Prevalence of Playing-related Musculoskeletal Disorders in String Players: A Systematic Review

Frederico Barreto Kochem, PT, MSc, and Julio Guilherme Silva, PT, PhD

Abstract

Objective: This systematic review aimed to assess the methodological quality of articles about the prevalence of playing-related musculoskeletal disorders (PRMDs) in string players and to identify the rate of prevalence and associated factors of PRMD.

Methods: Cross-sectional studies describing data on separate string players published in 5 different languages between January 1, 1980, and January 31, 2014, were included. The following databases were searched: MEDLINE, sciELO, and LILACS. Other sources and reference lists of published papers also were searched. The Loney Scale was used by 2 independent reviewers to evaluate the methodological quality, and only studies that achieved high scores were included.

Results: Of 1910 retrieved articles, 34 cross-sectional studies were selected for methodological assessment. However, only 8 studies reached satisfactory methodological quality scores. The prevalence rate of PRMD was alarmingly high, ranging from 64.1% to 90%. Women and older musicians were more affected in comparison to other instrumentalists. There seems to be a predominance of symptoms in the left upper limb in violinists and violists, whereas cellists and bassists report injuries in the right upper limb.

Conclusions: Professional and amateur string players are subject to development of PRMD. Low response rates were the most observed source of bias, and there is still a lack of publications with high methodological quality in the literature. (J Manipulative Physiol Ther 2018;41:540-549)

Key Indexing Terms: *Musculoskeletal Diseases; Prevalence; Occupational Diseases*

Introduction

Music can bring out emotions associated with leisure and wellbeing. However, it is difficult for the audience to imagine that the musicians are subject to occupational hazards as they play and perform.[1] Playing an instrument is a very complex task, and a professional musical career carries high physical and psychological demands.[2] On average, instrumentalists play 1300 hours annually in nonergonomic postures associated with conductor's pressure, performance anxiety, and a competitive work environment.[3,4] Furthermore, musicians have to practice individually and frequently teach and perform in chamber groups.[5] For these reasons, instrumental musicians are subject to a high risk of developing musculoskeletal diseases.[6]

The clinical symptoms include pain and functional limitations. These injuries can compromise their ability to continue playing their instrument(s) permanently and can even end a musician's career prematurely.[7] Publications that report on health problems and complaints of musicians date back to the 18th century.[8] One of the first reported cases was Robert Schumann's focal dystonia. A brilliant pianist in his younger years, he was forced by the disease to interrupt his instrumental career to become a composer.[9] Despite these early reports, it was only in the 1980s that performing arts medicine emerged as a medical specialty. This increased interest was due to an alarmingly high number of injured musicians and the creation of journals concentrating on these artists' problems.[10-12]

Many definitions of occupational diseases have been debated in the literature. Presently, the most accepted term used for music-related injuries is playing-related musculoskeletal disorders (PRMDs).[13] The concept of PRMD is any "pain, weakness, lack of control, numbness, tingling, or other symptoms that interfere with your ability to play your instrument at the level you are accustomed to."[14] Recent

Rehabilitation Sciences Program, Centro Universitário Augusto Motta, Rio de Janeiro, Brazil.

Corresponding author: Julio Guilherme Silva, PT, PhD, Rehabilitation Sciences Program, Centro Universitário Augusto Motta, Praças das Nações, no. 34, Bonsucesso, Rio de Janeiro, RJ, Brazil CEP 21041-010. Tel.: +55 21 98121 4557.
(e-mail: *jgsilva@hucff.ufrj.br*).

