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Prevalence of Playing-related Musculoskeletal Pain and Associated Factors among Professional Violinists

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Abstract

Objective: To evaluate the prevalence of playing-related musculoskeletal pain (MSP) with associated factors and the functional characteristics of neck and shoulder area in professional violinists and when compared with a control group of office workers.

Methods: 26 professional violinists (82% female) and 18 office workers as controls (80% female) aged 20-57 years participated. The prevalence of MSP was evaluated by Nordic Musculoskeletal Questionnaire (NMQ) and the intensity of MSP using Visual-Analogue Scale (VAS). Active range of motion (AROM) of neck and shoulder joints was measured using goniometry. Neck muscle strength was measured using manual dynamometer.

Results: In violinists, the prevalence of MSP in previous 6 months was 84.6%, whereas the most affected areas were low back (53.8%), neck (53.8%) and left shoulder (50.0%). Violinists had less ($p<0.05$) AROM in neck rotation to right, left shoulder flexion and left shoulder internal rotation than controls. Violinists had also less ($p<0.05$) internal rotation of left shoulder compared with their right shoulder. There was no significant ($p<0.05$) difference in neck muscle strength between left and right side in violinists and when compared with controls. A significant positive correlation between daily average workload and the intensity of MSP and a negative correlation between work experience and the intensity of MSP was suggested in violinists.

Conclusions: The prevalence of MSP among professional violinists is high, whereas the most affected areas are low back, neck and left shoulder. Violinists had asymmetry in AROM between body sides in neck and shoulder area. Violinists had no differences in neck muscle strength between body sides and when compared with control group. Violinists with higher daily average workload are in risk of experiencing more intense MSP. More experienced violinists tend to experience less intense MSP.

Keywords: Violinists; Musculoskeletal pain; Neck; Shoulder; Range of motion; Goniometry; Dynamometry

Introduction

Professional instrumental musicians are in a great risk of musculoskeletal overuse injuries. [1,2] Several studies have reported a prevalence of musculoskeletal pain (MSP) over 50% in musicians. [3-5]Most musicians working in a professional symphony orchestra have experienced musculoskeletal symptoms in neck, back and upper extremities, which affect their well-being in and outside of work. [6] It has been observed, that violinists have greater prevalence of MSP than other instrumentalists, and it is associated with playing technique, which requires larger amplitudes in range of motion than playing other string instruments. [7,8] Most common sites of MSP in violinists are chin, neck, shoulders, arms and back. [7] Also musculoskeletal overuse syndrome has reported in violinists left wrist, forearm and fingers. [9,10] MSP in left upper limb is twice as common as in right upper limb and is associated with more awkward limb position while playing. [10]

Due to asymmetrical playing technique the locations of MSP are different between left and right side of the body. [11] Holding the violin in place while playing is often associated with isometric tension in muscles elevating the left shoulder and in muscles rotating and laterally flexing neck to the left. This kind of prolonged tension can lead to overuse in the left trapezius superior and other neck muscles, such as the right sternocleidomastoideus muscle [12,13] Guettler et al., (1997) have evaluated left and right trapezius superior electromyographic (EMG) activity in violinists while playing and recorded a significantly higher EMG activity in the left trapezius superior muscle compared to the contralateral side [14].

MSP in violinists right shoulder is associated with repetitive movements of glenohumeral joint at the shoulder level or higher [15,16]. There has been found some decrease in active range of motion(AROM)of right glenohumeral joint when compared to control group, mainly slightly limited flexion, internal and external rotation, but the authors were unable to tell if it is correlated with shoulder pain or is it just simply a result of adaptation [17].

Both static and dynamic over activity of neck and shoulder muscles is related to chronic neck and shoulder pain and limitations in AROM. [18] In violin students suffering neck pain there has been demonstrated a higher EMG activity of sternocleidomastoideus muscles and superficial neck extensor muscles than in violin students without neck pain. Same study has found a reduction in left rotation of the neck in violin students with neck pain [19].

