



# Comparison of the effectiveness of a structured exercise program on nonspecific neck pain in string and woodwind players

Serkan Usgu<sup>1</sup> · Hasan Akbey<sup>2</sup> · Burhan Fatih Kocyigit<sup>3</sup> · Ahmet Akyol<sup>4</sup> · Yavuz Yakut<sup>1</sup>

Received: 15 October 2021 / Accepted: 29 December 2021 / Published online: 11 January 2022  
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## Abstract

To investigate the effect of a structured exercise training program on pain, functional status, physical function and quality of life (QoL) in string and woodwind players with nonspecific cervical pain. This study had a prospective cohort design and conducted on 40 musicians (26 male, 14 female) aged between 18 and 65 years with persistent nonspecific neck pain in the previous 3 months. Forty musicians were assigned to either violin ( $n=20$ , median age; 26.5 year, height; 1.67 m, body mass; 65 kg, BMI; 23.04 kg/m<sup>2</sup>) or ney group ( $n=20$ , median age; 27.5 year, height; 1.81 m, body mass; 75 kg, BMI; 23.35 kg/m<sup>2</sup>) and followed the same structured exercise program (3 days/week for 8 weeks). The primary outcome was neck pain intensity and assessed on a visual analog scale (VAS). Secondary outcomes; cervical range of motion (ROM) was measured using a goniometer, the jaw-to-sternum and jaw-to-wall distances were used for the assessment of cervical mobility, neck, shoulder and back muscles strength were assessed with a hand-held dynamometer, the Northwick Park Neck Pain and Short Form 36 (SF-36) questionnaires were also used. Normality of data distribution was checked using the Kolmogorov–Smirnov test. For evaluating the training effectiveness on outcome measures, Mann–Whitney  $U$  and Wilcoxon test were used compare pre-test and post-test values with/within groups, respectively. The primary outcome (pain intensity) was lowered %33 in both groups. However, the mean change was found similar (median mean changes;  $-2$  for both groups) ( $p > 0.05$ ). The secondary outcomes; cervical mobility, cervical flexion ROM, disability and muscle strength of the left middle trapezius, left hand grip, anterior and middle parts of the right deltoid, and cervical flexors also significantly improved in both groups ( $p < 0.05$ ). Only the mean changes of right serratus anterior, middle trapezius and cervical flexor muscles were higher in violin group than ney group ( $p < 0.05$ ). There was no significant difference in the cervical extension, right rotation, left rotation, right lateral flexion and left lateral flexion after the treatment in both groups ( $p > 0.05$ ). There was no significant difference between the groups after the exercise program in terms of pain, mobility, range of motion and SF-36 subdomains ( $p > 0.05$ ). Specific exercise program had similar positive effects on pain, cervical mobility, cervical flexion ROM and disability in string and woodwind players. Although several muscles showed similar improvements in strength, some muscle groups recovered differently. Physical needs specific to the instrument and performance should be taken into account when prescribing exercises to musicians having the same problem, but playing different instruments.

**Keywords** Exercise · Neck pain · Disability · Musicians · Rehabilitation

✉ Burhan Fatih Kocyigit  
bfk2701@hotmail.com

- <sup>1</sup> Department of Physical Therapy and Rehabilitation, Faculty of Health Sciences, Hasan Kalyoncu University, Gaziantep, Turkey
- <sup>2</sup> Department of Physical Therapy and Rehabilitation, Fırat University, Elazığ, Turkey
- <sup>3</sup> Department of Physical Medicine and Rehabilitation, Faculty of Medicine, Kahramanmaraş Sütçü İmam University, Kahramanmaraş, Turkey
- <sup>4</sup> Physiotherapy and Rehabilitation Application and Research Center, Hasan Kalyoncu University, Gaziantep, Turkey

## Introduction

Musicians need to deal with a range of challenges associated with repetitive, fast and complex movements [1]. During their performances, they have to maintain static and dynamic body movements for an extended period of time [2]. Faults in upper body posture, poor performance techniques and long playing times cause overuse injuries and musculoskeletal disorders [3, 4]. Musical performance-associated musculoskeletal disorders (MSD) are a common health concern

among professional musicians with a reported prevalence of varying from 9 to 68% [5].

