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RESEARCH ARTICLE

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Investigating the Link between Irregular Muscle Tension and Bodily Fatigue among High-Speed String Instrument Musicians

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ABSTRACT

Focal dystonia, the dysregulation or temporary loss of motor control during musical performance, is a condition among musicians of unknown cause and without preventative measures. Some research suggests that focal dystonia is caused by pain and muscular fatigue, resulting in excessive afferent pathway input. However, this argument has not been sufficiently supported through experimentation. In this study, we investigate the hypothesized correlation between bodily over-exertion and left-hand finger pain, using a control group consisting of musicians absent symptoms of irregular muscle tension. Although a diagnosis of focal dystonia is not employed, musicians with symptoms of irregular muscle tension are the target group of study, as they are believed to be pre-disposed to developing focal dystonia. The aim of this study is to identify factors that lead to onset of focal dystonia. The methodology employed in this study involves the inclusion of 82 Japanese musicians who specialize in high-speed stringed instruments. Regarding left finger muscular tension, subjects were divided into an over-exertion group and a normal tension group. During a period of rest from musical practice, subjects were given a questionnaire evaluating the degree of left finger pain. Muscular tension was used as a response variable, and analysis was conducted to reveal any causal link. Results revealed a stronger tendency for muscular tension to persist in the over-exertion group compared to the normal group, even when musical training despite bodily fatigue was stopped. Left finger pain was also higher in the over-exertion group.

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Introduction

Focal dystonia, also known as the musician's cramp, is a motor impairment seen among musicians that can lead to musical errors during performance or otherwise reduce the musician's ability to control unintentional movements [1]. For instance, a violinist who flexes their left middle finger in order to press the string to the fingerboard may unintentionally flex their ring finger at the same time or experience digital rigidity. Indeed, the primary symptoms of focal dystonia relate to loss of motor control due to irregular muscular tension [1]. Focal dystonia has been reported in 1% of all musicians [2], and often becomes a factor in ending a musician's career given the onset of unintended actions during performance. Focal dystonia occurs approximately twice as frequently among males compared to females [3], and possible genetic factors have also been reported [3]. The pathophysiology of this condition includes enlargement of the left hand and finger motor region of the cerebral cortex, and hypertrophy of the anterior corpus callosum, cerebellum, or other regions of the brain [4,5]. Moreover, the primary causes of these brain changes are reported to arise from sustained musical practice through pain and muscular fatigue, leading to afferent pathway sensory overload [6,7]. Within the cerebral cortex, irregular reduction in stimulation to the muscular control systems of the brain as well as over-exertion of muscular tension to the affected region of the body have been reported. However, the root causes of these mechanisms are believed to be chronic, irregular sensory input. Among studies investigating the causal factors of focal dystonia, researchers have found that compared to other musicians, those with focal dystonia spend a far greater time practicing, and report continued practice under endured fatigue as a latent trigger to onset [8]. However, the sample size studied was too small to draw any definitive conclusions pertaining to musicians and their practice environment. The precise amount of practice that leads to excitatory suppression of the basal ganglion control center remains unclear. Treatment for dystonia includes drug therapy [7], botulinum toxin injection [8], physical or occupational therapy [11,12], and stereotactic brain surgery [13]. However, these treatments only serve to reduce pain and spasm. A comprehensively effective means of treating or preventing dystonia remains elusive. This study aims to elucidate the relationship between practice habits and irregularity in muscular tension among stringed instrument musicians with risk factors for dystonia.

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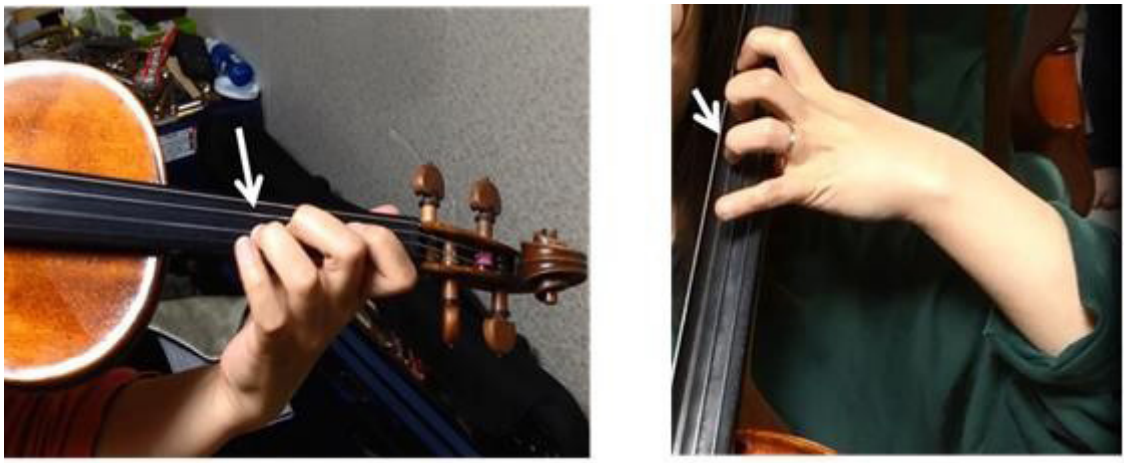

Figure 1: Symptoms of focal dystonia.