A professional instrumental musician´s occupation has been often compared with athletes [20]. Despite the comparison there is a small amount of research in the field of performing arts medicine. More research in instrumental musicians physical characteristics is needed

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for future evidence based prevention strategies and interventions [21-23]. Despite the fact, that violinists have a higher prevalence of MSP than other instrumentalists, the amount of violinists-specific research is low [1,8,24]. Most studies involving violinists also include other string instrumentalists in the same group, which can complicate having specific conclusions about violinists only. More studies of functional characteristics with a sample of only violinists are needed to develop efficient MSP prevention and intervention programs.[1]

The aim of this study was to evaluate the prevalence of playing-related MSP and the functional characteristics of neck and shoulder area in professional violinists in comparison with office workers as controls. For this study, the AROM of neck and shoulder joints and MVC force of neck muscles was measured in violinists and controls. Also, associated factors, such as pain intensity, daily average workload and work experience of violinists were recorded for analysis.

Subjects and Settings

Total of 26 violinists and 18 office workers as controls participated in this study. The age range for the violinists was 20-57 years and for the control group 21-57 years. Out of 26 violinists, 18.2% were male and for the control group 20.0% were male. The violinists were employed by one of the professional orchestras in Estonia: Estonian National Symphony Orchestra, Tallinn Chamber Orchestra and The Vanemuine Symphony Orchestra. The participation was voluntary. The control group consisted of office workers at the University of Tartu.The study took place at the participants workplace in January 2017. Inclusion criteria for the violinists was being employed full time by a professional orchestra. Inclusion criteria for the control group was a full time and mostly sedentary work with a computer with at least 6 hours of screen time per workday and no history as professional instrumental musician. Exclusion criteria for both groups were acute or chronic orthopaedic or neurological disease and a body mass index (BMI) over 30. All participants signed informed consent forms and the study was approved by the Ethics Review Committee on Human Research, University of Tartu. (Report nr 215/T-16)

Table 1 presents the features of the sample. Both groups were homogeneous for five variables shown in Table 1. The violinists were all right handed, had a mean work experience of 32.3±10.8 years and an average daily workload of 5.5±1.3 hours.

Questionnaires

NORDIC Musculoskeletal Questionnaire (NMQ) was used to determine the prevalence and location of playing-related MSP among violinists and work-related MSP among control group in the past 7 daysas acute painand 6 months as longer lasting or chronic pain [25]. Visual Analogue Scale (VAS) was used to identify the intensity of MSP [25]. Participants were asked to mark the intensity of MSP on a 10cm straight line. Violinists were asked to only mark MSP happening during playing and control group was asked to only mark pain during work.

Baecke Physical Activity Questionnaire (BPAQ) was used to record habitual physical activity in the past 12 months and to calculate Baecke Physical Activity Index (BPAI). BPAQ includes 16 questions, divided into 3 parts: occupational physical activity, physical exercises in leisure and leisure and locomotive physical activities. Occupational physical activity score characterizes the level of physicality of their work. Physical activity of exercising in leisure score depends on the intensity, duration and frequency of workouts and is only stated when the participant engages in any kind of work out on a regular basis. Leisure and locomotive score shows how physically active is the participant in their everyday activities outside of work and trainings. The validity and reliability of BPAQ has been confirmed when measuring the physical activity in adults [27,28].

In addition to these questionnaires participants were asked to note their dominant hand, work experience and average daily workload. Daily workload for violinists included practice, rehearsals and concerts. For the control group, daily workload included work-related computer screen-time in the office.

Measurement of functional characteristics

For this study, AROM in the neck and shoulder joints and MVC force of the neck muscles were measured. During the measurements, participants were sitting on a piano bench without the back support. The piano bench was adjusted, so the participant would have 90 degrees of flexion in their hip and knee joints and feet fully supported on the ground.

AROM of the neck was measured using a CROM goniometer (Performance Attainment Associates, USA). During the measurement, the participants had their forearms supported on their thighs and they were asked to keep their natural posture. Flexion, extension, lateral flexion and rotation to both sides were measured. AROM of the shoulder joints was measured using electronic inclinometer Acumar (Lafayette Instrument Company, USA) Flexion, extension, abduction, internal- and external rotation were measured. Internal and external rotation was measured in 90 degree abduction. The reading was fixed when the participants reached their maximal range, perceived pain or started to compensate with their trunk. Every function was measured three times and the arithmetical mean was recorded.