Instrument-specific body posture that musicians take may increase the risk of injuries [6]. Studies showed that string players (67%) are more affected by musculoskeletal disorders than wind players (54%) [7, 8]. Musicians playing in an elevated arm position (upper string) may be more prone to develop musculoskeletal disorders than those playing in a neutral arm position [9]. Violin is an upper string instrument. In violin playing, the instrument rests on the player's shoulder and is held firmly against the chin with lateral flexion and rotation of the cervical spine [10]. Violin playing requires two distinct techniques performed by two hands. The left hand holds the instrument and left fingers press down on the violin's strings with quick movements to produce specific pitches. The right hand is used to vibrate the strings. This is done by gliding a bow across the strings with the bow held with the right hand and requires both up-bowing and down-bowing. Ney is a harmonic woodwind instrument that is prominent in Turkish and Iranian musical traditions [11]. Ney is an end-blown flute that comes in many sizes, each producing different tones depending on the length and thickness of the instrument. When blowing a ney, the trunk and head flex forward more to better grasp the instrument. At the same time, depending on whether the instrument is left- or right-handed in construction, the right or left hand grasps the ney, while the other arm rests on the knee [11]. Ney is played by holding it at a certain angle so that air can be blown from the center of the lips. This angle is around 40°–45° and does not change in standing or sitting

position [12] (Fig. 1). These holding positions require an asymmetric, non-ergonomic posture and prolonged use of shoulder and neck muscles and the players experience pain in the spinal and upper extremity regions [5, 13]. Nyman et al. [9] reported that cervical pain is more common in orchestral musicians playing in an elevated shoulder position such as violists, violinist, flutists and trumpet players. Over activation of the shoulder muscles in an asymmetric position can cause overload on the cervical region. The type and weight of the instrument may also affect the magnitude of spinal overloading [4, 14, 15]. Ney requires less shoulder elevation than flute or trumpet but, as with violin, cervical rotation and lateral flexion are needed when playing ney, in order to stabilize the mouthpiece of the instrument in the mouth. Hyperactivity of orofacial and cervical muscles associated with musical performance can cause overloading of cervical region and temporomandibular joint, resulting in pain [16].

Recently, exercise programs have been used increasingly to manage musculoskeletal problems in musicians [17–19]. Certain strategies including exercise approaches have been developed to prevent such problems [20, 21]. These studies were conducted on orchestra musicians playing viola, violin, cello, contrabass (string), woodwinds, brass and percussion. The proportion of the participants playing musical instruments varies. It is difficult to create standardized exercise programs for participants playing these musical instruments, which have different biomechanical impacts. Therefore, general exercise approaches were applied and focused on performance-related musculoskeletal pain, prevalence and

**Fig. 1** Demonstration of violin (a) and ney (b) instruments and holding position



severity. From this perspective, the recommendation of a standard exercise program for musicians with different needs and musculoskeletal problems can be a matter of debate. Exercise training has been demonstrated to be an effective modality that improves postural alignment, mobility and stability in the management of nonspecific cervical pain in violinists [10]. In addition, single-group studies on cervical pain in violin players have reported positive effects of exercises on pain relief and posture correction [22, 23]. These studies generally involved musicians playing the same instrument. There may be some doubts among clinicians about the use or effectiveness of exercise training in musicians playing different instruments presenting with cervical pain. To the best of our knowledge, there are no comprehensive studies that examined the comparative effectiveness of exercise training on nonspecific neck pain in musicians playing different instruments, such as string and woodwind players. Thus, the aim of this study was to investigate the effects of a structured exercise training program on pain, disability, range of motion, mobility, strength and quality of life in ney and violin players with nonspecific neck pain.

## Materials and methods

### Study design and participants

This study had a prospective cohort design and conducted on 40 musicians aged between 18 and 65 years with persistent nonspecific neck pain in the previous 3 months. The study was carried out in a physical medicine and rehabilitation clinic between February 2018 and June 2019. Those with a pain intensity of 40 mm or worse in the previous 7 days as demonstrated by VAS (0–100 mm) were included in the study. A cutoff value of 40 mm was determined based on studies investigating various treatment modalities in patients with chronic neck pain [24].

Nonspecific neck pain was defined as perceived pain in the lateral and posterior aspect of the neck between the superior nuchal line and the spinous process of the first thoracic vertebra with no obvious underlying cause [25]. The diagnosis of nonspecific neck pain was made by a physical medicine and rehabilitation specialist with 10 years of experience in this field based on clinical assessments and radiological (X-ray and MRI) images. Patients underwent a detailed physical examination, including muscle strength, sensory and reflex assessments and specific tests. In case of suspicion by physical examination and anamnesis, participants were evaluated with blood tests and electromyography. Individuals with a history of spinal surgery or trauma in the last 3 months, inflammatory joint disorders, malignancy, discogenic pain, radiculopathy and neurologic deficit in upper extremity, polyneuropathy, physiologic or

systemic disorders, alcohol or substance abuse, using drugs (paracetamol, nonsteroidal anti-inflammatory drugs, myorelaxant drugs and tramadol etc.) during the study and those who participated in a physical therapy and rehabilitation program in the last 3 months or missed more than two sessions of the exercise training program were excluded from the study [26].

