

# Epidemiology of Musculoskeletal Disorders in Musicians - Systematic Review

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## ABSTRACT

Musicians performing over an instrument demands repetitive, awkward postures and postural stress from prolonged sitting or standing. Musicians are found to be more prone to the development of Playing-Related Musculoskeletal Disorders (PRMDs) due to these factors. PRMDs are defined as 'pain, weakness, numbness, tingling or other symptoms that interfere with their ability to play an instrument'. There is an increasing interest seen in the medical issues faced by the musicians performing over an instrument. There are different type of musicians playing different instruments which means different instrumentalists face different musculoskeletal disorders depending upon many factors. There are intrinsic and extrinsic factors involved which contribute to the development of PRMDs in musicians. Development of PRMDs is seen to be a cause of early termination of musician's career. The purpose of study is to review the epidemiology of musculoskeletal disorders in musicians.

**Key Words:** Musculoskeletal disorders, Musculoskeletal problems, Prevalence of musculoskeletal injuries, Postural disorders, Playing-related strain in instrumentalists and musicians.

## INTRODUCTION

A musician is a person who performs music. The term musician is used for a person who follows performing music as a profession. Musicians may perform on their own or as a part of group, band or orchestra. There are different types of musicians playing different instruments – percussionist, string musicians, pianist, wind musicians.

There is an increasing interest seen in medical conditions of performing artists in last 20 years<sup>1</sup>. Major Playing Related Musculoskeletal Disorders are to be found in musicians<sup>2</sup>. Earlier musicians were advised about "No pain, no gain" in order to achieve performance skills and excellence<sup>2</sup>. Though this advice was well intended, but it has proved to be responsible for putting the

musicians at a high risk of developing musculoskeletal disorders, eventually career ending, also called as Playing Related Musculoskeletal Disorders (PRMD's) or pain (PRP – Playing Related Pain)<sup>3</sup>. Pain and first symptoms of overloads are often underestimated by musicians in early stages sent by the body<sup>3</sup>. A bit of studies disclosed that musicians consider treating pain and disorders caused due to playing an instrument as an indication of fragility and inability<sup>3</sup>. Regrettably this perspective causes high incidence of impairment and expulsion from their profession<sup>3</sup>.

Performing music over an instrument demands repetitive, awkward postures while playing and postural stress from prolonged sitting or standing and transporting instruments, music stands,

microphones, speakers and other equipment's by the musician<sup>4</sup>. Relying on type of instrument, the musician has to attain an uneven posture (e.g. – violin, viola, flute, guitar) and even posture (e.g. – piano) and can play with persistently elevated upper limbs (e.g. – violin, flute) or not (e.g. – drums, piano)<sup>3</sup>. Even countless hours of practice contribute in enlargement of tissue damage<sup>3</sup>. The stress of upcoming concerts and contests contributes to tension and intensifies the condition<sup>3</sup>. These factors that are required for performing music over an instrument causes musicians to have high susceptibility of developing musculoskeletal problems like pain, overuse injuries, focal dystonia, nerve entrapment and peripheral neuropathies<sup>5</sup>. Most common symptom of overuse among instrumentalists is found to be pain and most commonly affected are the string players<sup>4</sup>. Set of instruments that lead to frequent occurrence of pain are string instruments and wind instruments<sup>4</sup>.

Musician career is endangered when they are no longer able to play instrument and can have undesirable impact on their economy because of musculoskeletal disorders as they need to take rest to heal from injuries<sup>6</sup>. It was shown in an overview of literature, musculoskeletal disorders more affected women than men<sup>6</sup>. It was found in the national survey of orchestral musician's that 76% of participants took off from performing due to occurrence of serious injury in their career<sup>6</sup>. It was stated by some small studies that 50% of treated musicians were unable to return back to their career of performing music<sup>6</sup>. According to the Bureau of Labour Statistics, approximately 264,000 musicians were found to be employed in United States in 2006<sup>6</sup>. Among them 50% to 76% of professional musician's reported occurrence of musculoskeletal injuries<sup>6</sup>. In a University of Texas study, it was stated that prevalence of musculoskeletal injuries amidst the brass instrument players (French horn, trombone, trumpet or tuba) was 61%<sup>6</sup>. Highest rate of injuries was found in female trombonists concerning left upper extremity and upper back<sup>6</sup>. A study conducted by

International Conference of Symphony and Opera musicians found that 70% of women and 52% of men reported incidence of Playing Related Musculoskeletal Disorders<sup>6</sup>.