The MVC force of neck muscles was measured using a digital dynamometer Lafayette Manual Muscle Testing System (Lafayette Instrument Company, USA). MVC force was measured in protraction, extension and lateral flexion to left and right. The unit of measurement for MVC force was kilograms. The participants were asked to keep their feet on the floor, shoulder in place and to avoid compensating with their trunk and limbs. The dynamometer was held by the researcher against the participant´s forehead, temporal region or occipital region, depending on the direction measured. The participants were asked to push their head against the dynamometer as hard as they could for five seconds while the researcher held the dynamometer in place. Every direction was measured three times, with 60 seconds of rest between the repetitions. Best of three repetitions was used in statistical analysis.

Features	Violinists (n=26) (Mean±SD)	Control group (n=18) (Mean±SD)	p
Age (years)	38.4±11.0	39.5±10.6	0.319
Height (cm)	169.3±8.3	170.9±6.3	0.601
Weight (kg)	65.5±15.3	68.6±14.2	0.409
BMI (kg/m²)	22.7±4.3	23.2±3.6	0.447
BPAI	7.8±1.1	7.6±1.2	0.879

Table 1: The anthropometric data and physical activity of the subjects (mean ±SD). BMI – body mass index, BPAI – Baecke Physical Activity Index.

Order of procedures

1. Participants were introduced to research methods, informed consent was signed.
2. Pre-test questionnaire was used to determine the participant´s suitability for this study.
3. Body weight and height was measured and BMI calculated.
4. Subjects filled out NORDIC questionnaire, VAS and Baecke physical activity questionnaire.
5. AROM of neck and shoulder was measured
6. MVC force of neck muscles was measured.

Statistical analysis

The data of functional characteristics is presented as mean ± SD. Paired t-test was used to analyze differences in AROM and MVC force between body sides and Student t-test was used when violinists were compared with control group. Chi-square test was used to compare the significance of differences in the prevalence of MSP between body regions. Pearson correlation analysis was used to find relations between pain characteristics, daily workload and work experience. For all analyses, a significance level of $p<0.05$ was used.

Results

Out of 26 violinists who participated in this study, 22 (84.6%) had experienced MSP in the past 6 months. The prevalence of MSP among violinists in the past 6 months was statistically significantly higher in low back, neck and left shoulder when compared with other regions ($p<0.05$) (Figure 1). In the past 6 months the prevalence of low back pain was 53.8%, for neck pain 53.8% and for left shoulder 50.0%. Violinists had a statistically significantly higher ($p<0.01$) prevalence of MSP in left shoulder (50.0%) when compared with the prevalence of left shoulder MSP in control group (6.0%).

18 of 26 violinists (69.2%) in this study had experienced MSP in the past 7 days.

The prevalence of MSP among violinists in the past 7 days was statistically significantly higher ($p<0.05$) in low back (42.3%) when compared with left elbow (11.5%), right elbow (11.5%), left wrist (3.8%) and right wrist (7.7%) (Figure 2)

In the past 7 days violinists also had statistically significantly higher prevalence of low back ($p<0.05$), neck ($p<0.05$) and left shoulder ($p<0.01$) MSP when compared with the same body regions among control group.

The pain intensity (VAS) was not significantly different ($p<0.05$) between neck (5.03 ± 1.70 points), left shoulder (5.18 ± 2.06 points) and right shoulder (3.59 ± 2.35 points) among violinists (Figure 3).

Table 2 presents the AROM of the neck in violinists and control group. Violinists demonstrated a significantly lower AROM in neck rotation to the right when compared with the control group ($p<0.05$). There were no statistically significant differences between the violinist´s body sides.

Violinists demonstrated a statistically significantly lower AROM in left shoulder flexion and internal rotation when compared with control group, as presented in Table 3. Violinists had also a statistically significantly lower AROM in left shoulder internal rotation when compared with their right shoulder ($p=0.048$).

There were no statistically significant differences in MVC force of the neck muscles between the measured groups (Table 4).

