



Effect of Chronic Non-specific Neck Pain on Aerobic Capacity in Females

Kadınlarda Kronik Non-spesifik Boyun Ağrısının Aerobik Kapasiteye Etkisi

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ABSTRACT

Objective: To examine the effect of chronic non-specific neck pain (NSNP) on maximal aerobic capacity (VO_{2max}) in females.

Methods: This study evaluated a total of 104 participants including 52 females aged 20–40 years who were diagnosed with chronic NSNP for at least 1 year (patient group) and 52 healthy females (control group). Mean age of the patient group was 31.04 ± 5.65 years and of the control group was 31.33 ± 5.10 years. Pain severity was evaluated with visual analog scale (VAS), neck disability degree with Neck Disability Index (NDI), and VO_{2max} with Bruce Protocol Treadmill Test.

Results: Mean VAS score was 5.86 ± 1.11 cm and mean disease duration was 4.72 ± 4.20 years in the patient group. There was no significant difference in terms of VO_{2max} level between the two groups ($p > 0.05$). However, in the patient group, there was a moderate negative significant correlation between NDI value and VO_{2max} level ($r = -0.344$, $p = 0.012$). In addition, there was a moderate positive significant relationship between pain duration (hours/day) and NDI value in the patient group ($r = 0.308$, $p = 0.026$).

Conclusion: As a result of the study, it was seen that there was no difference between the patient and healthy groups in terms of aerobic capacity. However, in the patient group, aerobic capacity decreased as the degree of neck disability increased. In the treatment of patients with neck pain, considering the respiratory dysfunction and the factors that cause it may contribute to the treatment processes.

Keywords: Cardiopulmonary exercise testing, disability evaluation, neck pain, pain measurement, respiration

ÖZ

Amaç: Bu çalışmanın amacı kadınlarda kronik non-spesifik boyun ağrısının aerobik kapasite üzerine etkisini incelemektir.

Yöntemler: Çalışmada non-spesifik boyun ağrısı tanısı almış, 20–40 yaş arası, en az 1 yıldır boyun ağrısı şikayeti olan 52 kadın ile 52 sağlıklı kadın olmak üzere toplam 104 birey değerlendirilmiştir. Hasta grubunun yaş ortalaması $31,04 \pm 5,65$ yıl, kontrol grubunun yaş ortalaması $31,33 \pm 5,10$ yıldır. Olguların, ağrı şiddeti; Görsel Ağrı Skalası, özür lülük düzeyleri; Boyun Özur Göstergesi (BÖG) ve aerobik kapasiteleri (VO_{2maks}); Bruce Treadmill Test Protokolü ile değerlendirilmiştir.

Bulgular: Hasta grubunda ağrı şiddeti ortalaması $5,86 \pm 1,11$ cm, hastalık süresi ortalaması ise $4,72 \pm 4,20$ yıldır. Hasta grup ile sağlıklı grup arasında VO_{2maks} değerleri arasında anlamlı farklılık yoktu ($p > 0,05$). Ancak kronik boyun ağrılı bireylerde, BÖG skorları ile VO_{2maks} değerleri arasında negatif yönlü anlamlı ilişki bulundu ($p = 0,012$). Ayrıca hasta grubunda gün içinde yaşanan ağrı süresi ile BÖG skorları arasında pozitif yönlü anlamlı ilişki tespit edildi ($p = 0,026$).

Sonuç: Çalışma sonucunda hasta ve sağlıklı grup arasında aerobik kapasite açısından fark olmadığı fakat hasta grubunda boyun özür lülük derecesi arttıkça aerobik kapasitenin azaldığı görülmüştür. Boyun ağrılı hastalara yaklaşımlarda respiratuvar etkilenim ve buna neden olan faktörlerin göz önünde bulundurulması tedavi süreçlerine katkı sağlayabilir.

