagittal slope gradually moves from lordosis to kyphosis affects some components of postural performance in the negative direction. Thus, postural performance may be impaired even if the clinical balance tests are normal and there is no balance problem in these patients. There is a need for more extensive studies on this subject.

The limitations of our study are that we did not take into account the difference in neck pain level between the groups and the presence of cervical root compression.

Ethical approval: Ethical approval was obtained from the ethics committee of Kahramanmaras Sutcu Imam University on 30.11.2015 in the session numbered 2015-16 with protocol number 218 and decision number 10. Written informed consent was obtained from all patients.

Conflicts of Interest: The authors declare that they have no conflicts of interest.

Research Contribution Rate Statement Summary: The authors declare that, they have contributed equally to the manuscript.

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