There was a statistically significant positive correlation between daily average workload and the intensity of MSP and a statistically significant negative correlation between work experience and the intensity of MSP in all three body areas recorded in this study (Table 5).

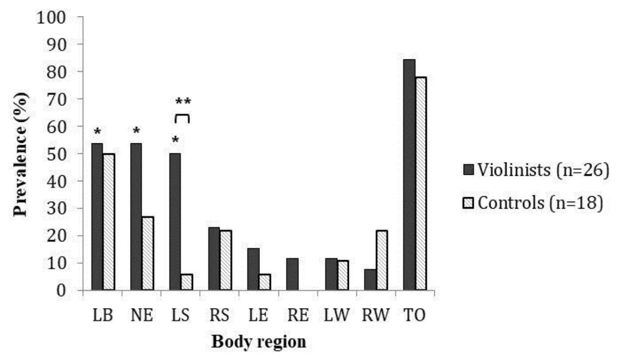

Figure 1: Prevalence of musculoskeletal pain in violinists and control group in the past 6 months in different body regions. LB – low back, NE – neck, LS – left shoulder, RS – right shoulder, LE – left elbow, RE – right elbow, LW – left wrist, RW – right wrist, TO – total. * - p<0.05 when compared with RS, LE, RE, LW and RW of violinists. ** - p<0.01.

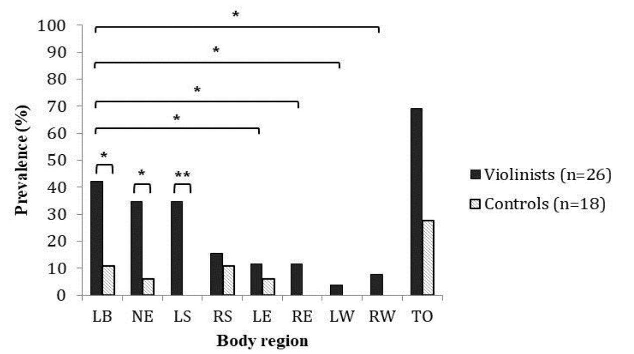

Figure 2: Prevalence of musculoskeletal pain of violinists and control group in the past 7 days in different body regions.LB – low back, NE – neck, LS – left shoulder, RS – right shoulder, LE – left elbow, RE – right elbow, LW – left wrist, RW – right wrist, TO - total. * - p<0.05, ** - p<0.01.

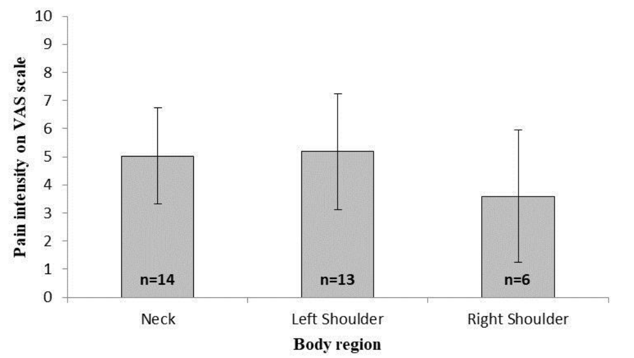

Figure 3: Pain intensity on VAS scale in violinists with neck, left shoulder and right shoulder MSP (mean ± SD).

Function	Violinists (n=26)	Control group (n=18)	p
Flexion (°)	57.2±10.3	60.2±7.9	0.307
Extension (°)	77.3±16.1	79.5±14.9	0.65
Lateral flexion left (°)	44.1±8.5	48.7±8.3	0.084
Lateral flexion right (°)	44.0±9.3	47.3±10.1	0.268
Rotation left (°)	67.4±8.2	72.2±10.4	0.103
Rotation right (°)	65.9±7.9	72.3±13.3*	0.043

Table 2: Mean (± SD) of neck AROM in violinists and control group. AROM – active range of motion, * - p<0.05 compared with violinists.