Violinist on left. Cellist on right. Attempting to press the string to the fingerboard with both the index and middle finger results in unintentional flexion of the ring finger due to linked mechanical action. This results in unintentional pressure on the fretboard, preventing the musician from performing correctly.

Methods

Subjects included for study were all high-speed stringed instrument musicians associated with Japanese professional orchestras (henceforth, "orchestral group"). Potential subjects were screened to disclude those with prior diagnosis of dystonia. Subjects were recruited by sending a survey request via mail to orchestral group managers. Orchestral groups who responded to the survey request were visited to obtain consent to participate in the study. The study was then explained, and a paper consent form was obtained from the subjects. Following consent acquisition, subjects were taken to a private room to conduct the investigation. Muscular tension was evaluated using a multifaceted approach that included palpation, passive action, and reflex given the wide variance seen because of changes to limp position or exercise planning [14]. The reflex test involved evaluation of Tromner's sign from C6 to T1 of the reflex center given that the target zone in this study was the left hand and fingers of stringed instrument musicians. Tension during finger flexion was evaluated by palpation and by catch upon fast passive stretch. Musicians with positive Tromner's sign were placed in the muscular tension over-exertion group, while others were placed in the normal group. Evaluative items included general information such as gender, age, handedness, musical instrument, and group affiliation (solo performer vs. orchestral group performer). Data regarding performance practice was collected by asking questions regarding practice rest. Practice rest was scored with rest at the start of practice being 0, rest at the point of mental fatigue but before physical fatigue as 2.5, rest at the point of both mental and physical fatigue as 5, and rest at the point of reaching one's physical limits as 10. Subjective survey was conducted using the Visual Analogue Scale for Criteria for stopping performance practice (VASCSP; Figure 2), a quantitative measure. To evaluate pain during practice, the VAS [15] was used as a quantitative measure. Statistical analysis involved performing a 2-group comparison for each general information element. Results of statistical analysis produced comparison between the normal and over-exertion groups with respect to a 2-item score for practice rest and pain during practice. The Wilcoxon rank sum test was performed to compare results between groups and confirm significance. Muscular tension was set as a response variable and other factors were set as independent variables. Stepwise multiple regression analysis was performed to produce a regression equation. EXSAS version 7.5 and STATCEL version 2 for Windows were used to calculate statistics. Analyzed data underwent member checking to validate a summary of the analysis results individually. Moreover, ethical considerations include the anonymous storage of subject data, avoiding non-academic use of obtained information, allowing subjects to discontinue the study at any time, explanation to subjects in verbal and written form that they will not be penalized by discontinuing or failing to consent to study participation, and acquiring confirmation of intent to participate. The ethics review board of Shonan University of Medical Science (medical research ethics approval No. 19-016) approved this study.

Results

Surveys were conducted at 18 orchestral groups, and 82 high-speed stringed instrument musicians returned responses. Regarding general information, responders consisted of 38 males, 44 females, maximum age of 72, minimum age of 27, average age of 45.4 ± 11.0, 75 right-handed, and 7 left-handed. There were 37 violists, 7 violists, and 38 cellists. The longest performance career lasted 70.5 years, the shortest was 20 years, and average performance career was 40.0 ± 10.9 years. 25 musicians were soloists, while 57 were orchestral group players. 27 musicians had normal muscular tension (32.9%), of which 6 (15.8%) were male, 21 (47.7%) were female, 25 (33.3%) were right-handed, 0 (0%) were left-handed, 12 (32.4%) played the violin, 2 (28.6) played the viola, and 13 (34.2% played the cello. 55 (67.1%) of the musicians were classified as over-exertion players, of which 32 (84.2%) were male, 23 (52.3%) were female, 69 (66.7%) were right-handed, 7 (100%) were left-handed, 25 (67.6%) played the violin, 5 (71.4%) played the viola, and 25 (65.8%) played the cello. Variable analysis of general information between the normal and over-exertion groups revealed that males experienced muscular tension over-exertion at a rate greater than females (p=0.02) Additionally, age, handedness, instrument, and musical career showed no differences between groups. Investigation into practice

