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Comparing the Impact of Specific Strength Training vs General Fitness Training on Professional Symphony Orchestra Musicians

A Feasibility Study

Lotte Nygaard Andersen, PhD, Stephanie Mann, BSc, Birgit Juul-Kristensen, PhD, and Karen Søgaard, PhD

Musculoskeletal symptoms, especially in the upper body, are frequent among professional symphony orchestra musicians. Physical exercise may relieve pain but might also interfere with playing performance. **OBJECTIVE:** To evaluate the feasibility and effect of “specific strength training” (SST) versus “general fitness training” (GFT). **METHODS:** A feasibility study using randomized controlled methods. Primarily, evaluations involved self-reported impact on instrument playing and satisfaction with the interventions. Secondary evaluations included pain intensity, hand-grip strength, aerobic capacity, body mass index, and self-assessed physical fitness. A total of 23 professional symphony orchestra musicians were randomly allocated to either the SST ($n=12$) or GFT ($n=11$) groups. Participants conducted three 20-minute exercise periods/wk at the workplace for 9 weeks. **RESULTS:** Evaluations of both interventions showed that approximately 50% of musicians were satisfied with the interventions and experienced a positive impact on playing, while 18% reported a slightly negative impact. From baseline to follow-up, SST showed a significant reduction in pain (26.3 ± 22.5 to 11.4 ± 15.2 mm), with no significant reduction for GFT (19.7 ± 24.0 to 13.5 ± 26.0 mm). GFT significantly

improved aerobic capacity (34.1 ± 7.9 mL/min/kg to 40.0 ± 13.6 mL/min/kg) compared to no significant gain for SST. For GFT, a significant improvement was seen in self-reported muscle strength (5.7 ± 1.3 to 6.5 ± 1.8) with a tendency toward significant improvement in self-reported aerobic fitness (5.6 ± 2.3 to 6.2 ± 2.5). **CONCLUSION:** Exercise interventions have the potential to improve musicians’ working situation. For future research, muscle-strengthening exercises and aerobic fitness exercises might be combined in an intelligently designed program, which may include other relevant educational activities. *Med Probl Perform Art* 2017; 32(2):94–100.

Musculoskeletal disorders and pain symptoms related to instrumental playing are highly prevalent among musicians,^{1,2} and most of these disorders are perceived to be work-related³ owing to factors such as repetitive movements, static postures, and a stressful and competitive lifestyle.^{4,5} Previously, it has been shown that the most prevalent complaints are pain symptoms or injury to the back, neck, and shoulder.^{1,3} Playing a musical instrument at an elite level requires many hours of rehearsal, and performances pose considerable demands on the musculoskeletal system.⁶ A systematic review found that for a 12-month period the prevalence of musculoskeletal complaints in professional musicians ranged from 41 to 93%.¹

Such problems may entail serious consequences for the musicians’ performance, their ability to play the instrument,³ and ultimately their career.⁶ Playing-related disorders of this kind depend on a number identifiable risk factors, as well as associated risk factors about which more scientific knowledge is needed.¹

Many different methods have been suggested for the treatment and prevention of playing-related disorders, but none has produced convincing evidence for their effects.⁷ Evidence is limited, and more knowledge is needed about physical exercises that might be specifically well suited for musicians. Among music students, non-randomized studies^{8,9} suggest a decrease in playing-related pain symptoms for those doing physical exercises, while a small randomized controlled trial in music students showed that endurance training over 6 weeks reduced the perceived

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exertion of instrument playing.¹⁰ Among professional symphony orchestra musicians, one study¹¹ of a combined intervention also showed improvements in musicians' physical competence and a decrease in playing-related musculoskeletal disorders, but the authors point out that the musicians' motivation is important for achieving effects. As a continuation of this, a study by Chan et al.¹² following musicians who used an exercise DVD found that this exercise program appeared to be feasible and effective in the management of playing-related musculoskeletal disorders.