The musicians [violin ( $n=29$ ) and ney ( $n=24$ ) players] who suffer the neck pain in members of Elazığ city choir and local musical associations were initially assessed in the beginning of study. The 13 musicians [violin ( $n=9$ ) and ney ( $n=4$ ) players] were dropped out after the application of the exclusion criteria and 40 musicians assigned to violin ( $n=20$ ) and ney ( $n=20$ ) groups. All participants received a structured exercise training program 3 times a week for a total of 8 weeks. Adherence to the exercise training program was checked using a follow-up schedule to ensure regular participation of the musicians. The following assessments were conducted at the beginning of the study and repeated after completion of 8 week exercise training program under the same conditions by the same investigator.

All subjects were informed about the nature and purpose of the study and signed written consent form. Ethical approval was obtained from the Ethics Committee for Non-Invasive Research Trials of Hasan Kalyoncu University Faculty of Health Sciences (decision number 2017/14).

## Assessments

### Primary outcome

#### Pain

The Visual Analog Scale (VAS) was used to measure the severity of pain. In this scale, 0 indicates “no pain” and 10 indicates the “worst pain imaginable” [27]. The participants were asked to mark the intensity of their pain on a 10 cm horizontal line and VAS scores were recorded for each participant.

### Secondary outcome

#### Functional status

The Northwick Park Neck Pain Questionnaire (NPQ) was used for the assessment of functional status and disability [28]. It is a 9-item scale that measures neck pain severity, neck pain and sleeping, numbness and tingling in the arms at night, duration of symptoms and complaints, carrying, reading and watching television, working and housework, social activities and driving. Each parameter has 5 possible answers and is scored between 0 and 4 points, where 0

denotes “no pain” and 4 denotes “worst pain”. The neck pain score is the sum of the points scored for the first 9 questions. The maximum score is 36 if all 9 questions are answered and 32 if only the first 8 questions are answered. Question 9 is not applicable if the subject does not drive. Then, NPQ percentage is calculated using the following formula:  $[(\text{neck pain score})/36] \times 100\%$ . The percentage ranges from 0 to 100%. Higher percentages indicate greater disability.

### Muscle strength

Muscle strength was measured using a digital muscle dynamometer (Jtech Commander Muscle Testing, JTECH Medical, USA). Anterior and middle parts of the deltoid muscle, serratus anterior, upper and middle parts of the trapezius muscle and cervical flexor and extensor muscles were evaluated. For each muscle, the participants were asked to maintain the test position for 5 s. Measurements were repeated 3 times at 60 s intervals and the average value was used in the analysis [29].

### Grip strength

Grip strength was measured using a hand dynamometer (Hydraulic Hand Dynamometer, Baseline, USA). Measurements were made in the sitting position, from either the right or left hand, with the elbow flexed at 90° and the arms in contact with the body without any abduction movement [30]. In this position, the participants were asked to squeeze the dynamometer with maximum force and measurements were repeated for the other arm. Each measurement was repeated three times at 30 s intervals and the average data was used in the analysis.

### Cervical range of motion (ROM)

Cervical flexion, extension, rotation and lateral flexion were measured using a universal goniometer with the head and trunk held upright while participants were in a seated position. The measurements were repeated three times and the average value was included in the analysis [31].

### Spinal mobility

The jaw-to-sternum and jaw-to-wall distance were measured with a tape measure. Participants were asked to stand upright in an anatomical position while leaning against the wall. In this position, the distance of chin tip (mental tubercle of the mandible) to the wall and chin tip to the incisura jugularis were used. Each measurement was repeated three times at 30 s intervals. Average of three measurements was recorded.

### Quality of life

Quality of life was evaluated using the SF-36 (36-Item Short-Form Survey) scale. The scale consists of eight subdomains with a total of 36 items. These subdomains are physical functioning, physical role functioning, bodily pain, general health perceptions, vitality, social role functioning, emotional role functioning and mental health [32]. The possible score ranges from 0 to 100 points. 0 point represents the greatest possible limitation of health, whereas 100 points represent the absence of health restrictions. The questionnaire was administered using the face-to-face interview technique. Scores were calculated for all subscales and recorded on a 0–100 range for each participant.

### Exercise protocol

All musicians received 40–45-min exercise sessions three times a week for eight weeks. The structured exercise protocol was designed to correct posture and improve mobility and strength. During postural training session, the participants were informed about the ideal posture and how to maintain a good posture during daily activities such as sitting and standing. The exercise program consisted of postural training, ROM (10 min), stretching (5–7 min), isometric (5–10 min) and stabilization exercises (5 min) (Appendix A). Exercise balls (Tonton, Gaziantep/Turkey) with a diameter of 18 cm, weight of 90 g and a load carrying capacity of up to 136 kg, made of soft elastic material, were used for stabilization exercises. The same exercise ball was provided to musicians in both groups and stabilization exercises were performed.

The exercise program was initiated with 10 repetitions in the first 2 weeks and increased to 15 repetitions during the following 3 weeks and 20 repetitions in the last 3 weeks [22]. 1 min breaks were permitted between the sets. Every training session consisted of warm-up (3–5 min), main exercise (30–35 min) and cooling periods (3–5 min). Examples of exercises included in the program are shown in Fig. 2.