Function	Violinists (n=26)	Control group (n=18)	p
Flexion (left) (°)	170.2±9.0	177.8±8.4*	0.052
Flexion (right) (°)	172.3±11.4	177.4±9.9	0.137
Extension (left) (°)	71.9±12.8	75.5±12.4	0.361
Extension (right) (°)	75.0±13.1	76.5±15.4	0.735
Abduction (left) (°)	172.6±10.1	177.7±8.7	0.089
Abduction (right) (°)	170.3±10.5	175.7±8.2	0.076
Internal rotation (left) (°)	67.7±11.4#	74.3±11.0*	0.049
Internal rotation (right) (°)	75.1±12.0	78.2±11.4	0.184
External rotation (left) (°)	103.9±15.1	110.2±16.3	0.191
External rotation (right) (°)	104.3±15.1	106.0±15.5	0.705

Table 3. Mean (±SD) of shoulder AROM in violinists and control group. * - p<0.05 compared with violinists, # - p<0.05 compared with violinist`s right side.

Function	Violinists (n=26)	Control group (n=18)	p
Protraction (kg)	7.9±2.6	9.5±3.3	0.08
Extension (kg)	10.5±3.7	12.1±2.9	0.137
Lateral flexion left (kg)	8.3±2.5	8.6±2.1	0.649
Lateral flexion right (kg)	7.5±2.4	8.0±1.8	0.464

Table 4: Mean (± SD) MVC force of neck muscles in violinists and control group. MVC – maximal voluntary contraction.

Body regions	Mean daily workload	Mean work experience
Neck	r=0.440*	r=-0.510**
Left shoulder	r=0.629***	r=-0.423*
Right shoulder	r=0.607***	r=-0.694***

Table 5: Pearson correlation between the intensity of MSP, daily workload and work experience. *-r ≥ 0.39 p<0.05; **- r≥0.49 p<0.01; ***- r≥0.60 p<0.001.

Discussion

The most relevant findings in this study were:

1. Among professional violinists a high overall prevalence of MSP in the last 6 months was recorded, whereas three most affected areas were low back, neck and left shoulder.
2. A significant decrease in the AROM of right cervical rotation was measured in violinists when compared with control group.
3. Violinists had significantly less AROM in left shoulders flexion and internal rotation when compared with control group and also significantly less shoulder internal rotation when compared with their right shoulder.
4. There were no significant differences in MVC force of neck muscles between violinists body sides or when compared with control group.
5. A significant positive correlation between daily average workload and the intensity of MSP and a significant negative correlation between work experience and the intensity of MSP in neck, left and right shoulder was found.

The overall prevalence of MSP in the last 6 months reported in our study (84.6%) was similar to the results of a study by Ackermann & Adams, who reported a 88.0% prevalence of MSP among violinists during their whole career [29]. Despite the results being similar, our study recorded the prevalence of MSP in only the last 6 months, what can indicate, that MSP is a common and persistent problem among professional violinists. The high prevalence of MSP in the last 6 months reported in our study can be due to the participation being voluntary, what can cause higher interest of participation among violinists currently experiencing MSP.

The results of the most common locations of MSP are somewhat different when compared with previous research. We reported the highest prevalence of MSP in the last 6 months in low back (53.8%), neck (53.8%) and left shoulder (50.0%) and accordingly in the last 7 days low back (42.3%), neck (34.6%) and left shoulder (34.6%). Ackermann & Adams found the highest prevalence of MSP in the left upper limb (69.0%) and right upper limb (53.0%), the current or previous episode of MSP was recorded.[29]Comparing the results of our study with Ackermann & Adams is difficult due to methodological differences in the specificity and accuracy of pain location when determining the location of MSP. Yeung et al., have also recorded a high prevalence of MSP in neck (32.0%) and shoulder (52.0%) among violinists, but the prevalence of MSP in left and right shoulder was not measured separately [30].