Amidst 1353 instrumentalist evaluated, major diagnoses included musculoskeletal disorders in 64%, peripheral nerve problems in 20% and focal dystonia in 8%<sup>1</sup>. Musculoskeletal disorders that were found included regional muscle pain syndrome in which upper limb, upper trunk and neck were most common<sup>1</sup>. Thoracic outlet syndrome, ulnar neuropathy at elbow and carpal tunnel syndrome<sup>1</sup>. Musicians playing violin or viola showed four times expansion in right forearm pain and twice risk for cervical pain, right shoulder pain and left forearm pain so as differentiated with pianists<sup>4</sup>. The least affected with playing-related musculoskeletal disorders are percussion musicians<sup>4</sup>. High rate of disorders is correlated with piano, guitar and harp<sup>4</sup>. Bilateral ulnar deviation is seen more in the wrist postures playing piano than in any other instrument<sup>4</sup>.

Playing Related Musculoskeletal Disorders are also caused due to issues involved in the interface between a musician and the instrument<sup>4</sup>. Intrinsic and extrinsic type of factors are involved<sup>4</sup>. Intrinsic factors for PRMD's consist of musician's size, strength, muscle tone, flexibility and existence of primary disorder<sup>4</sup>. Physical training is not highlighted in music schools which leads to development of risk factors for further life-threatening health conditions<sup>4</sup>. Musicians frequently spend time practicing for hours as differentiated with athletes<sup>4</sup>. Poor physical fitness contributes in occurrence of musculoskeletal disorders<sup>4</sup>. Extrinsic factors for PRMD's consist of the environment in which a musician performs and the technique used by the musician to play an instrument<sup>4</sup>. Techniques by which a musician plays an instrument involves the way a musician holds the instruments, force used to play an instrument and the occurrence of awkward and static or dynamic loading postures<sup>4</sup>.

Most musical instruments demand maintenance of awkward posture for prolonged period of time which is difficult to neglect<sup>7</sup>. Posture plays an important role in maintaining body tissue integrity<sup>7</sup>. Ergonomically incorrect posture can lead to numerous musculoskeletal disorders<sup>7</sup>. Example – increased tissue loading is seen in slumped posture with altered movement behaviour<sup>7</sup>. Posture change has consequences for both risk of injury and musical performance<sup>7</sup>.

Static load causes prolonged muscle contraction and tension across the joint and supportive soft tissue and bony structures<sup>4</sup>. Occurrence of static load is seen when an instrument is held in a fairly immobile position<sup>4</sup>. In divergence, dynamic load is force on joints, muscles and supportive structures<sup>4</sup>. There should be ideal balance between static load and dynamic load if aiming to reduce static load and increasing dynamic loads on connected joints and structures while playing<sup>4</sup>. Playing environment comprises of proper organization of work and break periods<sup>4</sup>. A hasty increase in practice session time can lead to increased strain on the associated joints and eventual incidence of pain and fatigue, consequently leading to occurrence of musculoskeletal disorders<sup>4</sup>. It was reported in a study that higher incidence of musculoskeletal disorders was found in musicians who practice for more than 20 hours per week<sup>4</sup>. Previously, many other researchers have stated that due to prolonged awkward posture while playing and prolonged static posture can lead to musculoskeletal disorders in musicians<sup>4</sup>.

**Aim:** To review the epidemiology of musculoskeletal disorders in Musicians.

**Objective:** To review the epidemiology of musculoskeletal disorders in Musicians.

## **MATERIALS AND METHOD**

The aim was to study and summarize the findings in the articles on epidemiology of musculoskeletal disorders that occur in musicians. This review was carried out by searching in databases including PubMed,

Google Scholar, ResearchGate, Science Direct, sciELO. Search was done using the following keywords Musculoskeletal disorders, Musculoskeletal problems, Prevalence of musculoskeletal injuries, Postural disorders, Playing-related strain in instrumentalists and musicians. Articles included in the study were between January 2011-December 2019 and the study was carried out in Pravara Institute of Medical Sciences. The inclusion criteria were, 1) Full text articles, 2) Articles which are published in last 10 years, 3) Cross-sectional studies and observational studies, 4) Population including population of all genders, 5) Population with age group ranging between 18-79 years. The exclusion criteria were as follows: 1) Duplicate articles, 2) Case reports, 3) Articles with only abstracts, 4) Statistics which did not present % of specific disorders.

### **Search Strategy:**

The following databases were searched: PubMed, Google Scholar, sciELO, Science Direct and Research Gate between January 2011- December 2019. In addition, other sources and reference lists of published papers were searched. The search keywords utilized were musicians; musculoskeletal disorders; musculoskeletal problems; prevalence of musculoskeletal injuries; postural disorders and playing-related strain in instrumentalists and musicians.

### **Study Selection:**

The preliminary search returned 84 published abstracts. Then 75 potentially relevant papers were identified and 9 duplicates were excluded. The second stage of the selection strategy involved the examination of each of the 75 screened abstracts and 20 articles were excluded due to inadequacy of statistical evaluation. In the next stage, 55 full text articles were assessed according to the eligibility criteria and 29 studies were excluded. Finally, 26 articles were selected for methodological quality assessment. 7 studies that

accomplished  $\leq 9$  points according to the QUADAS tool were excluded after the methodological quality assessment. Finally, 19 studies were included in the qualitative synthesis.