Anahtar Sözcükler: Kardiyopulmoner egzersiz testi, özür lülük değerlendirilmesi, boyun ağrısı, ağrı değerlendirilmesi, solunum

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Introduction

Neck pain is one of the most common complaints of the musculoskeletal system. Worldwide, 288.7 million cases of prevalent neck pain were reported in 2017 (1). Its annual prevalence ranges between 16.7% and 75.1% (2), with the prevalence increasing over time (3). Although the course of neck pain is usually characterized by exacerbation, symptoms do not completely resolve in most patients and the conditions in 5-10% of the patients become chronic (4). The state of pain and disability lasting for >12 weeks is classified as chronic neck pain (3). In cases wherein the underlying cause or specific disease cannot be identified in the vast majority of individuals with neck pain, non-specific neck pain (NSNP) leads to significant health and care costs, employee absenteeism and loss of productivity (5).

Chronic NSNP is a multifactorial disease that is associated with various dysfunctions in the cervical region and the adjacent structures (6). Because there is a close anatomical, musculoskeletal and neural connection between the cervical region and thoracic spine, it is reported that chronic neck pain may affect respiratory functions by causing biomechanical changes in the thoracic spine and thorax (7). In patients with neck pain, muscle weakness and fatigue, limitation of normal joint range of motion (ROM) in the cervical region, changing muscle activation patterns, pain, postural changes, loss of proprioception, and psychological conditions (such as anxiety, depression and kinesiphobia) can cause changes in vital capacity, functional vital capacity, respiratory muscle strength, blood chemistry, and rib cage/breathing pattern (8,9). Dimitriadis et al. (8), in their review in 2016; stated that changes in respiratory parameters such as maximal voluntary ventilation, partial arterial carbon dioxide pressure (PaCO_2), respiratory muscle strength and thoracic mechanics were consistently observed in all studies on neck pain and respiratory dysfunction, although there are respiratory indices for which the evidence provided conflicts. In another review conducted in 2017; a significant difference was observed in terms of maximal inspiratory pressure (PI_{max}), and maximal expiratory pressure (PE_{max}), in patients with chronic neck pain compared to asymptomatic patients, and it was reported that respiratory volumes and PaCO_2 were lower. Muscle strength, muscle endurance, cervical ROM, and psychological states; were found to be significantly associated with respiratory parameters. A significant relationship has been shown between chest expansion and neck pain (9).

$\text{VO}_{2\text{max}}$, an indicator of physical fitness, is mainly defined as the transport of O_2 and the ability of muscles to use O_2 . It is associated with the functionality of cardiovascular, respiratory, and muscular systems as well as hematological components (10-12). Conditions affecting the function of these systems may also lead to changes in $\text{VO}_{2\text{max}}$ in the long run. Given the respiratory effects in patients with neck pain, we think that aerobic capacity will decrease in patients with NSNP. There are studies in the literature that examine the relationship between neck pain and respiratory functions, insufficient data to examine the relationship between chronic NSNP and $\text{VO}_{2\text{max}}$. This study

aimed to investigate the effect of chronic NSNP on $\text{VO}_{2\text{max}}$.

Methods

Study Design and Ethics

This cross-sectional study was conducted between February 2017 and May 2018. The study was conducted in accordance with the Helsinki Declaration. Ethics approval was received from Pamukkale University Non-Interventional Clinical Research Ethics Committee (date: 13.12.2016, number: 22). A written informed participant consent form was received from each participant in the study.

Participants

One hundred forty participants were evaluated in the study (patient group: 52 participants, control group: 52 participants).