A weekly participant form was used in the follow-up of exercise programs. The exercises were performed and followed up in the same clinical setting by a physiotherapist with 7 years of experience who specializes in the health problems of musicians. The musicians were informed that they should inform the physiotherapist if they felt any discomfort or pain during the exercise sessions. In addition, participants were carefully monitored for early signs of fatigue (tremor, postural errors, technical inadequacy of exercise, muscle strain, overload). The compliance of the musicians to the exercise sessions was observed in the clinical setting.



**Fig. 2** The illustration of some exercises; **a1** spinal stabilization, **b** right upper trapezius stretching, **c1–2**; chin tuck and lateral isometric exercise, **d1–3**; extension, rotation and lateral flexion ROM exercises

## Statistical analysis

Statistical analyses were conducted using the Statistical Package for Social Sciences software package, version 22.0 (IBM Corp., Chicago, IL, USA). According to G-power analysis, the sample size with 80% power was calculated to be 16 for each group of the study (0.67 effect size, 0.05 margin of error). To compensate to potential drop outs, 40 musicians were intended to the study.

Data were expressed as median and min–max. Normality of data distribution was checked using the Kolmogorov–Smirnov test. Differences in pre-test and post-test values between the groups were compared using the Mann–Whitney *U* test. The Wilcoxon’s test was used to compare pre-test and post-test values within each group. Statistical significance level was set at  $<0.05$ .

## Results

A total of 40 musicians participated in this study and no drop-outs were happened in the groups. There was no significant difference between the two groups in terms of age, daily practice (hours), total time since playing the first

instrument (years) and body mass index ( $p > 0.05$ ). Baseline characteristics of the groups are presented in Table 1.

The pre-test and post-test comparison showed significant improvements in VAS, NPQ scores and jaw-to-sternum and jaw-to-wall distances in both groups ( $p < 0.05$ ). Following exercise program, cervical flexion ROM values significantly increased in both groups ( $p < 0.05$ ). On the other hand, no significant difference was detected in ROM measurements for cervical extension and right and left rotation in both groups ( $p > 0.05$ ). Right lateral flexion ROM values increased in ney players and left lateral flexion ROM values increased in violin players ( $p < 0.05$ ) (Table 2).

There was a significant increase in left hand grip strength in both groups ( $p < 0.05$ ), but no significant change was detected in right hand grip strength ( $p > 0.05$ ). Muscle strength increased in the middle part of left trapezius muscle, anterior and middle parts of right deltoid muscle and cervical flexor muscle in both groups ( $p < 0.05$ ). However, there was no significant increase in muscle strength in right upper trapezius muscle, left serratus anterior and middle part of deltoid muscle in both groups ( $p > 0.05$ ) (Table 3). While left upper trapezius and anterior deltoid muscle strength did not significantly change in violin players ( $p > 0.05$ ), increased strength was observed in ney players

**Table 1** Baseline characteristics of the participants

	Violin ( <i>n</i> = 20)		Ney ( <i>n</i> = 20)		<i>z</i>	<i>p</i>
	Median	Min–Max	Median	Min–Max		
Age (years)	26.5	18–63	27.5	19–51	–0.529	0.597
Daily practice (h)	3	1–6	2.5	1–5	–1.179	0.238
Playing Instrument (years)	6.5	2–45	8	2–28	–0.149	0.881
Body mass Index (kg/m <sup>2</sup> )	23.04	18.11–32.32	23.35	17.57–34.92	–0.176	0.860
Education status ( <i>n</i> , %)	<i>n</i>	%	<i>n</i>	%		
High school	2	10	2	10	–	–
University	16	80	13	65	–	–
Master degree	2	10	5	25	–	–

*Min*: minimum, *Max* maximum, *kg/m<sup>2</sup>* kilogram/square meter, *n* number, % percentage

in these muscles ( $p < 0.05$ ). Muscle strength of right serratus anterior, middle trapezius and cervical extensor muscles significantly improved in violin players ( $p < 0.05$ ) but no significant change was determined in these muscles in ney players ( $p > 0.05$ ) (Table 3). The mean change ( $\Delta$ ; delta values) of right serratus anterior, middle trapezius and cervical flexor muscles were higher in violin group than ney group ( $p < 0.05$ ). Other mean changes were found similar in both groups ( $p > 0.05$ ) (Table 3).

SF-36 subdomain scores for physical functioning, physical role functioning, vitality, emotional role functioning and general health perceptions did not significantly change in both groups following the exercise program ( $p > 0.05$ ). Social role functioning scores significantly increased in both groups ( $p < 0.05$ ). Emotional role functioning score increased in ney players ( $p < 0.05$ ) and bodily pain score increased in violin players ( $p < 0.05$ ). However, there were not found any differences in delta values ( $p > 0.05$ ) (Table 4).