**Data Extraction:**

The following information was extracted: author’s name, publication year, sample size, description of data collection methods, prevalence rate, response rate, outcomes and associated factors related to PRMD.

**Procedure:**

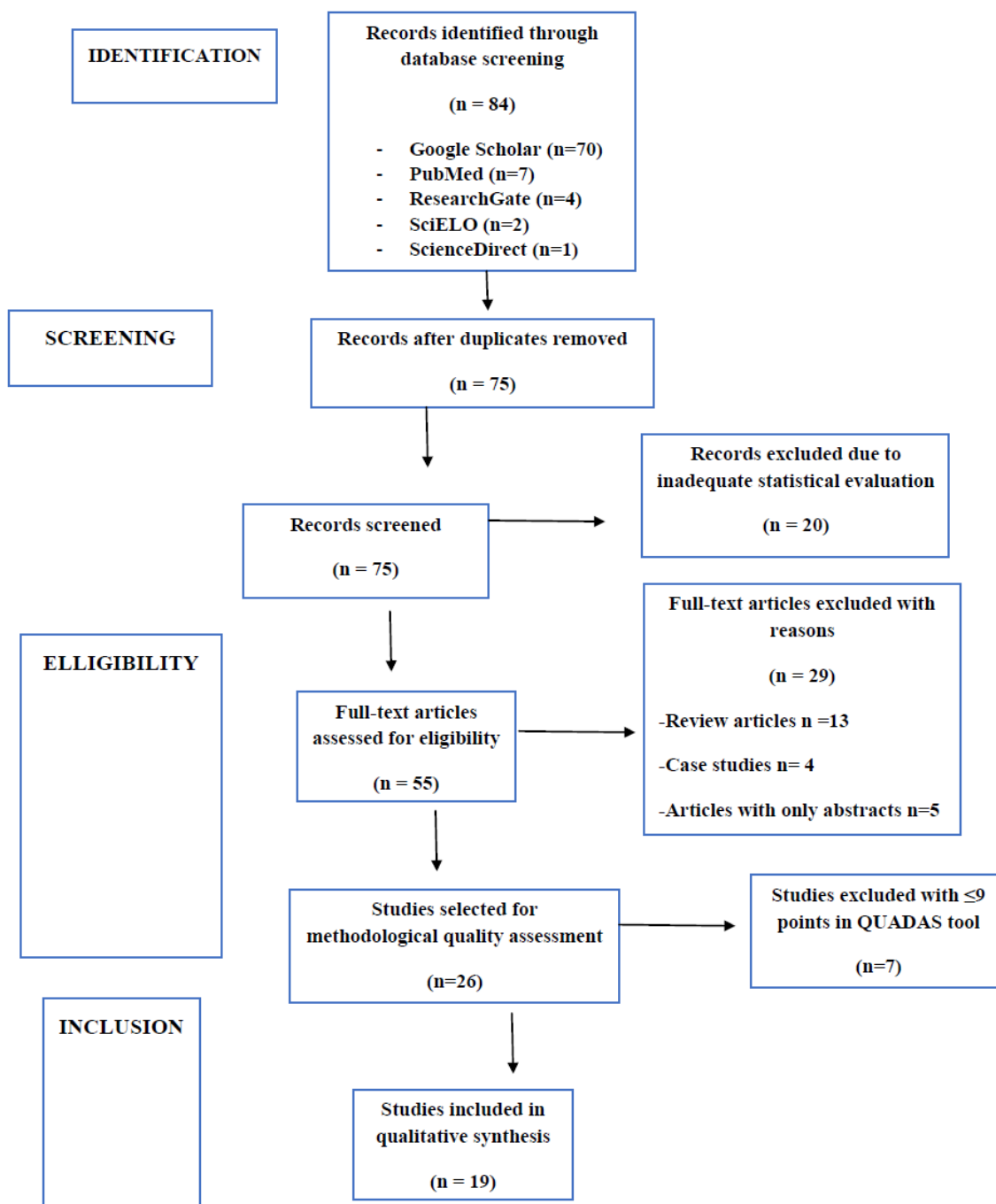


Figure 1- PRISMA flow diagram

**Assessment of Methodological Quality:**

The assessment of methodological quality was performed using QUADAS tool (Table 1). Whiting P, Rutjes AW, Reitsma JB, et.al established the development of QUADAS: a tool for the quality assessment of studies of diagnostic accuracy included in systematic reviews which was recommended by Cochrane Collaboration. This scale consisted of 7 questions concerning the sample size, presence of inclusion and exclusion criteria, use of

standard assessment method, type of samples studied (professional musicians or music students), presence of conflict of interest and presence of consent of local bioethics commission. The maximum score possible was 14 and the studies were classified as low evidential value (0-8 points), moderate evidential value (9-11 points) and high evidential value (12-14 points). Methodological Quality assessment of articles according to QUADAS tool was carried out (Table 2).