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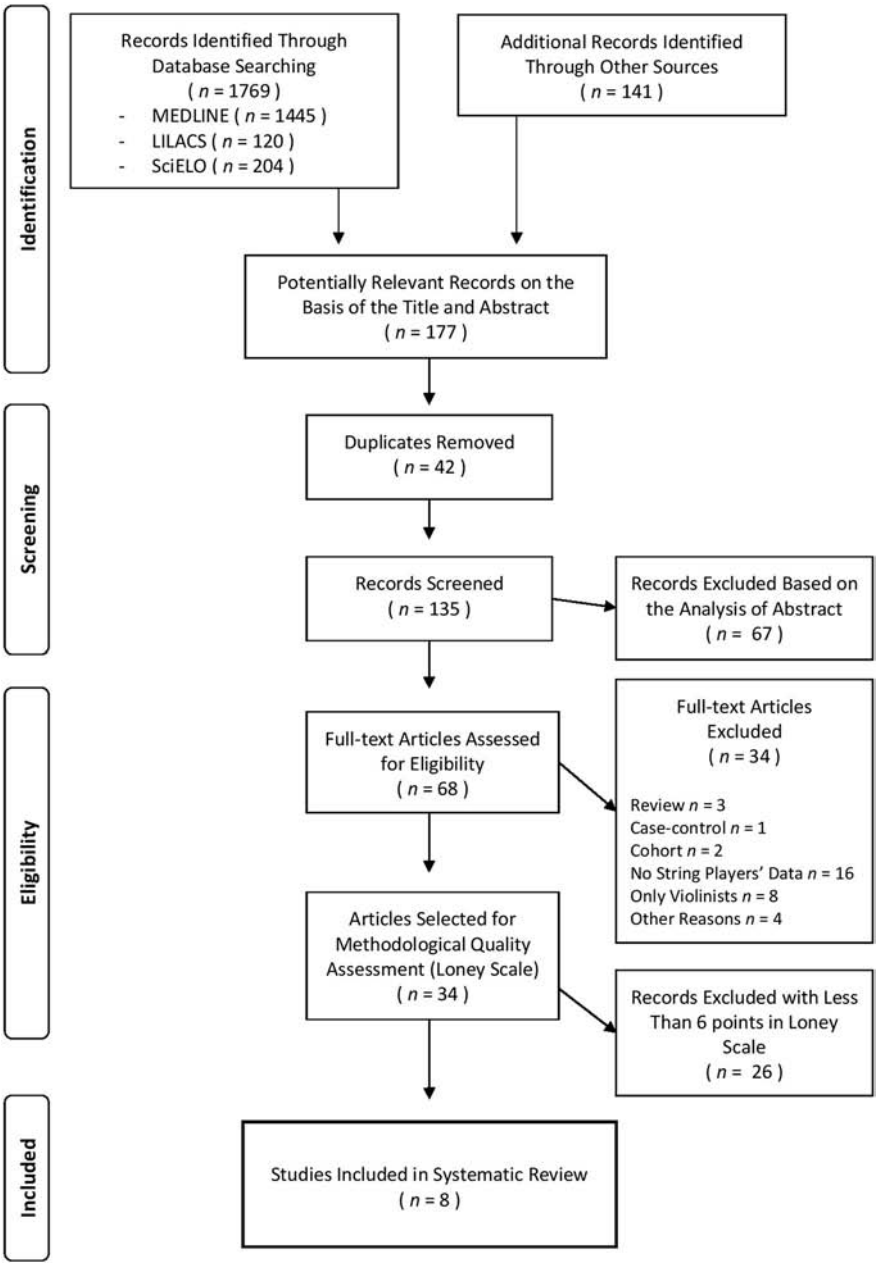

Fig 1. *PRISMA flow diagram.* PRISMA*, preferred reporting items for systematic reviews and meta-analysis.*

studies have indicated high prevalence rates of PRMD ranging from 44.7% to 93%, especially in string players.[15-20] Symptoms begin to appear when the musician increases the intensity and duration of his or her musical practice. Usually, pain is the artist's first symptom.[4] It is believed that the etiology of PRMD is multifactorial and can be associated with poor posture, nonergonomic instrument techniques, use of excessive force, and insufficient rest.[7] In addition, the aspects of instrument shape and size, the duration of rehearsals, and workplace environment can contribute to the development of PRMD.[21]

Conservatories and music colleges need early actions aiming at health promotion and prevention of PRMD. These activities may prepare musicians for subsequent professional demands, protect them from further injuries, and improve their performance.[22] Furthermore, it is essential that health professionals understand the instrumentalists' routine and workloads for precise evaluation of their symptoms and appropriate treatment of PRMD.[23]

Thus, the aim of this systematic review was to assess the methodological quality of articles about prevalence of