Inclusion criteria for the patient group

- Diagnosis of chronic NSNP at the Brain and Nerve Surgery Outpatient Clinic of Pamukkale University Training and Research Hospital
- Chronic NSNP for ≥ 1 year
- Female, age between 20-40 years
- Pain severity of ≥ 4 the visual analog scale (VAS)

Inclusion criteria for the control group

- Age of 20-40 years and healthy
- Female sex

Exclusion criteria for the study

- Diagnosis of cardiopulmonary diseases
- Smoking habit
- Presence of traumatic cervical injuries
- Upper or lower respiratory tract infection within the past month
- Having received any physical therapy within the past year
- Regularly exercising habit
- Undergoing spinal and thoracic surgery
- Being obese [body mass index (BMI) ≥ 40 kg/m²]
- Presence of clinical abnormalities of the thoracic cage and vertebral column
- Presence of neurological disease, diabetes mellitus and malignancies
- Presence of professional industrial risks or severe comorbidities

Regarding the patient group, the records of 4,538 females who presented to the Brain and Nerve Surgery Outpatient Clinic of Pamukkale University Training and Research Hospital due to neck pain during the past five years were reviewed. There were

438 patients who met the exclusion and inclusion criteria. Each patient was called and invited to participate in the study. Among these, the records of 56 females who agreed to participate were evaluated. Two of these patients were excluded from the study because they experienced pain in the lower back and knee during VO_{2max} testing. Additional two patients were excluded from the study because VO_{2max} measurement was not completed due to a technical problem of the device. The study was completed with a total of 52 patients (Figure 1).

Regarding the control group, 53 healthy females who met the criteria and agreed to participate in the study were evaluated. Among these, one female was excluded because VO_{2max} measurement could not be completed due to a technical problem of the device. The study was completed with 52 healthy participants (Figure 1).

Assessment Scales

Information such as age, sex, body weight and height, BMI, medications taken, disease history, working status, smoking and alcohol use and exercising habits of all participants was recorded using a prepared sociodemographic form. In addition, the frequency of pain (day/week) and duration of pain experienced during the day (hour/day) were recorded by questioning.

VAS was used to evaluate pain severity, Neck Disability Index (NDI) was used to evaluate the degree of neck disability and Bruce Protocol Treadmill Test was used to evaluate VO_{2max} .

VAS

VAS was used to assess pain severity. VAS is a valid and reliable measurement scale of chronic pain severity (13). VAS usually comprises two lines representing the extreme ends of pain severity (e.g., no pain and excessive pain) and a 100 mm distance between these two lines. Patients assess pain severity by leaving a mark on the line, representing pain severity. VAS scores are given by measuring the distance from the “no pain” end of the line (14).

NDI

To determine the degree of neck disability in patients with chronic neck pain, NDI was used. The Turkish version of this index, which was developed by Vernon and Mior (15) in 1991, was created by Aslan et al. (16) in 2008. NDI comprises ten parts: pain severity, personal care, lifting loads, reading, headache, concentration, work life, driving, sleep, and leisure. There are six possible answers for each part, with scores between 0 (no pain and no functional limitation) and 5 (worst pain and maximum limitation). At the end of the survey, the scores of the selected options are summed and the incapability’s of the patients are determined. A score between 0 and 4 points indicates no disability, a score between 5 and 14 points indicates mild disability, a score between 25 and 34 points indicates severe disability and a score of >35 indicates complete disability (15,16).