The present feasibility study was intended to provide additional knowledge about the effects on musicians of preventive activities comprising two contrasting forms of physical exercises. Both of these forms of standardized physical exercise have, in randomized controlled designs, proved effective in pain reduction for workers in monotonous jobs who experience musculoskeletal troubles.^{13,14} For musicians, however, the high quality of their performance is paramount, and while physical exercise may relieve pain, it might also interfere with playing performance. This could be the case in specific strength training in particular. Accordingly, each program was submitted to particular scrutiny in order to provide methodological information for future studies combining two exercise programs.

The aim of the present feasibility study was to evaluate, among professional symphony orchestra musicians, the feasibility of "specific strength training" (SST) as compared to "general fitness training" (GFT) to assess their relative self-reported impact on instrument playing and the musicians' satisfaction with such interventions. A secondary aim was to record objectively measured hand-grip strength, aerobic capacity, and body mass index (BMI), as well as self-reported measures of pain, physical fitness, muscle strength, and endurance. More specifically, the hypotheses were that SST would have a more pronounced effect on pain reduction than GFT, that GFT would have a more pronounced effect on aerobic capacity, and that both types of exercise would have a positive impact on playing an orchestral instrument.

METHODS

Design and Settings

The current feasibility study was a parallel randomized controlled study conducted in the workplace. The information meeting, interventions, and pre- and post-intervention tests and assessments were performed at the Odense Symphony Orchestra, Denmark. This paper reports the effects on the participants measured immediately after completion of the 9-week intervention. The pre-assessments prior to the start of the intervention were used as baseline measurements and compared to the outcomes measured after termination of interventions.

All methods were carried out following approved guidelines. All participants signed a consent form that was in accordance with the Declaration of Helsinki. The inter-

vention procedures that were used in the present trial were approved by the Regional Scientific Ethics Committee for Southern Denmark (project-ID S-20110040).

Study Population and Randomization

The study population consisted of professional symphony orchestra musicians of the Odense Symphony Orchestra. Inclusion criteria were that they should be employed by the orchestra during the study period. Exclusion criteria were serious physical conditions or illnesses that could interfere with participation in the interventions, e.g., cardiovascular disease or pregnancy.

All musicians ($n=73$) in the orchestra were invited to an information meeting. After the meeting, 27 musicians agreed to enroll in the study. Recruited participants were randomized to participate in either the SST or GFT group. The study made use of an allocation concealment procedure to ensure that group allocation was not known until the participant was enrolled in the study. Participant flow was registered as recommended by the CONSORT.¹⁵

Interventions

Both SST and GFT groups received supervised physical exercises 3 times/week for 20 minutes over 9 weeks. Both types of intervention are add-on workplace-based physical activity interventions, meaning that they are additional to any existing lifestyle activity, and both interventions amounted in total to 1 hr/wk spent on exercises. If participants were unable to attend the training at the workplace, they were encouraged to exercise on their own.

Musicians most often report pain symptoms in the neck region (including trapezius)¹⁶ but also in the back and shoulder areas. These self-reported symptoms should be seen alongside results of a previous study, which showed convincing effects of SST and GFT on shoulder and neck pain reduction in office workers with chronic trapezius myalgia¹³; therefore, the exercise protocol for SST and GFT in our study closely followed this previous training protocol. Three trained physiotherapy students supervised and corrected the groups as they exercised. Interventions started within 1 week after the baseline measurements.

The SST group performed supervised high-intensity specific strength training, focusing on the neck and shoulder muscles. The program for the neck and shoulder muscles contained five dumbbell exercises; one-arm row (45° bend with hand and knee on flat bench), shoulder abduction (standing), shoulder elevation (standing), reverse flies (45° prone on bench), and upright row (standing). All exercises were performed with consecutive concentric and eccentric muscle contractions. During each training session, three of the five exercises were performed with three sets per exercise following an undulating schedule, shoulder elevation being the only exercise that was performed during each session.

In the first session, the training load was individually assessed and adjusted so it corresponded to the maximum load that could be lifted 15 times (15 repetitions maximum

~70% of maximal intensity). During the intervention period, the training load in a set was progressively increased from the 15 repetitions maximum at the beginning of the training period to 8–12 repetitions maximum (~75–85% of maximal intensity) during the later phase.