**Table 1. QUADAS tool: quality assessment of studies of diagnostic accuracy included in systematic reviews.**

Q. No.	QUESTIONS AND PUNCTUATIONS	
Q1.	The size of the studied group	0-9 – 0 pts. 10-99 – 1 pt. More than 100 – 2 pts.
Q2.	Presence of exclusion criteria	None – 0 pts. Present – 2 pts.
Q3.	Presence of inclusion criteria	None – 0 pts. Present – 2 pts.
Q4.	Standard assessment of ailments	Other/No information – 0 pts. Interview/Questionnaire – 1 pt. Standard Questionnaire – 2 pts.
Q5.	The group studied professional musicians	No information – 0 pts. University students/School students – 1 pt. Professionals – 2 pts.
Q6.	Presence of a conflict of interest	Present – 0 pts. No information – 1 pt. None – 2 pts.
Q7.	The presence of the consent of the local bioethics commission	No information – 0 pts. Present – 2 pts.
	Punctuations: 0-8 – low evidential value 9-11 – moderate evidential value 12-14 – high evidential value	

**Table 2. Methodological quality assessment according to QUADAS tool of the literature.**

Sr No.	Author of the Article and Year of Publication	Title of the article	Punctuations							Result
			1	2	3	4	5	6	7	
1.	A. Steinmetz et.al 2012	Playing-related musculoskeletal disorders in music students-associated musculoskeletal signs	1	2	2	1	1	2	0	9 (moderate)
2.	Flavio M. Silva, PT, ScD et.al 2018	Musicians injuries: upper quarter motor control deficits in musicians with prolonged symptoms- a case control study	1	2	2	1	2	1	0	9 (moderate)
3.	Dianna Kenny et.al. 2013	Performance-related musculoskeletal pain, depression and music performance anxiety in professional orchestral musicians: a population study	2	2	2	2	2	0	2	12 (high)
4.	Filiz Ozdemir et.al 2019	Evaluation of work-related musculoskeletal disorders and ergonomic risk levels among instrumentalist musicians	1	2	2	2	2	0	2	11 (moderate)
5.	Chia-Ying Ling et.al. 2018	Playing-related musculoskeletal disorders among classical piano students at tertiary institutions in Malaysia	2	2	2	1	2	2	2	8 (low)
6.	Adedayo T. Ajidahun et.al. 2017	Musculoskeletal problems among string instrumentalist in South Africa	2	2	2	1	2	0	2	11 (moderate)
7.	P. Sathya et.al 2019	A study to find prevalence of upper limb problems in musicians	2	2	2	1	1	0	0	8 (low)
8.	Sagar Vedpathak et.al 2017	Common musculoskeletal injuries faced by Indian drummers	1	2	2	1	2	0	0	8 (low)
9.	E. Savino et.al 2013	Musculoskeletal disorders and occupational stress of violinists	1	2	2	2	1	2	0	10 (moderate)
10.	Helene M Paarup et.al 2011	Prevalence and consequences of musculoskeletal symptoms in symphony orchestra musicians vary by gender: a cross-sectional study	2	2	0	2	2	0	2	10 (moderate)