Table 1. *The Methodological Scoring System Used to Rate Included Studies*

Loney Scale Questions[25]	Scoring Criteria Used
1. Are the study design and sampling method appropriate for the research question?	Cross-sectional design and described study population (1 point)
2. Is the sampling frame appropriate?	Prevalence estimates of PRMD were referenced (1 point)
3. Is the sample size adequate?	Sample size ≥33 participants (prevalence estimated = 65%; relative precision = 25%; 95% CI) (1 point)
4. Are objective, suitable, and standard criteria used for measurement of the health outcome?	Reliable and standard measurement instrument (1 point)
5. Is the health outcome measured in an unbiased fashion?	Reported the steps taken to reduce bias (1 point)
6. Is the response rate adequate? Are refusers described?	It was considered an adequate response rate ≥80%, and refusers were described (1 point)
7. Are the estimates of prevalence given with confidence intervals (CI) and in detail by subgroup, if appropriate?	Presented CI for odds ratio and subgroup analysis (1 point)
8. Are the study participants and the setting described in detail and similar to those of interest to you?	Study participants described (1 point)
Total Score	8 points

CI, confidence interval; PRMD, playing-related musculoskeletal disorders.

PRMD in string players. A further objective was to identify the prevalence rate and associated factors of PRMD.

Methods

This systematic review was described in accordance with the preferred reporting items for systematic reviews and meta-analysis.[24]

Eligibility Criteria

This study included cross-sectional (prevalence) studies that were published between January 1, 1980, and January 31, 2014, and that described the data of separate string players. There was no restriction on the level of playing ability or grades; accepted articles included amateur (student) and professional musicians. Eligible studies also must have described the data collection methods. Accepted articles were published in English, Portuguese, French, Italian, or Spanish. Aiming to increase the methodological rigor of this systematic review, only studies that had achieved a score ≥6 points according to the Loney Scale were included. Papers without abstracts were excluded.

Search Strategy

The following databases were searched from November 2013 to February 2014: MEDLINE, sciELO, and LILACS. In addition, other sources and reference lists of published papers were searched. The search terms used were musicians; musculoskeletal; musculoskeletal disease; prevalence; frequency; incidence; orchestra; pain; PRMD; string players; instrumentalists. Furthermore, the following Boolean search strings were used:

- (“musculoskeletal diseases” OR “musculoskeletal”) AND (“diseases” OR “musculoskeletal diseases” OR “musculoskeletal”) AND (“disorders” OR “musculoskeletal disorders”) AND (“musicians”)
- (“musician” OR “musician’s” OR “musicians”) AND (“musculoskeletal diseases”)
- (“musician” OR “musician’s” OR “musicians”) AND (“occupational diseases”)
- (”musician” OR ”musicians”) and (”prevalence” OR ”frequency” OR ”incidence”)
- (”string players”) AND (”prevalence” OR ”frequency” OR ”incidence”)

Study Selection

The initial search returned 1910 published abstracts. Then 177 potentially relevant papers were identified, and 42 duplicates were excluded. The second stage of the selection strategy involved the examination of each of the 135 screened abstracts and the application of eligibility criteria. In the next stage, 68 full article texts were assessed, and 34 studies were excluded. Finally, 34 articles were selected for methodological quality assessment. However, only 8 studies that had fulfilled a minimum of 6 Loney Scale[25] points were included (n = 8). Two investigators independently performed all stages (Fig 1).

Data Extraction

The following information was extracted: author’s name, publication year, country, sample size, the number