The most often self-reported symptoms among musicians are similar to those reported in other job groups with highly repetitive work demands in static postures. Previous studies have shown convincing evidence on a pain-reducing effect of physical exercise among office workers with myalgia¹³ as well as in a general population of employees.¹⁶ Therefore, the feasibility of these efficient exercise protocols SST and GFT were tested among musicians.

The rationale for using SST and GFT is to improve the physical capacity of the musicians in order to prevent musculoskeletal disorders. The GFT strategy relies on the previously shown positive general effect on functional capacity lowering the relative strain of a given work task¹⁷ that may underlie the positive effects on pain.^{13,18} For SST, the exercises specifically target the activation of the painful muscles in the neck region.¹⁹ This has been shown superior to other types of exercises regarding pain alleviation and improving muscular strength and function of the exercised muscles.^{13,20,21} Particular awareness was directed at the specific implementation of the exercises. This included instruction in stabilization of the trunk, pelvis, and scapula as well as encouraging appropriate rhythmic breathing.

The GFT group performed high-intensity general fitness training for the legs only.¹³ This consisted of exercise on a bicycle ergometer for 20 min, with relative workloads of 50–70% of maximal oxygen uptake (VO_2max). Subjects bicycled in an upright position with their back at a 90° angle to the ground without holding onto the handlebars with their hands. It was emphasized that the subjects in GFT should relax their shoulders during exercising, meaning that all their weight rested on their buttocks. The saddle was aligned vertically, and the height was set so knees were slightly bent when the pedal was at its lowest point. A relative workload of 50% of VO_2max was used during the initial training sessions; it was progressively increased towards 70% during the following weeks and was maintained at that intensity throughout the remaining training period. The relative workload was estimated on the basis of the known relationship between heart rate (HR) and oxygen uptake: i.e., relative workload = (working HR – resting HR)/(maximum HR – resting HR). Resting HR was set at 70 bpm and maximum HR was estimated as $208 - (0.7 \times \text{age})$.²² HR was monitored during each training session to ensure optimal training intensity. Polar FT2 heart rate monitor and Polar T31 heart rate sensors (Polar Electro, Kempele, Finland) were used for monitoring.

Outcomes

All measurements took place at baseline and were repeated after termination of the 9 wks of interventions. Primarily, participants evaluated their overall satisfaction with the

interventions and evaluated the impact of the physical exercises on playing their instrument by answering questionnaires with responses ranging from positive to negative on a 5-point Likert scale.

Baseline information from participants was collected using a questionnaire. In addition, secondary outcomes were evaluated. BMI is based on height and body weight, which were measured without shoes and wearing light clothes. Pain intensity during the last 7 days was measured on a 100-mm visual analogue scale (VAS),^{23,24} ranging from “no pain” at 0 mm to “worst imaginable pain” at 100 mm.^{23,24} It was measured at baseline and at the end of the 9 wks of intervention.

Hand-grip strength (right hand) was measured in kilograms with a hand-held dynamometer.²⁵ Participants were instructed to stand upright with the safety strap around their wrist, with their arm at right angles and their elbows by the side of the body. Wrist extension only up to 30° was allowed. The participants were strongly encouraged to squeeze with maximum effort. Three trials were recorded and an extra trial was conducted if force varied by more than 3 kg compared with a previous attempt.²⁵

Aerobic capacity was estimated using the Aastrand Rhyming Test, a 1-point submaximal test.²⁶ The participants cycled at 60 repetitions/min at a workload set at a level referenced to the gender and condition of the individual. HR was measured during the exercise, and the test ended when the participant reached a steady state HR of between 120 and 160 bpm, with a change of <5 beats between 2 consecutive minutes. Based on testing workload and HR during testing, aerobic capacity was estimated using Aastrand’s nomogram. Finally, the estimated aerobic capacity was adjusted for age, gender, and normalized to body weight.²⁷ All tests were conducted by three student physiotherapists, who had received careful instruction and training in the full test protocol.

Self-assessed physical fitness was evaluated using three of the five validated questions in the Stroyer questionnaire.²⁸ The questions concern aerobic fitness, muscle strength, and endurance. The participants were asked, “How would you rate the following components of physical fitness compared to people of your own age and gender?” An example of one question is, “How would you rate your muscle strength compared to people of your own age and gender?” A Likert scale was used, with 1 representing “poor” or “weak” and 10 representing “good” or “strong.” The three scales were provided with illustrations at each end of the scale for aerobic fitness, muscle strength, and endurance.