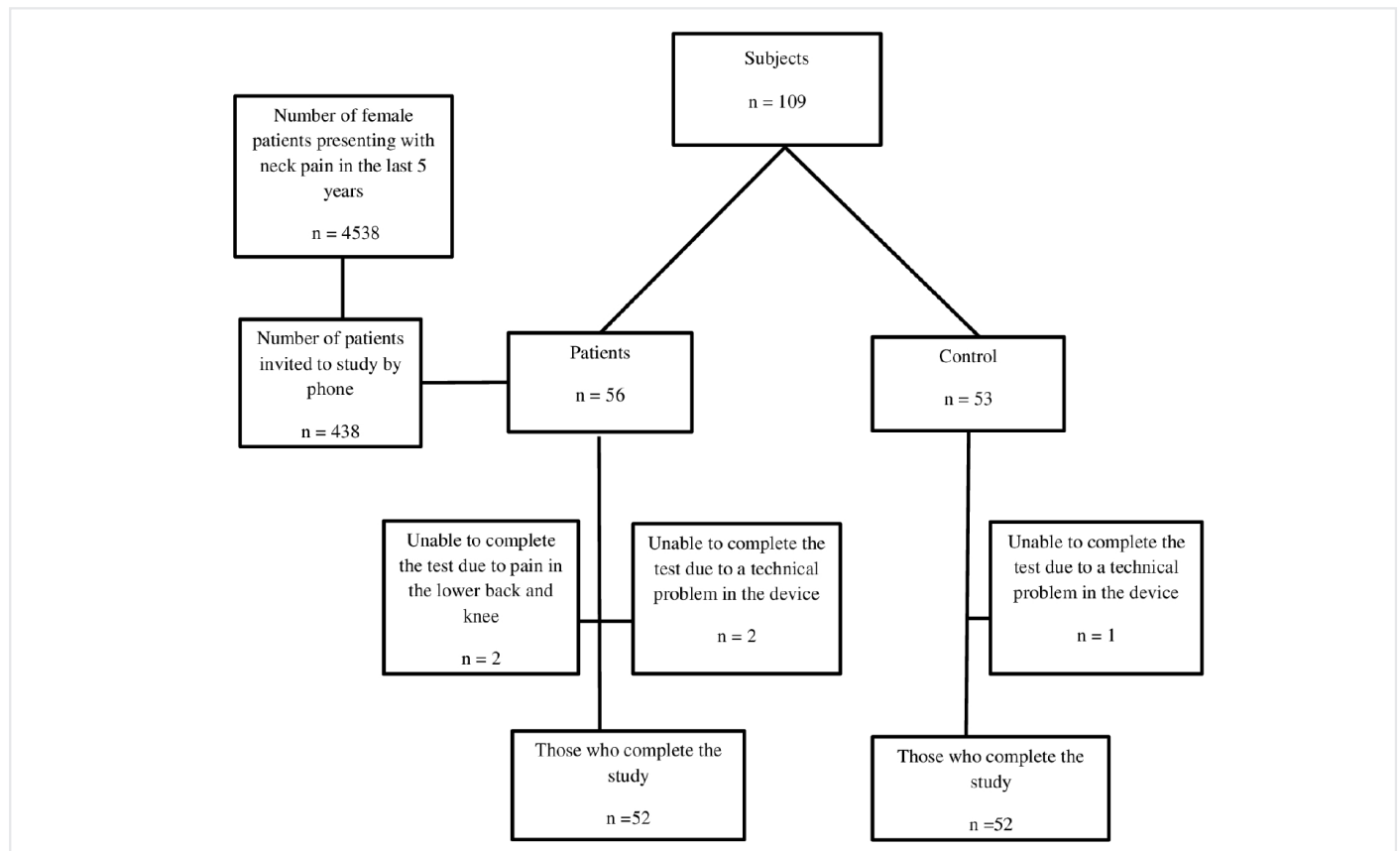


Figure 1. Flow chart of participant selection

Bruce Protocol Treadmill Test

The Bruce Protocol Treadmill Test was developed in 1963 by Bruce et al. (17). This protocol is one of the most common protocols used in clinics for the measurement of non-invasive estimated VO_{2max} . In the Bruce Protocol Treadmill Test, treadmill speed increases with 2-3 MET increments every three min (2% increase in slope). During this test, the participant is expected to reach the maximum possible speed (17-19).

After applying the Bruce Protocol Treadmill Test, the estimated VO_{2max} was calculated using this formula:

$$VO_{2max} \text{ (mL/kg/min)} = 132.853 - (0.0769 \times \text{body weight}) - (0.3877 \times \text{age}) + (6.315 \times \text{sex}) - (3.2649 - \text{duration}) - (0.156 \times \text{heart rate})$$

where body weight is measured in kilogram, female is scored 0 and male is scored 1, and duration is measured in min.

Before starting the test, the participants were provided the necessary information, and their blood pressure, resting heart rate, and oxygen saturation were measured. At the end of each level and at the end of the test, these measurements were repeated. Their heart rate at the end of the test was considered the maximum heart rate. The age-dependent VO_{2max} norm values for female gender are provided in Table 1.