When the scores after the exercise program were compared between the two groups, there was no statistically significant difference in terms of VAS, NPQ, jaw–sternum and jaw–wall distances, cervical ROMs, muscle strength and SF-36 subdomains ( $p > 0.05$ ). There were significant differences after treatment in four parameters (left grip strength, right middle trapezius strength, cervical flexor and extensor strength), which were also significantly different before exercise ( $p < 0.05$ ).

## Discussion

This study demonstrated beneficial effects of the exercise program on pain, functional status, disability and cervical mobility in string and woodwind musicians suffering from nonspecific cervical pain. In addition, different positive effects were observed on muscle strength and ROM.

The exercise program performed in our study reduced pain intensity, disability and improved functionality in violin and ney players. We consider that these positive effects resulted from improvements in mobility, muscle strength and ROM. Neck and shoulder pain delays the activation of the muscles in those regions and alters muscle coordination and activation of synergistic muscles [33]. Activation of cervical flexor muscles is required to stabilize the instrument in violin and ney performers [2]. In a recent meta-analysis evaluating pain associated with increased muscle activity in instrumental musicians with musculoskeletal pain as assessed using electromyography, moderate level evidence was found for increased activity of the sternocleidomastoid muscle in pain induction, but there was limited evidence supporting an increase in lower trapezius, deltoid and upper cervical extensor muscles in the musicians [2]. In another study, the activity of the superficial cervical flexor muscles (sternocleidomastoid and anterior scalene muscles) and trapezius muscles were increased due to chronic neck pain in viola and violin player [34]. The exercise program that we applied may have led to a reduction in the activation of sternocleidomastoid muscle by improving cervical posture and reducing jaw-to-sternum and jaw-to-wall distances. Consistent with our findings, the cervical exercise program consisting of various stretching and strengthening exercises has been found to be effective for relief of pain and improved posterior tilt of the neck and functionality level in violin players with neck pain [10, 23]. It has been emphasized that strengthening the deep neck muscles ensures proper cervical posture, reduces the tone of the hypertonic muscles (sternocleidomastoid, levator scapulae, upper trapezius), and even decreases the overuse of breath control muscles (i.e., scalene muscles) for musical performance in orchestral musicians [17].

The limitations in cervical extension and rotation ROM were reported to be a distinctive feature in individuals with neck pain [35, 36]. In our study, while cervical flexion and left lateral flexion ROM increased in violin players, cervical

**Table 2** Comparison of pain, disability and mobility, range of motion values between and within groups

	Ney ( <i>n</i> =20)										Between group	
	Violin ( <i>n</i> =20)											
	Pre-T	Post-T	Δ	<i>z</i>	<i>p</i>	Pre-T	Post-T	Δ	<i>z</i>	<i>p</i>	Pre-T	Post-T
VAS (score)	6 (4–9)	4 (0–6)	–2 (–7.2)	–3.126	<b>0.002</b>	6 (4–8)	4 (0–6)	–2 (–6.2)	–3.165	<b>0.002</b>	0.773	0.607
NPQ (score)	0.36 (0.25–0.53)	0.27 (0.11–0.36)	–0.11 (–0.36 to 0.06)	–3.741	<b>0.001</b>	0.3 (0.22–0.5)	0.21 (0.11–0.33)	–0.12 (0.31–0.08)	–3.399	<b>0.001</b>	0.989	0.061
Jaw–sternum (cm)	12 (10–13)	11.5 (9–13)	–1 (–1 to 0)	–3.464	<b>0.001</b>	12 (9–16)	11.5 (8–25)	–1 (–1 to 13)	–2.524	<b>0.012</b>	0.698	0.866
Jaw–wall (cm)	23.5 (15–30)	19 (10–28)	–3.5 (–7 to 3)	–3.430	<b>0.001</b>	24 (19–27)	20.5 (15–27)	–4 (–6 to 2)	–3.575	<b>0.001</b>	0.989	0.784
Flexion (°)	60 (45–79)	60 (50–77)	5 (–10.10)	–2.229	<b>0.026</b>	55 (40–82)	55 (51–75)	5 (–5 to 10)	–2.829	<b>0.005</b>	0.943	0.485
Extension (°)	57.5 (35–70)	55 (45–70)	0 (–5.10)	–0.775	0.360	57.5 (45–80)	55 (50–75)	–5 (–10 to 5)	–1.713	0.087	0.079	0.331
R. rotation (°)	60 (40–80)	60 (45–75)	0 (–10.5)	–0.775	0.439	60 (50–75)	60 (50–80)	0 (–5 to 5)	–1.000	0.317	0.268	0.631
L. rotation (°)	60 (50–80)	60 (45–75)	0 (–5.5)	–0.577	0.564	57.5 (45–70)	55 (45–70)	0 (–5 to 5)	–0.905	0.366	0.305	0.052
R. lateral flexion (°)	55 (35–80)	55 (45–75)	5 (–10.5)	–1.713	0.087	55 (40–70)	55 (45–70)	5 (–5 to 5)	–2.324	<b>0.020</b>	0.894	0.826
L. lateral flexion (°)	50 (35–70)	55 (40–70)	2.5 (–5.10)	–2.000	<b>0.046</b>	55 (40–70)	55 (45–70)	0 (–5 to 5)	–1.897	0.058	0.638	0.459