The high prevalence of low back MSP among our participants might be because all of the participants worked in an orchestra with average daily work load of 5.5 hours, during which they play their instrument in a sedentary position without using the back support. Prolonged sitting with a hyperlordotic low back without using a back support is considered as a risk factor of developing muscle fatigue and low back pain [31]. The high prevalence of MSP in neck and left shoulder area has been explained by the static posture necessary for keeping the violin in place while playing [7].The fact that we found a statistically significantly higher prevalence of MSP in the last 6 months in low back, neck and left shoulder when compared with right shoulder, both elbows and wrists, can indicate that structures responsible for static posture are in higher risk of developing MSP than structures involved with dynamic repeated movements. The results of our correlation analysis suggest, that higher daily workload can increase the pain intensity of neck and shoulder MSP. Since it has been found, that longer playing hours put musicians into a greater risk of MSD prevalence [32], we suggest, that longer playing hours also contribute to the increase of perceived pain intensity. It is also possible, that violinists with higher daily workload have a greater exposure to MSP-related psychosocial factors, such as high work demands or low social support, contributing to the development and persistence of playing-related MSP [33,34]. The statistically significant negative correlation found between work experience and pain intensity in the neck and shoulders, suggests that more experienced violinists have become to adapt with MSP. It is also possible, that due to high physical demand and high prevalence of MSP, older violinists in professional orchestras are the ones who have adapt and not suffered MSP threatening their career like many other musicians [35].This result also suggests that the prevention of MSP among musicians should start early, preferably in music schools, to reduce MSP and potential career-ending musculoskeletal issues among young musicians with a long career ahead of them.

We found a significantly decreased AROM of right cervical rotation in violinists as compared to control group. This change might be caused by violinist´s specific neck posture, while playing. Holding the violin in place while playing requires neck rotation and lateral flexion to the left. Because our violinists were professionals and had a lot of work experience (with the mean of 32.3 ± 10.8 years), this change can be caused by long-term adaptation. We did not record a correlation between this change and the prevalence of MSP, but further studies are required to differentiate normal adaptation from the cause of MSP.

The reduction of AROM in left shoulder flexion and internal rotation found in this study can also explained by static posture necessary for playing the instrument. Violinist´s left hand technique requires an adduction and submaximal external rotation in the glenohumeral joint. Such specific static posture might lead to tightness of the posterior adductor and external rotator muscles, causing loss of mobility in internal rotation and overhead movements [36]. It is clear, that the changes in neck and shoulder AROM found in this study are a result of a long term adaptation to specific physical load, but it is unclear if these changes can contribute to MSP or the development of MSP.

We did not find any statistically significant differences in MVC force of neck muscles when violinists were compared with the control group or when violinists left and right side were compared. This result suggests that despite there being some differences in the mobility of the neck and shoulder structures, the strength of neck muscles is not influenced.

Our methods for this investigation had an advantage of using well-known questionnaires and instruments for measurements. Self-evaluation tools such as NORDIC questionnaire, VAS scale and BPAQ are all tools with proven validity and reliability [27,28,37,38] For measuring physical characteristics, Acumar TM Digital Inclinometer, CROM goniometric and Lafayette hand-held dynamometer are all widely used instruments for research. For better reliability, all measurements were taken by the same physical therapist.

The main limitations of this study are a small sample size, gender ratio and the absence of pain-related psychosocial data. Because of the small amount of male subjects and the overall small sample size, male and female subjects were added to the same sample group for bigger overall sample size. Despite the gender ratio being similar between violinists and control group, further studies should focus on researching male and female violinists separately for better reliability. Due to small sample size of control group, there was not enough subjects with MSPs for adequate comparison of MSP intensity, therefore only violinists MSP intensity was presented. Another limitation is the absence of isometric MVC force measurements of the shoulder and periscapular muscles. This measurement was planned but ultimately canceled for time expenditure reasons. Further research should investigate the prevalence and properties of MSP at rest, while playing and after playing the instrument to develop better prevention and intervention strategies. Psychosocial components should be investigated to achieve better understanding of contributing factors to the development and persistence of playing-related MSP. Future research should also compare violinists individual practice habits to the prevalence and associated factors of playing-related MSP.

Authors' contributions

Martin Argus organized the study, carried out the measurements and statistical analysis and drafted the manuscript.

Mati Pääsuke advised on choosing the research methods and supervised on drafting of the manuscript.

Jaan Ereline advised on the methods and process of statistical analysis.

Authors read and approved the final manuscript.

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Declaration of conflicting interests

The authors declare that there is no conflict of interests.

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