11.	Helene M Paarup et.al 2012	Occurrence and co-existence of musculoskeletal symptoms and findings in work-attending orchestra musicians – an exploratory cross-sectional study	2	2	2	0	2	2	0	10 (moderate)
12.	Katriina Viljamaa et.al 2017	Musculoskeletal symptoms among finish orchestral musicians	2	2	2	2	2	0	2	12 (high)
13.	Érico Felden Pereira et.al. 2014	Work related stress and musculoskeletal complaints of orchestra musicians	1	2	0	2	2	2	2	8 (low)
14.	Laura M Kok et.al. 2013	A comparative study on the prevalence of musculoskeletal complaints among musicians and non-musicians	2	2	2	1	1	0	2	10 (moderate)
15.	Dusica L. Maric et.al 2019	A painful symphony: the presence of overuse syndrome in professional classical musicians	1	2	2	1	2	0	2	10 (moderate)
16.	Y. Kaufman-Cohen et.al. 2011	Correlation between risk factors and musculoskeletal disorders among classical musicians	1	2	2	2	2	2	2	13 (high)
17.	A. Steinmetz et.al. 2015	Frequency, severity and predictors of playing-related musculoskeletal pain in professional orchestral musicians in Germany	2	2	0	2	2	0	2	10 (moderate)
18.	Adedayo Tunde Ajidahun et.al. 2016	Upper extremity disability among string instrumentalists-use of the quick dash and the ndi	1	2	0	2	2	0	2	9 (moderate)
19.	Yael Kaufman-Cohen et.al. 2018	The correlation between upper extremity musculoskeletal symptoms and joint kinematics, playing habits and hand span during playing among piano students	1	2	2	1	1	0	1	8 (low)
20.	Frederico Baretto Kochem et.al 2017	Prevalence and associated factors of playing-related musculoskeletal disorders in brazilian violin players	2	2	2	2	2	2	2	14 (high)
21.	Heiner Gembris et.al 2017	Health problems of orchestral musicians from a life span perspective: results of a large-scale study	2	2	0	2	1	0	2	9 (moderate)
22.	Cláudia Maria SOUSA et.al. 2017	Playing-related musculoskeletal disorders of professional orchestra musicians from the north of portugal: comparing string and wind musicians	2	2	0	1	2	2	2	11 (moderate)
23.	Laura M. Kok et.al. 2016	The influence of sudden increase in playing time on playing-related musculoskeletal complaints in high-level amateur musicians in a longitudinal cohort study	1	2	2	2	2	1	0	8 (low)
24.	Luis Heredia et.al. 2014	Playing-related musculoskeletal problems among musicians of orquesta buena vista social club and supporting bands	1	2	0	2	2	0	0	7 (low)
25.	Mark Porter et.al. 2018	Extent of playing-related musculoskeletal problems in irish traditional music community a survey	1	2	0	2	1	2	2	10 (moderate)
26.	R. Leaver 2011	Musculoskeletal pain in elite professional musicians from british symphony orchestras	2	2	2	2	2	2	0	12 (high)

### 3. RESULT

The studies methodological quality was shown to be of moderate evidential value. Fourteen of 26 assessed articles using the QUADAS tool were classified as of moderate evidential value, seven studies as low evidential value and five studies as high evidential value. The main methodological faults according to the QUADAS tool were absence of specificity of exclusion criteria used in sample selection followed by inadequate information about conflicts of interest and presence of consent.

The sample size of included articles ranged from 12 to 2536 music professionals and music students. These subjects reported ages ranging from 18 to 79 years of age. Total number of males included in the study were n=3050 and total number of females were n=2737. Most studies included orchestral musicians<sup>11,14,22-24,29</sup>. Eight

papers included the string instrumentalists<sup>18,26-29,33,37</sup> and some studies included combination of different instrumentalists like percussionists, wind musicians, keyboardists, trombone players, brass players<sup>9,13,26-28,37</sup>. One paper also included fiddle players<sup>36</sup>. Two studies included violinists alone<sup>21,32</sup>.

#### Sociodemographic factors:

##### Gender-

Effect of gender as a determinant for musculoskeletal disorders has been frequently examined<sup>11,14,18,22,24,28,29,32</sup>. In multivariate analysis in the cross-sectional study, it was found that females were most likely to experience musculoskeletal symptoms like pain, disability at early stage than their male colleagues. Also, females presented greater risk to develop musculoskeletal disabilities<sup>32</sup>. A

Multivariate study presented, female musicians reported significantly more often incidences of pain that affected with their performance<sup>11</sup>. The prevalence rate of PRMD was measured during different times and there was a significant association found between being a female gender and musculoskeletal symptoms in at least one anatomic region<sup>22</sup>. The prevalence of symptom in one anatomic region within twelve months was reported by 97% of women and 83% of men. Seven days or more of symptoms were experienced by 86% of women and 67% of men and 63% of women and 49% of men had problems for more than 30 days within a year<sup>22</sup>. A study showed difference between anatomic regions where the musculoskeletal symptoms were experienced by female and male professional orchestra musicians. The study states that female musicians experienced significantly more neck, elbow and wrist pain than their male colleagues. However, analysis of results of papers showed that there is positive association between gender and musculoskeletal disorders.

**Age-**

Co-relation between age and musculoskeletal disorders was analysis from

the cross-sectional studies<sup>14,18,29,32</sup>. Age showed a significant association with presence of musculoskeletal problems in low back, left shoulder, right shoulder, left hand, head, neck, TMJ, teeth/jaw, right and left fingers<sup>18,29</sup>. Older musicians suffered from physical problems more frequently than their younger colleagues. The percentage of physical problems increased with age<sup>14</sup>. Older musicians were more likely to complain about their musculoskeletal symptoms<sup>32</sup>.

**Psychosocial factors:**

A positive association between stage fright or performance anxiety and musculoskeletal disorders was found in a multivariate analysis of two cross-sectional studies<sup>11,29</sup>. Performance anxiety was a remarkable factor related to PRMD development in neck, shoulder, elbow and wrist<sup>29</sup>.

**Health-related factors:**

Co-relation of cigarette smoking with musculoskeletal disorders was found in a univariate analysis, but papers performing multivariate analysis presented no such effect<sup>31,37</sup>.