Bold *p*<0.05; *Pre-T* pre training, *Post-T* post training, *Min* minimum, *Max* maximum, *R* right, *L* left, (°) angle; *cm* centimeter, *NPQ* Northwick Park Questionnaire

**Table 3** Comparison of muscle strength values between groups and within groups

	Violin ( <i>n</i> = 20)										Ney ( <i>n</i> = 20)				Between group			
	Pre-T		Post-T		Δ	z	p	Pre-T		Post-T		Δ	z	p	Pre-T		Post-T	
	Median (min–max)	Median (min–max)	Median (min–max)	Median (min–max)	Median (min–max)			Median (min–max)	Median (min–max)	Median (min–max)	Median (min–max)	Median (min–max)			p	p	p	p
R-Grip strength	28.34 (15.87–49.89)	28.34 (18.14–45.35)	0 (–4.54 to 2.27)	–0.575	0.566	35.14 (15.87–49.89)	34.01 (15.87–45.35)	–1.13 (–4.54 to 2.27)	–1.624	0.104	0.347	0.109	0.082					
L-Grip strength	23.81 (13.6–47.62)	23.81 (11.34–43.09)	–2.27 (–9.07 to 2.27)	–2.695	<b>0.007</b>	31.75 (13.6–47.62)	29.48 (13.6–45.35)	–2.27 (–6.8 to 2.27)	–3.341	<b>0.001</b>	0.403	<b>0.047</b>	<b>0.047</b>					
Upper right trapezius	10.88 (6.35–18.59)	10.88 (7.25–16.78)	–0.22 (–1.82 to 1.81)	–0.041	0.967	11.57 (8.16–16.78)	12.24 (8.16–16.78)	0.45 (–1.36 to 1.82)	–1.818	0.069	0.149	0.946	0.439					
Upper left trapezius	11.57 (6.35–15.42)	11.34 (8.16–14.96)	0.67 (–2.27 to 1.81)	–0.445	0.656	10.65 (7.25–15.42)	10.88 (9.07–15.87)	0.45 (–0.91 to 2.27)	–1.977	<b>0.048</b>	0.615	0.796	0.935					
R-Serratus anterior	9.97 (6.8–14.51)	10.43 (7.71–14.96)	0.91 (–0.91 to 2.72)	–2.646	<b>0.008</b>	10.65 (7.25–15.87)	10.66 (8.16–15.87)	0.22 (–1.36 to 1.82)	–0.407	0.684	<b>0.023</b>	0.364	0.881					
L-Serratus anterior	10.2 (7.25–18.59)	11.11 (8.16–17.23)	0.45 (–1.36 to 1.82)	–1.537	0.124	10.43 (6.35–18.14)	10.43 (6.35–17.69)	0.45 (–0.91 to 1.81)	–1.668	0.095	0.817	0.892	0.968					
R-Middle trapezius	9.07 (5.44–14.51)	10.2 (4.98–13.6)	0.91 (–3.17 to 2.72)	–2.100	<b>0.036</b>	10.89 (6.35–15.42)	10.88 (7.71–14.06)	0.45 (–1.82 to 1.81)	–0.525	0.600	<b>0.030</b>	<b>0.012</b>	0.067					
L-Middle trapezius	8.16 (4.53–15.42)	9.74 (5.89–16.32)	1.13 (–0.91 to 2.72)	–3.217	<b>0.001</b>	10.65 (4.53–14.51)	11.34 (7.25–15.42)	0.68 (–0.91 to 2.73)	–2.411	<b>0.016</b>	0.259	0.075	0.090					
R-Anterior deltoid	9.97 (4.53–16.78)	10.2 (5.44–17.69)	0.91 (–1.82 to 2.27)	–2.891	<b>0.004</b>	10.88 (6.35–14.96)	11.79 (7.71–15.87)	1.36 (–0.9 to 2.27)	–3.734	<b>0.001</b>	0.194	0.184	0.067					
L-Anterior deltoid	9.07 (5.44–15.42)	9.74 (5.89–14.96)	0.45 (–1.36 to 2.72)	–1.949	0.051	10.43 (4.53–15.42)	10.88 (7.25–14.96)	0.90 (–0.9 to 3.18)	–2.792	<b>0.005</b>	0.828	0.154	0.145					
R-Middle Deltoid	10.65 (6.35–14.06)	11.34 (8.16–16.78)	0.91 (–0.91 to 3.18)	–3.165	<b>0.002</b>	10.88 (5.89–14.96)	11.57 (7.71–15.87)	0.91 (–1.36 to 3.18)	–2.184	<b>0.029</b>	0.506	0.315	0.334					
L-Middle deltoid	10.88 (6.8–14.96)	11.11 (6.8–14.96)	0.45 (–0.91 to 2.72)	–1.626	0.104	10.43 (5.89–15.42)	10.88 (6.35–15.82)	0.45 (–1.36 to 2.26)	–1.067	0.286	0.673	0.724	0.935					
Cervical flexor	5.89 (4.53–8.16)	6.8 (5.44–9.07)	0.91 (0–1.36)	–3.863	<b>0.001</b>	6.8 (4.53–9.07)	7.03 (6.35–9.07)	0.45 (–1.82 to 1.82)	–2.051	<b>0.040</b>	<b>0.019</b>	<b>0.002</b>	<b>0.033</b>					
Cervical extensor	5.66 (4.53–7.25)	6.35 (4.53–8.16)	0.45 (–0.91 to 1.36)	–2.005	<b>0.045</b>	7.02 (4.08–9.07)	7.25 (4.98–8.16)	0.22 (–1.82 to 1.36)	–0.024	0.981	0.243	<b>0.010</b>	<b>0.030</b>					