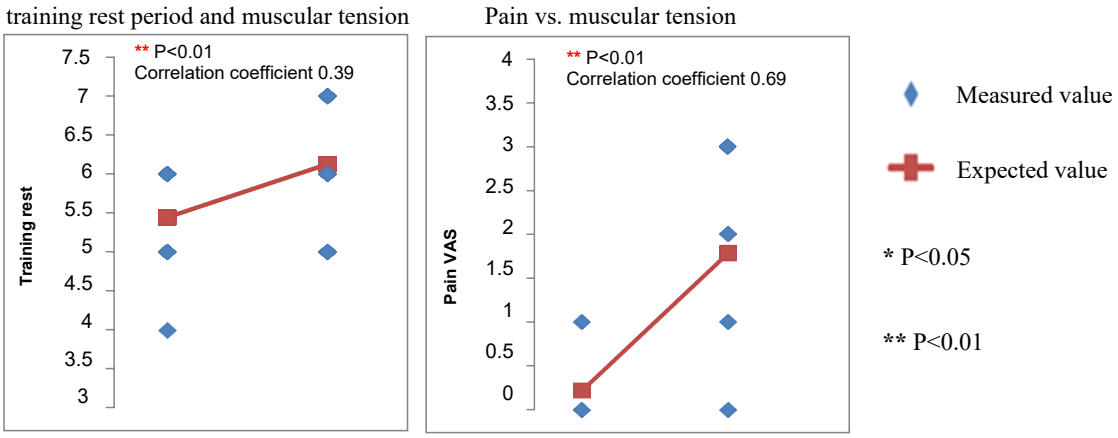

Figure 2: Regression function and scatter diagram.

rest habits revealed that those in the over-exertion group practiced longer than those in the normal group (P=0.004). The severity of practice-associated left-hand pain was lower in the normal group compared to the over-exertion group (P=0.004). Considering soloists only, inter-group comparison revealed that soloists in the normal group experienced less pain than in the over-exertion group (P=0.004).

Figure 2: Regression function and scatter diagram.

The multiple regression function confirmed correlation between muscular tension and practice rest duration, and between muscular tension and pain.

Discussion

Irregular muscular tension among high-speed stringed instrument musicians

The results of our study reveal that 67.1% of the musicians studied suffered from over-exertion of muscular tension. While a previous study found no instances of Tromner's reflex among 30 healthy subjects [16], the results of our study show an exceedingly high rate of positivity. A focal dystonia rate of 1% among all musicians has previously been reported [2]. However, we should not discount musicians who experience hindrances to their musical performance due to irregular muscular tension that do not result in performance errors. In the over-exertion group, there were more males than females, and this gender distribution is in line with previous large-scale surveys of focal dystonia among musicians [2,17]. This raises the question of whether musicians who experience irregular muscle tension that later resolves are the ones who develop focal dystonia.

Practice rest and left finger pain

Our investigation found that the over-exertion group experienced longer periods of practice rest compared to the normal group. Moreover, musicians in the over-exertion group were more likely to experience irregular muscular tension as they continued to practice under fatigue conditions. Left finger pain was more common among the irregular muscular tension group, and it was suggested that pain affected irregular muscular tension. These findings coincide with a prospective study investigating the relationship between dystonia and pain [8]. From these results, it is clear that bodily fatigue and continued practice with disregard to pain increase the likelihood of irregular muscular tension.

Measures to prevent dystonia

Preventative measures for dystonia based on the results of this study include immediate rest from practice following bodily fatigue or pain in the hands or fingers. Prior to resuming practice, musicians should take ample rest, perform stretches to alleviate pain, improve the condition of compressed soft tissue, or other such measures. With respect to pain intervention and psychological support for anxiety, Tanabe and other occupational therapists report that those with focal dystonia who undergo palliative soft tissue therapy and psychological support are better able to recover [11,18]. Treatment of underlying soft tissue compression that leads to pain and sensory-motor input dysregulation is expected to be effective in preventing dystonia. Independent stretching before and after practice alone will not recover soft tissue damaged by over-training. This suggests that further study into the preventative efficacy of treatment by occupational therapists is warranted.

Limitations

This study has provided useful information into the causal factors of focal dystonia. However, no generalizations can be made regarding the efficacy of preventative measures that avoid these causal factors. The results of this study call into question the efficacy of preventative measures. As such, a future large-scale investigation of prevention implementation and follow-up efforts is warranted.

Conclusion

High-speed stringed instrument musicians considered to be pre-disposed to focal dystonia given the presence over-exerted muscular tension tend to practice while experiencing bodily fatigue more often than musicians with normal muscular tension. Moreover, musicians experiencing irregular muscular tension experience pain in their left hand more often than musicians with normal muscular tension.

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