**Work-related factors:**

Sr No.	Author Of The Article	Title Of Article	Name Of The Journal	Sample Size	Age/Gender	Type Of Instrument Played	Result And Conclusion Of Article
1.	A. Steinmetz et.al 2012	Playing-related musculoskeletal disorders in music students-associated musculoskeletal signs	European Journal of Physical and Rehabilitation Medicine	N=55	18 and above years/ Both genders	All orchestral musicians (except viola and tuba)	This study reported 81% of musicians experienced pain and discomfort while playing instruments. 6.5% indicated pain to be 'almost always' and 34.4% indicated pain to occur 'very often'. 18.8% indicated pain 'rarely' associated with playing instrument. In 44.1% occurred during and after playing an instrument, in 28.6% musicians pain appeared within less of 1 hour of playing an instrument. Music students were found to have more positive findings in musculoskeletal examination than non-music student group.

<i>Table 3 Continued...</i>							
2.	Flavio M. Silva, PT, ScD et.al 2018	Musicians injuries: upper quarter motor control deficits in musicians with prolonged symptoms- a case control study	Musculoskeletal Science and Practice	N=81	18-65 years/ both genders	Student or professional Instrumental musicians.	This study concludes that musicians with prolonged upper quarter playing related pain presented with higher prevalence of scapular dyskinesis and lower craniocervical flexion test performance when compared to musicians with no history of prolonged upper quarter playing related pain.
3.	Dianna Kenny et.al 2015	Performance-related musculoskeletal pain, depression and music performance anxiety in professional orchestral musicians: a population study	Psychology of Music	N=377	18-68 years/ both genders	Orchestra musicians.	This study concludes that 318 (84%) musicians reported pain interfering with performance, 100 (26.7%) reported never experienced PRMD, 184 (49.1%) musicians reported pain rating between 2 and 6, 91 (24%) musicians reported PRMD constantly. Female musicians reported significantly more frequent occasions of pain interfering with their performance. Performance anxiety shows positive association with musculoskeletal disorders development.
4.	Filiz Ozdemir et.al 2019	Evaluation of work-related musculoskeletal disorders and ergonomic risk levels among instrumentalist musicians	Annals of Medical Research	N=46	18-50 years/ both genders	Violinists, side flutists, pianists and balgama players.	This study found that most common pain areas in any period during lifetime were found as hand-wrist (65.2%), neck (58.8%), shoulders (52.3%). In last 12 months, most frequent areas were wrist (50%), back (43.5%) and neck (39.7%). In last month were hand-wrist (17.4%), neck (17.7%) and waist (17.7%). On the day of evaluation, neck 16.8%, shoulders 12.8% and lower back 11.2% were reported. Higher ergonomic risk level was found among piano and violin players.
5.	Adedayo T. Ajidahun et.al 2017	Musculoskeletal problems among string instrumentalist in south africa	South African Journal of Physiotherapy	N=114	18-78 years/ both genders	String instrumentalists	This study concludes that prevalence of musculoskeletal problems that affect the performance is high among string instrumentalists in South Africa.
6.	E. Savino et.al 2013	Musculoskeletal disorders and occupational stress of violinists	Journal of Biological Regulators and Homeostatic Agents	N=12	23-26 years/ both genders	Violinists	This study concludes that painful symptoms related to upper limbs were found to be 83.3%, 33.30% of lower limbs, 16.67% had pain related to jaw. Referred pain in right or left shoulders or both affected 16.67% and 33.33% subjects complained about painful symptoms in right elbow.
7.	Paarup et.al 2011	Prevalence and consequences of musculoskeletal symptoms in symphony orchestra musicians vary by gender: a cross-sectional study	BioMed Central	N=342	37-50 years/ both genders	Orchestra musicians	This study concludes high annual prevalence of 90% for PRMDs. Within the last year most symphony orchestra musicians experienced musculoskeletal symptoms in neck, back and upper extremities.