Table 2. *Selected Studies for Methodological Quality Assessment*

Author/Year	Country	Sample (n)	Prevalence	Loney Scale Score
Paarup, et al[51]	Denmark	216	76.4%	7 (Good)
Paarup, et al[36]	Denmark	342	90%	7 (Good)
Leaver, et al[6]	England	243	86%	6 (Good)
Ranelli, et al[35]	Australia	731	77%	6 (Good)
Steinmetz, et al[50]	Germany	408	89.5%	6 (Good)
Abréu-Ramos and Micheo[49]	Puerto Rico	75	81.3%	6 (Good)
Kaufman-Cohen and Ratzon[47]	Israel	59	83%	6 (Good)
Yeung, et al[48]	Hong Kong	39	64%	6 (Good)
Steinmetz, et al[34]	Germany	408	47%	5 (Regular)
Ackermann, et al[39]	Australia	377	84%	5 (Regular)
Zetterberg, et al[31]	Sweden	227	89%	5 (Regular)
Kok, et al[4]	Netherlands	83	89.2%	5 (Regular)
Barton, et al[18]	USA	97	64.9%	5 (Regular)
Álvarez, et al[40]	Spain	48	68.7%	5 (Regular)
Fotiadis, et al[37]	Greece	147	81.6%	5 (Regular)
Monaco, et al[1]	Italy	65	50.7%	5 (Regular)
Trelha, et al[41]	Brazil	45	77.8%	5 (Regular)
Kaneko, et al[38]	Brazil	241	65%	4 (Regular)
Brandfonbrener[19]	USA	330	79%	4 (Regular)
Roset-Llobet, et al[23]	Spain	1639	77.9%	4 (Regular)
Burkholder and Brandfonbrener[29]	USA	314	84.4%	4 (Regular)
Guptill, et al[32]	USA	108	87.7%	4 (Regular)
Middlestadt and Fishbein[33]	USA	1378	66%	4 (Regular)
Joubrel, et al[43]	France	141	76.6%	3 (Regular)
Mazzoni, et al[20]	Brazil	29	93%	3 (Regular)
Larsson, et al[45]	USA	660	77%	3 (Regular)
Brown[30]	USA	36	66%	3 (Regular)
Caldron, et al[42]	USA	250	59%	3 (Regular)
Fry[28]	Australia	1249	9.3%	3 (Regular)
Andrade & Fonseca[44]	Brazil	419	88%	3 (Regular)
Mathews and Mathews[27]	England	29	55.1%	3 (Regular)
Dawson[17]	USA	329	44.7%	2 (Poor)
Lederman[46]	USA	1353	64%	2 (Poor)
Fry[5]	Australia	485	64%	1 (Poor)

of string players included, description of data collection methods, prevalence rate, response rate, string player outcomes, and associated factors related to PRMD.

Assessment of Methodological Quality

The assessment of methodological quality was performed using the Loney Scale.[25] Loney et al[25] established a guideline for critical appraisal of published articles concerning a health condition prevalence or incidence. This scale consists of 8 questions subdivided into 3 domains: validity of the study methods, interpretation, and applicability of the results.[26] Each methodological scoring criterion was previously determined by authors and is listed in Table 1. Two independent evaluators participated in this step, and disagreements were resolved by consensus. The maximum score possible was 8, and the studies were classified as poor methodological quality (0 to 2 points), regular methodological quality (3 to 5 points), or good methodological quality (6 to 8 points).

Results

A total of 1910 citations were retrieved. These papers were assessed for eligibility in several stages, as outlined in the flow diagram (Fig 1). The most frequent reasons for exclusion were no data on string players and samples composed of only violinists. Finally, 34 reports were selected for methodological quality assessment, with 28 English-language studies, 3 Portuguese-language studies, 1 Spanish-language study, 1 Italian-language study, and 1 French-language study.

The studies' methodological quality was shown to be regular (Table 2). Twenty-three of 34 evaluated articles using the Loney Scale[25] were classified as regular methodological quality,[1,4,18-20,23,27-45] 3 studies as poor methodological quality,[5,17,46] and 8 as good methodological quality.[6, 35, 36, 47-51] The main methodological faults,