Statistical Analysis

Data were analyzed using SPSS for Windows version 21.0 (IBM SPSS, Armonk, NY: IBM Corp.). Continuous variables are expressed as mean \pm standard deviation and categorical variables as numbers and percentages. The normal distribution of data was examined by the Kolmogorov-Smirnov test. Because parametric test-based assumptions of all data were provided, the independent samples t-test was determined to compare differences between independent groups. Pearson's correlation analysis was performed to examine the relationship between continuous variables. In all analyses, a p value of <0.05 was considered statistically significant. The sample size was calculated using G*Power 3.1 (University Dusseldorf, Germany) software. In a study performed by Dimitriadis et al. (20), a significant difference was shown in the maximum voluntary ventilation values between subjects with chronic neck pain and healthy controls, with an effect size of 0.58. Accordingly, we calculated that a total of 104 subjects

(patient group: 52, control group: 52) should be included with 95% confidence level and 90% power in this study.

Results

The demographic and clinical characteristics of the participants are given in Table 2. There were no significant differences between the two groups in terms of demographic data ($p \geq 0.05$, Table 2).

VO_{2max} level was measured in both groups, and VO_{2max} levels were grouped according to age range. Accordingly, in the patient group, 22 participants (42.3%) had moderate VO_{2max} level, 14 (26.9%) had adequate VO_{2max} level, 14 (26.9%) had good VO_{2max} level and 2 (3.8%) had low VO_{2max} level (Table 2). In the control group, 20 participants (38.5%) had moderate VO_{2max} level, 15 (28.8%) had adequate VO_{2max} level, 15 (28.8%) had good VO_{2max} level and 2 (3.8%) had low VO_{2max} level (Table 2). The mean VO_{2max} level of the patient group (31.82 ± 6.37) was slightly lower than the control group (32.06 ± 5.97) and there were no a significant difference ($p=0.943$; Table 2).

In the patient group, there was a moderate positive correlation between NDI value and pain duration ($r=0.308$, $p=0.026$). In addition, there was a moderate negative correlation between NDI value and VO_{2max} level ($r=-0.344$, $p=0.012$; Table 3).

Discussion

This study focused on investigate to the aerobic capacity in people with chronic NSNP complaints by comparing them to healthy people. In this study, a significant positive relationship was found between the degree of neck disability and the duration of pain experienced during the day. When the VO_{2max} was examined, a negative relationship was observed between the degree of neck disability and VO_{2max} in the patient group, although there was no difference between the groups in terms of VO_{2max} . The increase in the degree of neck disability appears to be associated with a decrease in aerobic capacity.

In this study, the entire patient group had a mild to severe degree of neck disability. In addition, the increased degree of neck disability was associated with increased pain duration during the day. Several studies have reported that various physical and biomechanical factors are associated with the degree of neck disability (21-24). Yip et al. (22) found that increased forward head position was moderately associated with the degree of neck

Table 1. Age-dependent VO_{2max} levels for females

VO_{2max} (mL/kg/min)	Low level	Adequate level	Moderate level	Good level	High level
Age groups (years)					
20-29	<24	24-30	31-37	38-48	>49
30-39	<20	20-27	28-33	34-44	>45
40-49	<17	17-23	24-30	31-41	>42
50-59	<15	15-20	21-27	28-37	>38
60-69	<13	13-17	18-23	24-34	>35

VO_{2max} : Maximal aerobic capacity, mL: Milliliter, kg: Kilogram, min: Minimum

disability. Tsang et al. (23) compared the muscle activations of healthy people and people with neck pain during movement and found significant differences in the activation patterns of multiple cervical and thoracic muscles. They reported that this was significantly associated with pain level and functional limitation.