8.	Paarup et.al 2012	Occurrence and co-existence of musculoskeletal symptoms and findings in work-attending orchestra musicians – an exploratory cross-sectional study	BioMed Central	N=216	20-69 years/ both genders	Orchestra musicians	This study concludes that Symptoms and findings both were most common found in back, neck and shoulders.
9.	Katriina Viljamaa et.al 2017	Musculoskeletal symptoms among finnish orchestral musicians	Medical Problems of Performing Artists	N=361	45.0±10.0 years/ both genders	Orchestra musicians	This study concludes that symphony orchestra musicians experience nearly twice as much as musculoskeletal symptoms of the neck and upper extremities.
10.	Laura M Kok et.al 2013	A comparative study on the prevalence of musculoskeletal complaints among musicians and non-musicians	BioMed Central	N=577 (n=83 music students n=494 medical students)	Music students mean age – 21.5 years and medical students mean age – 22.1 years/ both genders	Classical instrument musicians	This study concludes that musculoskeletal complaints are significantly more common among musicians compared to non-musicians with higher number of upper extremity complaints.
11.	Dusica L. Maric et.al 2019	A painful symphony: the presence of overuse syndrome in professional classical musicians	International Journal of Morphology	N=50	21-58 years/ both genders	Professional classical musicians	This study concludes that high prevalence of overuse syndrome is found in professional classical musicians. The upper back and neck were the most frequent symptom site for musicians and primary symptom was pain.
12.	Kaufman-Cohen and Ratzon et.al 2011	Correlation between risk factors and musculoskeletal disorders among classical musicians	Occupational Medicine	N=59	26-66 years/ both genders	Classical musicians	This study concludes PRMD annual prevalence of 83% .73% musicians suffered from PRMDS in more than one joint. 58% reported upper extremity pain during past year. High prevalence of shoulder pain (55%), lower back pain (49%), upper back pain (42%) and neck pain (39%). 61% of the string players reported shoulder pain. The RULA score was significantly higher among string players in comparison to wind players.
13.	Steinmetz et.al 2015	Frequency, severity and predictors of playing-related musculoskeletal pain in professional orchestral musicians in germany	Clin Rheumatol	N=408	Mean age – 43.9 years/ both genders	Professional orchestra musicians	This study concludes with 89.5% lifetime prevalence of PRMDs in musicians. String players, particularly violinists, were the most affected instrument group, with 50% of musicians indicating more than 5 pain regions. Female sex and stage fright were proven to be predictors of musculoskeletal pain.
14.	Adedayo Tunde Ajidahun et.al 2016	Upper extremity disability among string instrumentalists- use of the quick dash and the ndi	Congent Medicine	N=99	33.3±15.3 years/ both genders	String instrumentalists	This study concludes that musculoskeletal problems were reported by 35 (35.7%) respondents (last 7 days) and 56 (56.6%) reported symptoms of musculoskeletal disorders over the last year. Musculoskeletal problems were mainly reported in the low back (50.5%), upper back (49.5%) and neck (46.5%) and left shoulder (44.4%). Problems were reported in four or more body regions in the upper extremity and trunk by 39 (39.4%) of the string instrumentalists.

**Table 3 Continued...**

15.	Frederico Baretto Kochem et.al 2017	Prevalence and associated factors of playing-related musculoskeletal disorders in brazilian violin players	Medical Problems of Performing Artists	N=106	Male mean age – 24 years Female mean age – 23 years/ both genders	Violinists	This study concludes that the prevalence of PRMD among Brazilian violin players is alarmingly high both in last 12 months (86.8%) and last 7 days (77.4%). The most reported painful regions were the neck, thoracic spine and upper limbs.
16.	Heiner Gembris et.al 2017	Health problems of orchestral musicians from a life span perspective: results of a large-scale study	Music & Science	N=2536	20-69 years/ both genders	Orchestra musicians	The study concludes that over half of orchestral musicians (55%, n =1,396) had physical problems that affected their playing. The prevalence increased significantly with advancing age, and string players and harpists had an above average frequency of experiencing physical problems. Almost half of (49%) orchestral musicians stated they felt pressure to perform.
17.	Cláudia Maria SOUSA et.al 2107	Playing-related musculoskeletal disorders of professional orchestra musicians from the north of portugal: comparing string and wind musicians	Acta Med Port	N=112	Mean age 37.8 years/ both genders	String and wind instrumentalists	This study concludes that approximately two thirds of professional orchestra musicians from the North of Portugal suffer from PRMD. Pain is more prevalent in string players but more intense in wind players.
18.	Mark Porter et.al 2018	Extent of playing-related musculoskeletal problems in the irish traditional music community	Medical Problems of Performing Artists	N=79	Mean age 35.38 years/ both genders	Fiddle players	This study concludes that PRMDs are a problem for Irish traditional fiddle players, especially during times of intense playing such as festivals. There was a positive association found between development of PRMDs and increased hours of play.
19.	R. Leaver et.al 2011	Musculoskeletal pain in elite professional musicians from british symphony orchestras	Occupational Medicine	N=243	23-64 years/ both genders	Symphony orchestra musicians	86% annual prevalence rate affecting neck, low back and shoulder. Weak association found with psychosocial work stressors and performance anxiety.

Six papers studied the association between musculoskeletal disorders and the instruments<sup>13,22,28-30,36</sup>. Result of some studies present that upper string players are more likely to experience musculoskeletal symptoms when compared to other instruments<sup>22,29,36</sup>. A study reported a positive association between average weekly orchestra hours with number of symptomatic upper limb joints<sup>31</sup>. Biomechanical risk factors were found to be related to playing a musical instrument<sup>31</sup>. A paper presented a multivariate analysis which showed that number of affected areas and practice hours significantly elevates the disability scores for the general DASH scores and performing arts score<sup>30</sup>. A higher disability score is associated with an

increase in the severity of musculoskeletal problem<sup>30</sup>. A Quick Exposure Check (QEC) was carried out to determine the ergonomic risk level which was found higher among piano and violin players. Higher ergonomic risk levels were stated by musicians who reported low back pain and hip-thigh pain<sup>13</sup>.