Statistical Analysis

Differences in baseline characteristics between groups were tested using Pearson’s χ^2 for distribution of categorical variables, and continuous variables were tested with an independent samples *t*-test. Secondary outcomes were analyzed in accordance to the intention-to-treat principle, i.e., all ran-

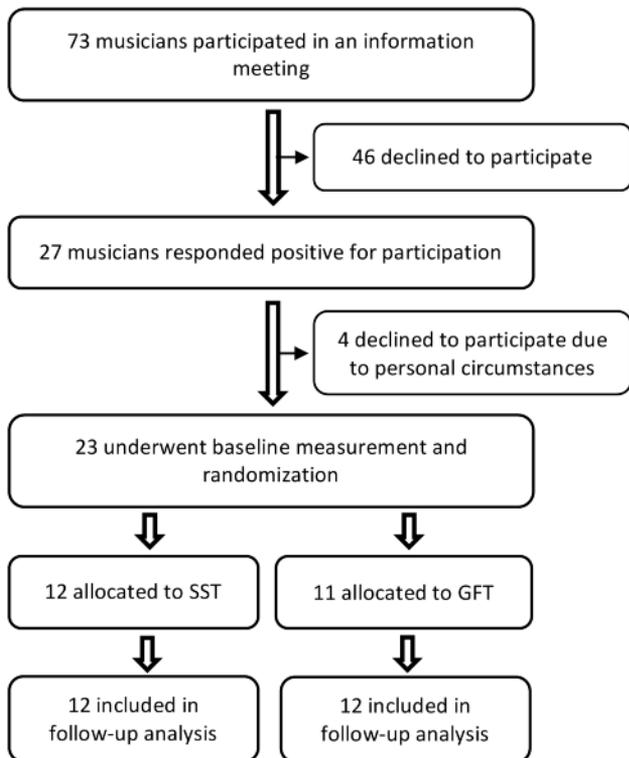


FIGURE 1. Flow diagram of the participants from information meeting to final analysis.

domized participants were included in analyses, with missing values substituted with carried forward or backward, and leaving measured values with a delta-value of null.

The primary evaluation of participants' satisfaction and of the impact of the physical exercises on playing their instrument was scrutinized based on a descriptive summary approach for possible trends in the quantitative data. A descriptive summary approach was used because the small number of participants in the groups made statistical comparisons between them impossible. A paired-samples *t*-test was used for comparison within groups of continuous secondary outcomes from baseline to follow-up. A mixed-design ANOVA was used for analysis of time \times group interactional effects. Categorical outcomes were analyzed using Pearson's χ^2 -test. $p \leq 0.05$ was considered to indicate statistical significance. IBM SPSS Statistics for Windows, ver. 22.0 (IBM Corp; Armonk, NY) was used for data analysis.

RESULTS

A total of 23 musicians were included in this feasibility study. The chart of participants' progress through the study is shown in Figure 1. Baseline demographics for the randomized participants in the SST and GFT groups are given in Table 1. Mean adherence rate for interventions was 43%, besides which participants carried out physical exercises on their own, giving an additional 10%. The mean adherence rate for GFT was 57% and for SST 31%.

TABLE 1. Baseline Demographics for Intervention Groups

	SST (n=12)	GFT (n=11)
Gender, F/M, n(%)	8/4 (66.7/33.3)	6/5 (54.5/45.5)
Age, mean (SD), yrs	44.7 (11.0)	47.2 (7.8)
Violin/other instrument, n	7/1	9/4
No. of years playing the instrument (SD), yrs	34.8 (11.2)	37.5 (9.1)

TABLE 2. Impact on Playing and Satisfaction

	SST (n=7)	GFT (n=10)
Impact of physical exercises on playing their instrument		
Negative/slightly negative ¹	2	1
No impact	1	4
Slightly positive/positive ²	4	5
Overall satisfaction with physical interventions		
Dis-/less satisfied ³	3	2
Satisfied	1	2
Very/extremely satisfied ⁴	3	6

Absolute numbers are reported. Collapsed categories: ¹negative and slightly negative; ²slightly positive and positive; ³dissatisfied and less satisfied; ⁴very and extremely satisfied.