Young et al. (24) showed that psychological conditions such as depression and somatization were strongly associated with disability (NDI) in patients with neck pain. In our study, as the duration of pain experienced during the day increased in people with neck pain, it may have caused a limitation in daily activities

Table 2. Demographic and clinical characteristics of the participants

Demographic and clinical characteristics	Patient group (n=52)	Control group (n=52)	p*
	X ± SD	X ± SD	
Age (years)	31.04±5.65	31.33±5.10	0.417
Weight (kg)	64.76±10.54	66.67±12.25	0.428
Height (cm)	164.38±5.75	162.46±5.84	0.993
Body mass index (kg/m ²)	23.93±3.56	25.23±4.52	0.205
Occupation			0.953
Student	7 (13.5%)	6 (11.5%)	
Housewife	20 (38.5%)	20 (38.5%)	
Employee	25 (48.1%)	26 (50%)	
Disease duration (years)	4.72±4.20	n/a	-
Pain duration (hours/day)	19.54±13.46	n/a	-
VAS (cm)	5.86±1.11	n/a	-
NDI	13.92±4.91	n/a	-
Degree of neck disability			-
No disability	-		
Mild disability	26 (50%)		
Moderate disability	25 (48.1%)		
Severe disability	1 (1.9%)	n/a	
Complete disability	-		
VO _{2max} (mL/kg/min)	31.82±6.37	32.06±5.97	0.943
VO_{2max} level			0.983
Low level	2 (3.8%)	2 (3.8%)	
Adequate level	14 (26.9%)	15 (28.8%)	
Moderate level	22 (42.3%)	20 (38.5%)	
Good level	14 (26.9%)	15 (28.8%)	
High level	-	-	

SD: Standart deviation, NDI: Neck Disability Index, VAS: Visual analog scale, kg: Kilogram, cm: Centimeter, VO_{2max}: Maximal aerobic capacity, n/a: Not applicable
 *Independent samples t-test

Table 3. Relationship between VO_{2max} level, disease duration, pain duration, pain severity and NDI value in the patient group

Variable	Disease duration (years)	Pain duration (hours/day)	Pain severity	NDI value
Disease duration (years)				
Pain duration (hours/day)	r=-0.048 p=0.735			
Pain severity	r=0.226 p=0.107	r=0.153 p=0.278		
NDI value	r=0.095 p=0.503	r=0.308* p=0.026	r=0.245 p=0.080	
VO_{2max}	r=0.047 p=0.743	r=-0.211 p=0.134	r=-0.101 p=0.477	r=-0.344* p=0.012

NDI: Neck Disability Index, VO_{2max}: Maximal aerobic capacity
 * Pearson correlation analysis

by causing avoidance of movement, and thus an increase in disability.

In this study, it was found that there was a decrease in VO_{2max} level due to an increased degree of neck disability in the patient group. For aerobic capacity, it is necessary to evaluate all the factors that determine the effectiveness of the oxidative mechanisms of the muscles during physical activity, such as the functionality of the cardiovascular, respiratory and muscular systems, and hematological components (10-12). Therefore, changes in the function of the respiratory system can also affect aerobic capacity (10-12,25). Some studies have shown a strong relationship between the cervical region and associated pathologies and respiratory dysfunctions in chronic NSNP. P_Imax, P_Emax, inspiratory capacity, expiratory volume, FEV1 and FVC values and PaCO₂ significantly decreased in individuals with chronic NSNP compared with healthy individuals (9,26-30). Chronic neck pain by hyperventilation, leading to respiratory dysfunction; may cause a blood chemistry compensation similar to that observed in chronic respiratory patients (8). Impairment of oxidative mechanisms at any level leads to a decrease in O₂ intake (12). The decrease in the amount of O₂ carried in the blood can cause premature fatigue in the respiratory muscles and affect VO_{2max} over time (8).