#### 4. DISCUSSION

Musicians are the workers who are exposed to several occupational hazards during their performance and practice period and are at high risk of developing Playing Related Musculoskeletal Disorders (PRMDs). The consequences of these injuries or disorders can lead to permanent performance loss or can even lead to premature termination of musical career<sup>8</sup>.

Though there is still a lack of publications with high methodological quality in the literature, 19 of 26 selected articles of moderate and high methodological quality were included in this review to study the epidemiology of musculoskeletal disorders in musicians.

The prevalence rate of PRMDs reported by musicians in last 12 months ranged from 86% to 90% in both genders<sup>22,26,28,37</sup>. Leaver et.al carried out a survey study using questionnaire on 243 British orchestral musicians (51% of 478 approached musicians) out of which 86% presented with musculoskeletal pain within the last 12 months. According to the findings of Kaufman-Cohen and Ratzon, who investigated the risk factors and musculoskeletal disorders in 59 classical orchestra musicians, 83% of the participating musicians reported symptoms in at least one body region within past 12 months. Kok et.al conducted a Dutch research study along with 83 orchestral musicians which presented with a prevalence rate for PRMD of 89.2% in the last 12 months indicating most affected anatomic regions neck, shoulders, elbows, wrists/hands and thoracic spine.

According to the studies few risk factors were found to have positive association with development of PRMDs. Dianna Kenny et.al conducted a population study on 377 orchestra musicians from Australia in which female musicians significantly reported more recurrent pain incidences that interfered with their performance. Compared to males, females had significantly higher susceptibility for having musculoskeletal symptoms Paarup et.al (2011). Kaufman-Cohen and Ratzon investigated the correlation between different risk factors and potential incidence of PRMD in classical musicians and found that female musicians report more musculoskeletal disorders than male musicians. Thus, female gender has proved to be a risk factor for development of PRMDs. Performance anxiety is positively related to development of musculoskeletal

disorders according to a cross-sectional study carried out by A. Steinmetz et.al. This indicates positive association of musculoskeletal disorders and psychosocial factors.

The type of instrument played by a musician is a known risk factor for the development of musculoskeletal disorder. Adedayo T. Ajidahun et.al conducted a cross-sectional study among the string instrumentalists in South Africa and reported that 77% of string instrumentalists reported problems in one or more anatomic regions with 35% presently undergoing problems that are hindering with their performance. Musculoskeletal problems of severity ranging between mild to moderate were presented in this study. Similar results were found in a study conducted by Steinmetz et.al (2015) utilizing the numerical pain rating scale. A study was carried out in North Portugal by Claudia Maria SOUSA et.al comparing string and wind musicians with 112 professional orchestra musicians participating with results showing 62.5% of interviewed musicians suffer from acute PRMD with an average of from 5 to 3.8 VNS (verbal numeric scale). Results indicate that string players (67.1%) are more affected than wind players (54.1%) by PRMDs. Paarup et.al (2011) investigated from questionnaire data obtained from 342 professional musicians from Danish symphony orchestras and found a very high prevalence of musculoskeletal symptoms in neck, back and upper extremities among professional symphony orchestra musicians. The symptoms had extensive impact on musician's level of function in work with altered or impaired way of playing an instrument in both leisure as well as work time. Woodwind players were found to be having remarkably low risk for musculoskeletal problems as compared to other instrument groups.

The most frequently affected anatomic regions among string players were upper limbs and vertebral column. 61% of musicians reported shoulder pain according

to Kaufman-Cohen and Ratzon. Practice hours and amount of time spend playing an instrument presents positive association with the presence of musculoskeletal pain (Steinmetz et.al 2015). Kok et.al (2013) states that overuse syndrome is the maximum reported diagnosis amid the instrumental musicians experiencing PRMDs. Filiz Ozdemir et.al conducted a cross-sectional study including 46 instrumentalist musicians to evaluate the work-related musculoskeletal disorders and ergonomic risk levels and found high incidence of WMSDs and higher ergonomic risk levels among musicians.

## 5. CONCLUSION

Based on our analysis of included studies, most of the study stated high prevalence of Playing-Related Musculoskeletal Disorders among musicians. These disorders are associated with intrinsic factors like age, gender and psychosocial characteristics and extrinsic factors like work environment, practice hours and instrument type. The average PRMD prevalence among musicians ranges from 45% to 55%. High prevalence of PRMDs is found majorly in string players.

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