The most common reason the participants did not participate was lack of time.

Impact on Playing and Satisfaction

We found that 80% of participants in GFT (n=6 and 2) and 57% of participants in SST (n=3 and 1) were "satisfied" or "very/extremely satisfied" with interventions, respectively (Table 2). A few in both interventions (SST=3, GFT=2) were not satisfied. However, all of these were in the "less satisfied" category and none in the "dissatisfied" category. As for the impact of physical exercises on playing their instrument, about 50% in both SST (n=4) and GFT groups (n=5) registered a positive impact on performance with their instrument, and only 3 participants in total experienced a slightly negative impact of the interventions of performance.

Pain Intensity

No significant difference ($p=0.29$) was found between groups when comparing change scores for SST and GFT (Table 3). A significant within-group reduction in pain intensity from baseline to follow-up was found for SST ($p=0.05$), while GFT showed no significant decrease ($p=0.09$) from baseline to follow-up.

Hand-Grip Strength

For hand-grip strength, no significant differences were found within ($p=0.84$ and 0.95) or between the SST and GFT groups ($p=0.85$) (Table 3).

TABLE 3. Outcome Evaluation After 9 Weeks of Intervention

	SST (n=12)*			GFT (n=11)			p-Value Time x Group Interaction
	Baseline	Follow-up	p	Baseline	Follow-up	p	
Pain intensity VAS, 0–10 mm (SD)	26.3 (22.5)	11.4 (15.2)	0.05	19.7 (24.0)	13.5 (26.0)	0.09	0.29
Hand grip strength	35.3 (13.2)	35.4 (13.4)	0.84	39.4 (13.2)	39.6 (13.5)	0.85	0.95
Aerobic capacity, mL/min/kg (SD)	34.0 (11.3)	32.2 (10.9)	0.09	34.1 (7.9)	40.0 (13.6)	0.03	<0.01
BMI, kg/m ² (SD)	28.6 (5.1)	28.2 (5.7)	0.89	26.0 (3.9)	26.5 (5.1)	0.53	0.74
Self-assessed physical fitness							
Aerobic fitness	5.0 (1.8)	5.25 (1.7)	0.19	5.6 (2.3)	6.2 (2.5)	0.09	0.31
Muscle strength	4.8 (2.2)	5.1 (2.1)	0.34	5.7 (1.3)	6.5 (1.8)	<0.01	0.15
Endurance	5.4 (2.3)	5.6 (2.2)	0.59	5.7 (2.2)	6.1 (2.1)	0.22	0.64

*Five carried-forward values.

Aerobic Capacity

A significant improvement in aerobic capacity between groups ($p<0.01$) was found for GFT compared to SST (Table 3). Significant within-group improvement was also seen for GFT ($p=0.03$), while SST showed no significant change in aerobic capacity.

BMI

BMI of 26 to 28 as seen at baseline (Table 3) indicates that participants were overweight. No significant differences were found when comparing SST and GFT at baseline ($p=0.74$), nor were significant differences found when comparing baseline to follow-up within groups ($p=0.89$ and 0.53).

Self-Assessed Aerobic Fitness, Strength, and Endurance

No significant between-group differences ($p=0.31$, 0.15 , and 0.64) were found when comparing change score for self-assessed aerobic fitness, muscle strength, and endurance (Table 3). For self-assessed muscle strength, a significant ($p<0.01$) within-group difference was found for GFT, but no significant difference ($p=0.09$) was seen for self-assessed aerobic fitness from baseline to follow-up.

DISCUSSION

The present feasibility study using randomized controlled methods showed that physical exercise interventions potentially have a positive impact on instrument playing, and that musicians were satisfied overall with performing physical exercise interventions. For musicians, a negative impact on their instrument performance may make an exercise intervention unacceptable and thereby prevent them from taking part in the exercises. If, for example the physical exercises involve handgrip of dumbbells, it may change pressure sensations in the fingers, which may have a negative impact on their performance on the instrument. In contrast, if the physical exercises are perceived as positive for their performance, this may increase motivation for participation. Therefore, both positive and negative impacts on playing are important factors to consider when

designing and teaching physical exercise interventions for musicians.