Table 3. *Included Articles Description*

Author/Year	Total Sample (n); Age (y)	String Players (n [%])	Methods	Prevalence	String Players Outcomes	Conclusion	Loney Score
Paarup, et al[51]	216; 20-69	136 (62)	The musicians rated their complaints on an examiner-blinded scheme to assess the prevalence of perceived symptoms. Later, these participants were examined for clinical findings in the neck, back, and upper limbs.	76.4% (Weekly)	75% of upper strings players and 80% of lower string players presented clinical findings in the neck.	The most common of perceived symptoms areas were neck, back, and shoulders. There was a discrepancy between perceived symptoms and clinical findings. Should not be considered a diagnostic stand-alone test.	7 points
Paarup, et al[36]	342; 37-50	208 (60)	The questionnaire was designed to assess the prevalence of playing-related musculoskeletal disorders; 441 musicians from 6 symphony orchestras were invited, with 342 answering the questionnaire (response rate 78%).	90% (Annual)	Lower-string players had a significantly higher odds ratio of symptoms in neck and back for more than 30 days.	Compared to a sample of the general workforce, symphonic musicians had a higher prevalence of musculoskeletal problems.	7 points
Leaver, et al[6]	243; 23-64	151 (62)	A questionnaire concerning mental health, musculoskeletal symptoms, physical activities at work, and musical habits was used. Fourteen orchestras were invited (response rate 51%).	86% (Annual)	The odds ratio of low back pain was 50% lower in brass players than in string players.	Somatizing tendency was the primary associated factor, but stage fright has less impact.	6 points
Ranelli, et al[35]	731; 7-17	199 (27)	Instrumental music students of government schools were invited. The Young Peoples Activity Questionnaire was used to assess playing-related musculoskeletal disorders.	77% (Lifetime)	Upper-string players reported problems in the neck and left upper limb. Lower-string players reported problems in the right upper limb.	Sex, age, playing time, and instrument played were associated with prevalence of reported symptoms in children musicians.	6 points

Steinmetz, et al[50]	408; mean, 43.9 (SD ±10.3)	229 (56)	Although 720 professional orchestral musicians were approached, only 408 were included in the sample (response rate 57%). A questionnaire was designed for sociodemographic and physical data.	89.5% (Lifetime)	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.	6 points
Abréu-Ramos and Micheo[49]	75; Mean, 37.9 (SD ±9.9)	47 (62)	The musicians answered a questionnaire concerning demographic data, musical habits, and playing-related musculoskeletal disorders. Later, an upper-body clinical examination was performed.	81.3% (Lifetime)	Violin and viola players reported a high percentage of neck and left shoulder pain. However, cello and bass players reported a higher prevalence of right upper limb symptoms.	Musicians have a high prevalence of upper-body musculoskeletal problems. String players and female participants were the most commonly affected groups.	6 points
Kaufman-Cohen and Ratzon[47]	59; 26-66	39 (66)	The Standardized Nordic Questionnaire, Disabilities of the Arm, Shoulder, and Hand and NIOSH Generic Job Stress Questionnaire were used. The RULA was used for clinical examination.	83% (Annual)	61% of the string players reported shoulder pain. The RULA score was significantly higher among string players in comparison to wind players.	The RULA score and the perceived physical environment were the 2 strongest statistical predictors for musculoskeletal problems.	6 points
Yeung, et al[48]	39; not reported	25 (64)	The questionnaire was designed to obtain demographic data, playing habits, musculoskeletal symptoms and non-playing-related musculoskeletal symptom information.	64.1% (Annual)	The most common areas of symptoms were shoulder/ upper arm (52%) and neck (32%).	Younger and less-experienced musicians were more likely to develop symptoms. Regular exercises appear as a preventive factor.	6 points

NIOSH, National Institute for Occupational Safety and Health; *RULA*, rapid upper limb assessment; *SD*, standard deviation.

according to the Loney Scale, were inadequate response rate (29 papers), biased health outcome (27 papers), the absence of confidence intervals (CIs) and detailed subgroups (25 papers), and nonstandardized criteria for measurement of health outcome (21 papers).

The sample size of the included articles ranged from 39 to 731 professional orchestra musicians and music students.[6,35,36,47-51] These artists reported ages ranging from 7 to 69 years, and the average length of time practicing music ranged from 4.7 to 26.5 years. Most of the study samples were composed of string players, except for 1 article in which pianists prevailed.[35] Regarding the PRMD, the prevalence rate was measured during different times. Three studies found the PRMD lifetime prevalence rate ranging from 77% to 89.5%.[35,49,50] For a 12-month prevalence, 4 articles detected a rate ranging from 64.1% to 90%.[6,34,43,48] Only 1 study evaluated the musician's symptoms over the last week, and the prevalence rate found was 76.4%.[51]

Discussion

Instrumentalists are workers who are exposed to several occupational hazards during their artistic practice, particularly the risk of developing PRMDs. The consequences of these injuries can result in permanent performance impairment or can even end one's musical career prematurely.[5-7] However, there is still a lack of publications with high methodological quality in the literature, and these studies have been given little emphasis with regard to reducing the potential sources of bias. For this reason, only 8 of 34 selected articles of methodological quality assessment achieved satisfactory scores according to the Loney Scale (≥6 points) (Table 3).