In addition, respiratory dysfunction may also develop due to psychological conditions such as anxiety, depression, kinesiophobia, or catastrophobia and accompanying changes such as altered breathing pattern. Patients' avoidance of cervical movements due to pain and psychological factors may lead to movement inhibition, resulting in changes in thoracic cage mechanics and respiratory dysfunction (8). This avoidance may also affect aerobic capacity by causing a decrease in the physical activity level of individuals. Although not evaluated in our study, we think that physical inactivity may be one of the reasons for the decrease in VO_{2max} level with the increase in the degree of neck disability in the patient group in this study. Mihailova and Kaminska (31) reported that the amount of weekly physical activity in students aged 20-36 years has a positive correlation with VO_{2max} and high lung volumes. In addition, in a 1-year prospective cohort study; It was reported that there was a negative significant relationship between the number of daily walking steps and the onset of neck pain in sedentary workers (32).

In this study, it was found that there was a decrease in VO_{2max} level due to increased degree of neck disability in the patient group but there was no difference between the patient and healthy groups in terms of VO_{2max} . To the best of our knowledge, there is only one study investigating the relationship between chronic NSNP and VO_{2max} . Yalcinkaya et al. (33) examined physical fitness parameters in 80 patients with chronic NSNP and 80 matched healthy individuals and similarly noted that there was no difference in terms of VO_{2max} levels among females in both groups. We believe that the reason why there was no difference between the two groups in our study may be because the pain severity was not very high in the patient group. In a study published in 2018, moderate/severe disabled patients with chronic NSNP, mildly disabled patients and healthy individuals

were compared in terms of cervical motor function and respiratory muscle strength, and it was reported that there was a difference between only moderate/severe disability group and healthy group (34). Perry et al. (35) showed that severe pain in females with chronic NSNP is associated with decreased VO_{2max} level. In addition, the very young age group included in our study may be the reason why no difference was found with healthy controls. VO_{2max} ; it is a parameter that changes depending on age, and physical activity, which decreases with increasing age, also has an effect. Pulmonary function and aerobic capacity decrease by about 40% between the ages of 25 and 80. Studies show that VO_{2max} decreases between 0.2 and 0.5 mL.min-1kg-year-1 (~0.5% per year) after the age of 30, and this decrease may accelerate after the age of 40-50 (25).

The strength of the present study is that, to the best of our knowledge, it is the first study to examine the relationship among pain parameters, degree of neck disability and VO_{2max} in chronic NSNP. It was conducted only among females, which increases its importance in the literature. It has been reported in the literature that female gender is one of the risk factors for NSNP (3). The prevalence of chronic neck pain, the burden of neck pain and the number of years lived with disability are higher in female gender than male gender (36,37). In addition, VO_{2max} level decreased with advanced age (25). In this regard, the enrolment of a young population is important to eliminate the effect of other factors that reduce VO_{2max} level. The limitations of present study are that there is no comparison between the genders, the fatigue levels of the individuals are not evaluated, and the severity of pain in our patient group is moderate. Patients with a higher mean pain severity should be included in future.

Conclusion

In conclusion, it has been found that aerobic capacity decreases due to an increase in the degree of neck disability in people with chronic NSNP complaints. Effects of respiratory dysfunction should be taken into account in approaches for people with chronic NSNP. Chronic NSNP and associated respiratory effects may lead to a decrease in the physical activity levels in daily lives due to reasons such as pain, kinesiophobia, catastrophobia and muscle fatigue, thereby reducing VO_{2max} level in the long run. Because there is insufficient data in the literature to examine the relationship between chronic NSNP and VO_{2max} , further randomized controlled studies are needed to cover this deficiency.

Ethics

Ethics Committee Approval: Ethics approval was received from Pamukkale University Non-Interventional Clinical Research Ethics Committee (date: 13.12.2016, number: 22).

Informed Consent: A written informed participant consent form was received from each participant in the study.

Peer-review: Externally peer reviewed.

Authorship Contributions

Concept: Ö.M., F.A., O.T.A. Design: Ö.M., F.A., O.T.A. Data Collection or Processing: Ö.M. Analysis or Interpretation: Ö.M., F.A. Literature Search: Ö.M. Writing: Ö.M., F.A.

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