The results also suggest that intensive strength training is a promising initiative for prevention of pain among professional symphony orchestra musicians. The SST intervention indicated a potential positive effect on pain intensity, while GFT only tended to decrease pain intensity. In contrast, GFT significantly improved participants' aerobic capacity. For BMI, no statistically significant effects were seen for either group. No effect could be demonstrated for hand-grip strength, but assessment procedures could be followed and are feasible. Hand-grip strength is a relevant outcome to include in a future study with a longer intervention period, because it has correlations with the development of disability,²⁹ i.e., for musicians, the development of difficulties in playing their instrument.

The positive results on self-assessed muscle strength for GFT are surprising in the context of this study, since only SST carried out muscle-strengthening exercises. A reason for this result can be related to a previous finding by Pronk et al.,¹⁷ who showed that greater functional capacity, as measured by cardiorespiratory fitness, is related to increased productivity and reduced relative effort in performing the same work. When musicians improve aerobic capacity, they require less relative effort to perform their work, and this they can interpret this as a feeling of greater muscle strength.

To our knowledge, the present study is the first to assess the effects of physical exercises among professional symphony orchestra musicians in a randomized controlled design. Previously non-randomized studies on preventive interventions have been conducted among music students.^{30,31} Zander et al.³⁰ showed no positive effects of exercises on the physical symptoms of music students, but Lopez et al.³¹ concluded that warm-up exercises may be recommended because their experimental group reported a 78% decrease in playing-related disorders compared to a control group. However, as Manchester³² stated in his editorial, it is still questionable whether it makes sense to instruct instrumental musicians to carry out warm-up routines or specific strengthening exercises to prevent playing-related disorders until efficacy studies can confirm that such exercises make a difference.³²

The present feasibility study on the effect of physical exercise confirms the conclusions from a non-randomized control group study of an exercise intervention for musicians.³³ From that study, Chan et al.³³ concluded that a tailored exercise program over 10 weeks for Australian symphony orchestra musicians was effective in managing performance-related musculoskeletal disorders, and especially in reducing the frequency and severity of performance-related musculoskeletal disorders. Also a randomized controlled comparing 11 specific strength exercises with 11 specific endurance exercises, conducted among music students in Australia,¹⁰ concluded that the endurance training had a significant impact on the students' perceived exertion of playing. However, more evidence on preventive interventions among symphony orchestra musicians is needed, and it may be relevant to conduct randomized controlled trials that consider potentially specific needs of specific instrument groups. This would mean that exercise programs should be tailored to specific instrument groups.^{33,34} In their design, future interventions might also need to allow for gender differences in the prevalence of pain symptoms and associated risk factors.^{1,35} The present feasibility study showed that positive effects could be gained both from SST and GFT. Future interventions may therefore find it relevant to combine the two into a program intelligently designed for musicians.

Davies and Mangion³⁶ have also found that playing-related stress and poor health over the previous year were associated with an increase in musculoskeletal disorders. Viewed holistically, our understanding of stress, health conditions, and the potential effects of physical exercises would suggest that it might be relevant to incorporate physical exercises as part of a multifaceted intervention. Such a multifaceted intervention would include strength, flexibility, and aerobic fitness exercises, postural and kinesthetic training, and educational activities addressing important issues concerning, for example, behavioral change, pain mechanisms, prevention and treatment of overuse syndromes, and coping with performance-related stress.

This study has some limitations due to the nature of being a feasibility study (e.g., a usual sort of power calculation has not been undertaken) and that we did not do statistical analyses on musicians' evaluations of interventions' impact on playing their instrument nor on the musicians' overall satisfaction with the interventions. In addition, the conservative intention-to-treat principle for analysis with carry-forward and backward of missing observations was used in our analysis, and this may lead to underestimating the intervention effects on pain, hand-grip strength, aerobic capacity, and BMI. Moreover, only two types of training were included. Even though musicians were supervised to perform exercises correctly, it would have been appropriate to include, for example, specific core stability training and kinesthetic training. A strength of this study is that, despite the number of participants, it is designed as a randomized controlled compar-

son. It has shown that it is possible to conduct a randomized controlled trial for symphony orchestra musicians at their workplace.