Bold *p* < 0.05; *Pre-T* pre training, *post-T* post training, *min* minimum, *max* maximum, *R* right, *L* left

**Table 4** Comparison of SF-36 subdomain values between groups and within groups

	Violin ( <i>n</i> = 20)						Ney ( <i>n</i> = 20)						Between group					
	Pre-T		Post-T		Δ	z	p	Pre-T		Post-T		Δ	z	p	Pre-T		Post-T	
	Median (min–max)	Median (min–max)	Median (min–max)	Median (min–max)	Median (min–max)	Median (min–max)	Median (min–max)	Median (min–max)	Median (min–max)	Median (min–max)	Median (min–max)	Median (min–max)	Median (min–max)	Median (min–max)	Δ	p	Δ	p
Physical functioning	70 (35–90)	75 (50–95)	5 (–25 to 40)	–1.794	0.073	85 (40–100)	80 (50–95)	–5 (–40 to 55)	–1.794	0.073	0.265	0.079	0.475					
Physical role functioning	50 (0–100)	50 (25–100)	0 (–50 to 75)	–0.818	0.413	37.5 (0–100)	75 (25–100)	25 (–75 to 100)	–1.889	0.059	0.194	0.216	0.613					
Emotional role functioning	0 (0–100)	33.3 (0–66.7)	0 (–66.7 to 66.7)	–0.512	0.609	16.65 (0–100)	66.7 (0–100)	33.3 (–33.4 to 100)	<b>–2.218</b>	<b>0.027</b>	0.247	0.976	0.156					
Vitality	47.5 (20–80)	57.5 (35–80)	10 (–40 to 35)	–1.815	0.069	55 (20–80)	60 (45–80)	5 (–25 to 60)	–1.090	0.276	0.625	0.248	0.182					
Emotional well being	64 (28–84)	70 (40–80)	6 (–36 to 40)	–1.419	0.156	68 (24–80)	72 (40–80)	2 (–28 to 36)	–1.296	0.195	0.625	0.505	0.667					
Social role functioning	56.25 (0–75)	75 (37.5–87.5)	12.5 (–25 to 75)	<b>–2.153</b>	<b>0.031</b>	56.25 (12.5–87.5)	75 (37.5–87.5)	12.5 (–12.5 to 62.5)	<b>–2.391</b>	<b>0.017</b>	0.901	0.856	0.714					
Bodily pain	55 (22.5–100)	72.5 (55–100)	12.5 (–22.5 to 55)	<b>–3.026</b>	<b>0.002</b>	67.5 (32.5–90)	77.5 (55–100)	1.25 (–12.5 to 45)	–1.500	0.134	0.235	0.108	0.678					
General health perceptions	50 (25–85)	60 (30–75)	5 (–35 to 40)	–1.398	0.162	50 (30–80)	62.5 (40–75)	5 (–30 to 40)	–1.375	0.169	0.775	0.806	0.967					

Bold *p* < 0.05. *Pre-T* pre training, *Post-T* post training, *Min* minimum, *max* maximum

flexion and right lateral flexion ROM increased in ney players. Considering the way, the musical instrument is held in violin and ney players, this difference could be acceptable. Stabilization of the instruments with unilateral flexion of head may cause over activity upper trapezius. The stretching and ROM exercises included in our program relaxed the upper trapezius muscle on the side that was used for stabilizing the instrument. Moreover, increased strength of back and shoulder muscles in both groups may have produced a favorable mechanical effect to relax overloaded upper trapezius muscle. As previously demonstrated, reducing muscle activity in the upper trapezius muscle and increasing serratus anterior muscle activation provide functional improvements in neck posture and proprioception [37].