In conclusion, the present feasibility study using randomized controlled methods emphasizes that physical exercise interventions have a potential for improving working conditions for musicians. Musicians were satisfied with the interventions, and results indicated that exercises have potential positive effects on playing performance. Relevant improvements on pain intensity and aerobic fitness were shown, and musicians themselves reported that they felt stronger following the fitness training program. Future research that would follow on from the present results could involve combining muscle-strengthening exercises and aerobic fitness training as well as devoting greater attention to educational activities such as behavioral changes and performance-related issues.

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REFERENCES

1. Kok LM, Huisstede BM, Voorn VM, et al: The occurrence of musculoskeletal complaints among professional musicians: a systematic review. *Int Arch Occup Environ Health* 2016;89(3):373–96. doi: 10.1007/s00420-015-1090-6
2. Zaza C: Playing-related musculoskeletal disorders in musicians: a systematic review of incidence and prevalence. *CMAJ* 1998; 158:1019–25.
3. Ackermann B, Driscoll T, Kenny DT: Musculoskeletal pain and injury in professional orchestral musicians in Australia. *Med Probl Perform Art* 2012;27(4):181–7.
4. Sousa CM, Machado JP, Greten HJ, Coimbra D: Occupational diseases of professional orchestra musicians from northern Portugal: a descriptive study. *Med Probl Perform Art* 2016;31(1):8–12. doi: 10.21091/mppa.2016.1002
5. Holst GJ, Paarup HM, Baelum J: A cross-sectional study of psychosocial work environment and stress in the Danish symphony orchestras. *Int Arch Occup Environ Health* 2012;85(6):639–49. doi: 10.1007/s00420-011-0710-z
6. Chan C, Ackermann B: Evidence-informed physical therapy management of performance-related musculoskeletal disorders in musicians. *Front Psychol* 2014;5:706. doi: 10.3389/fpsyg.2014.00706
7. Ioannou CI, Altenmüller E: Approaches to and treatment strategies for playing-related pain problems among Czech instrumental music students: an epidemiological study. *Med Probl Perform Art* 2015;30(3):135–42.
8. Spahn C, Hildebrandt H, Seidenglanz K: Effectiveness of a prophylactic course to prevent playing-related health problems of music students. *Med Probl Perform Art* 2001;16(1):24–32.
9. Kava KS, Larson CA, Stiller CH, Maher SF: Trunk endurance exercise and the effect in instrumental performance: a preliminary study comparing Pilates exercise and a trunk and proximal upper extremity endurance exercise program. *Music Perform Res* 2010;3(1):1–30.
10. Ackermann B, Adams R, Marshall E: Strength or endurance training for undergraduate music majors at a university? *Med Probl Perform Art* 2002;17(1):33–41.