Neck pain causes a reduction in cervical extensor strength and also hand grip strength [33, 38]. Postural changes in the neck were reported to compromise neural conduction velocity, blood flow and oxygenation and reduce ability of the nervous system to stimulate hand muscles [39, 40]. We think that the increase in the left hand grip strength might be due to increased muscle strength and cervical alignment. However, the right hand grip strength did not change in the study groups. The reason for this may be that the right hand muscle strength was at a sufficient level before the treatment or that it was not affected by the postural positions.

Our structured exercise training led to strengthening of the left middle trapezius muscle, right anterior and middle parts of the deltoid muscle and cervical flexors in both groups. Despite performing similar exercises, the study groups experienced differential gains in muscle strength: increased muscle strength in the left upper trapezius and anterior deltoid muscles in ney players and the right serratus anterior, middle trapezius and cervical extensor muscles in violin players. Although our exercise program did not include isolated strengthening exercises, we consider that differential improvements in muscle strength may be related to instrument playing techniques and weight of instrument. The weight difference between violin (3.4 kg) and woodwind (1.9 kg) can change the strength of spinal and shoulder muscles [7]. In violin players, while the back muscles bear the weight, the other arm takes an elevated position and performs the bowing with static and dynamic movements. In contrast, the lighter ney is held statically with both hands. Different neurophysiological and biomechanical requirements of the musicians while playing the instrument may cause variations in the strength of shoulder and back muscles. In a scoping review on the effects of exercise-based interventions on musculoskeletal problems of musicians, it was underlined that anatomical and physiological demands of musicians may vary significantly during their performances and expected optimal results may not be obtained using the same exercises for all musicians [18]. Differential improvements in muscle strength as observed in our study

suggest that individualized strengthening exercises specific to the instrument and the nature of the music produced should be prescribed to musicians with the same musculoskeletal problem. Further studies that investigate the effects of instrument-specific exercise programs on neck pain are warranted to draw definitive conclusions.

Neck pain can cause severe disability and negatively affect overall health and quality of life [41, 42]. Individuals with neck pain have a lower quality of life than individuals without neck pain [43]. In an observational study on neck pain without involving an intervention, neck disability, pain severity and quality of life did not change over a period of 18 months in violinists, violists and pianists [44]. Studies in quality of life in individuals with chronic neck pain have shown that strengthening, stabilization and flexibility exercises for cervical muscles are associated with an improvement in quality of life and reduction of neck pain [42, 45]. In the current study, improvements were seen in neck pain and functional status but only social role functioning improved in both groups. As such, bodily pain scores decreased in violin players while emotional role functioning scores improved in ney players. It was considered that improved social and emotional role functioning was associated with the reduction of pain. In the aforementioned study, a reduction in mental health was observed in musicians with neck pain who did not receive any treatment, with no changes in the pain intensity and functionality [44]. We believe that besides their physiological effects, exercises are important to improve social functioning and emotional well-being of the individuals. Further studies with long-term follow-up would be needed to see improvements also in physical functioning, physical role functioning, vitality and general health perception parameters of SF-36.

## Limitations

This study has a number of limitations. The study was conducted as a single-center and the sample size of the study was relatively small. Researchers were not blinded. In addition, self-reported scales were used for outcome assessment. Therefore, there is a potential risk of bias in the study. Participants were evaluated after an 8-week rehabilitation program, so the study did not provide long-term results.

Inclusion of an objective method to the study such as electromyography for assessment of muscle activation would have provided further data, allowing comparisons with other studies. Considering the static position and repetitive movements of the musicians during prolonged performances, assessment of the dynamic force in addition to the static force would have provided a different perspective. Nevertheless, positive physical improvements obtained as a result of this study are important in terms of reducing

the playing-related problems with appropriate exercises in musicians.

## Conclusion

This study showed that same exercise training program had similar positive effects on pain, functionality, posture and social role in string and woodwind musicians. However, differential improvements were observed in muscle strength and ROM. Instrument-specific and physical requirements should be considered when prescribing exercises to musicians with the same musculoskeletal problem who play different instruments. Further studies are needed to investigate the effectiveness of instrument-specific exercise training for performing musicians with the same musculoskeletal problems.

**Supplementary Information** The online version contains supplementary material available at <https://doi.org/10.1007/s00296-021-05085-x>.

**Author contributions** SU and HA designed the study; SU, HA and AA provided the data; BFK and YY made the statistical analyses; SU and AA contributed the analysis tools; SU, HA, BFK, AA and YY authored and reviewed drafts of the paper; SU and HA prepared the tables and figures; SU, HA, BFK, AA and YY reviewed and approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

**Funding** Not funded.

## Declarations

**Conflict of interest** All authors declare that they have no conflict of interest.

**Ethical statement** This study was approved by the Ethics Committee for Non-Invasive Research Trials of Hasan Kalyoncu University Faculty of Health Sciences (approval number 2017/14).

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