11. de Greef M, van Wijck R, Reynders K, et al: Impact of the Groningen exercise therapy for symphony orchestra musicians program on perceived physical competence and playing-related musculoskeletal disorders of professional musicians. *Med Probl Perform Art* 2003;18(4):156–61.
12. Chan C, Driscoll T, Ackermann B: Exercise DVD effect on musculoskeletal disorders in professional orchestral musicians. *Occup Med (Oxford)* 2014;64(1):23–30. doi: 10.1093/ocmed/kqt117
13. Andersen LL, Kjaer M, Sogaard K, et al: Effect of two contrasting types of physical exercise on chronic neck muscle pain. *Arthritis Rheum* 2008;59(1):84–91. doi: 10.1002/art.23256
14. Nielsen PK, Andersen LL, Olsen HB, et al: Effect of physical training on pain sensitivity and trapezius muscle morphology. *Muscle Nerve* 2010;41(6):836–44. doi: 10.1002/mus.21577
15. Schulz KF, Altman DG, Moher D: CONSORT 2010 statement: updated guidelines for reporting parallel group randomised trials. *Int J Surg* 2011;9(8):672–7. doi: 10.1016/j.ijsu.2011.09.004
16. Andersen LL, Christensen KB, Holtermann A, et al: Effect of physical exercise interventions on musculoskeletal pain in all body regions among office workers: a one-year randomized controlled trial. *Man Ther* 2010;15(1):100–4. doi: 10.1016/j.math.2009.08.004
17. Pronk NP, Martinson B, Kessler RC, et al: The association between work performance and physical activity, cardiorespiratory fitness, and obesity. *J Occup Environ Med* 2004;46(1):19–25. doi:10.1097/01.jom.0000105910.69449.b7
18. Sculco AD, Paup DC, Fernhall B, Sculco MJ: Effects of aerobic exercise on low back pain patients in treatment. *Spine* 2001;1(2):95–101.
19. Paarup HM, Baelum J, Manniche C, et al: Occurrence and co-existence of localized musculoskeletal symptoms and findings in work-attending orchestra musicians: an exploratory cross-sectional study. *BMC Res Notes* 2012;5:541. doi: 10.1186/1756-0500-5-541
20. Zebis MK, Andersen LL, Pedersen MT, et al: Implementation of neck/shoulder exercises for pain relief among industrial workers: a randomized controlled trial. *BMC Musculoskel Disord* 2011;12:205. doi: 10.1186/1471-2474-12-205
21. Ylinen J, Takala EP, Nykanen M, et al: Active neck muscle training in the treatment of chronic neck pain in women: a randomized controlled trial. *JAMA* 2003;289(19):2509–16. doi: 10.1001/jama.289.19.2509
22. Tanaka H, Monahan KD, Seals DR: Age-predicted maximal heart rate revisited. *J Am Coll Cardiol* 2001;37(1):153–6. doi: S0735-1097(00)01054-8
23. Huskisson E: Measurement of pain. *Lancet* 1974;304(7889):1127–31.
24. Williamson A, Hoggart B: Pain: a review of three commonly used pain rating scales. *J Clin Nurs* 2005;14(7):798–804. doi: 10.1111/j.1365-2702.2005.01121.x
25. Clinical Assessment Recommendations, 2nd ed. Chicago: American Society of Hand Therapists; 1992.
26. Åstrand PO, Rodahl K, Dahl HA, Stromme SB. *Textbook of Work Physiology*, 4th ed. Stockholm: Human Kinetics; 2003.
27. Astrand I: Aerobic work capacity in men and women with special reference to age. *Acta Physiol Scand Suppl* 1960;49(169):1–92.
28. Stroyer J, Essendrop M, Jensen LD, et al: Validity and reliability of self-assessed physical fitness using visual analogue scales. *Percept Mot Skills* 2007;104(2):519–33. doi: 10.2466/pms.104.2.519-533
29. Bohannon RW: Hand-grip dynamometry predicts future outcomes in aging adults. *J Geriatr Phys Ther* 2008;31(1):3–10.
30. Zander MF, Voltmer E, Spahn C: Health promotion and prevention in higher music education: results of a longitudinal study. *Med Probl Perform Art* 2010;25(2):54–65.
31. Martin Lopez T, Martinez J: Strategies to promote health and prevent musculoskeletal injuries in students from the high conservatory of music of Salamanca, Spain. *Med Probl Perform Art* 2013;28(2):100–6.
32. Manchester RA: Prevention of performance-related musculoskeletal disorders [editorial]. *Med Probl Perform Art* 2014;29(4):179–80.
33. Chan C, Driscoll T, Ackermann BJ: Effect of a musicians' exercise intervention on performance-related musculoskeletal disorders. *Med Probl Perform Art* 2014;29(4):181–8.
34. Leaver R, Harris EC, Palmer KT: Musculoskeletal pain in elite professional musicians from British symphony orchestras. *Occup Med (Oxford)* 2011;61(8):549–55. doi: 10.1093/ocmed/kqr129
35. Paarup HM, Baelum J, Holm JW, et al: Prevalence and consequences of musculoskeletal symptoms in symphony orchestra musicians vary by gender: a cross-sectional study. *BMC Musculoskel Disord* 2011;12:223. doi: 1471-2474-12-223
36. Davies J, Mangion S: Predictors of pain and other musculoskeletal symptoms among professional instrumental musicians: elucidating specific effects. *Med Probl Perform Art* 2002;17(4):155–69.

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