The prevalence rate of PRMD ranged from 64.1% to 90%, and most musicians reported symptoms in the last 12 months before data collection.[6,36,47,48] According to Kaufman-Cohen and Ratzon,[47] 66% of the 39 string players surveyed reported upper-limb pain in the last year. In a study by Steinmetz et al,[50] which involved a sample of 408 instrumental musicians with 229 string players, 90.3% of upper string players (violinists and violists) and 90.6% of lower string players (cellists and bassists) reported more than 5 painful body areas due to artistic practice. Likewise, Abréu-Ramos and Micheo[49] found that 93.3% of lower string players reported the presence of PRMD at some point in their careers, and 83.6% of musicians surveyed believed that the cause of these injuries were their musical activity.

The most commonly affected body regions among string players were upper limbs and vertebral column. According to Kaufman-Cohen and Ratzon,[47] 61% of musicians reported shoulder pain. However, there seems to be a predominance of symptoms in the upper left limb in upper string players, whereas lower string players report injuries in the upper right limb. Similarly, the results found by Ranelli et al[35] corroborate this hypothesis. Violin and viola players reported mostly pain in the neck, followed by the left shoulder, left elbow, and left hand. In contrast, the most frequent pain regions among cellists and bassists were the lumbar spine, right shoulder, right elbow, right hand, and the left elbow. One possible explanation for this difference is that the left arm of upper string players functions to sustain the weight of the instrument, with a predominance of static postures. In addition, the presence of symptoms in the right arm of lower string players can be related to the bow handgrip and bowing techniques.[35,49] However, there is a discrepancy between these musculoskeletal symptoms and clinical findings in the same regions, which shows the fluctuating nature of musculoskeletal injuries.[51]

The development of PRMD occurs for a variety of reasons.[48] According to Leaver et al,[6] there are occupational and nonoccupational factors. The results of their study with 243 musicians revealed that nonoccupational factors, such as sex, age, the somatizing tendency (using the Brief Symptom Inventory), and mood (using the Short-Form-36 Questionnaire), are reliable predictors of pain. Women were more often affected than men, especially regarding neck pain (odds ratio [OR] 2.0, 95% CI 1.2-3.3, $P < .05$) and shoulder pain (OR 2.2, 95% CI 1.3-3.8, $P < .05$). Older musicians commonly reported elbow pain, particularly those aged from 40 to 50 years (OR 3.3, 95% CI 1.3-7.9, $P < .05$) and those older than 50 years (OR 4.1, 95% CI 1.6-9.8, $P < .05$). A high somatizing score was a predictor of pain in all body regions with an OR ranging from 2.5 for wrist pain (95% CI 1.2-4.9, $P < .05$) to 5.5 for shoulder pain (95% CI 2.7-11.0, $P < .05$). Also, a low mood score was related to neck pain (OR 2.8, 95% CI 1.6-4.9, $P < .05$) and shoulder pain (OR 2.1, 95% CI 1.2-3.6, $P < .05$). Corroborating these findings, Paarup et al[36] observed that most of the analyzed painful regions in women were statistically significant for 12-month prevalence (OR 6.5, 95% CI 2.3-18.2, $P < .0001$) and weekly prevalence (OR 3.0, 95% CI 1.9-4.5, $P < .0001$). According to Steinmetz et al,[50] performance anxiety also was a significant factor associated with PRMD development in neck (OR 1.67, 95% CI 1.00-2.78, $P < .05$), left shoulder (OR 1.99, 95% CI 1.28-3.09, $P < .05$), right elbow (OR 1.85, 95% CI 1.12-3.06, $P < .05$), left elbow (OR 2.18, 95% CI 1.28-3.72, $P < .05$), right wrist (OR 1.95, 95% CI 1.21-3.14, $P < .05$), and left wrist (OR 1.99, 95% CI 1.28-3.09, $P < .05$). The amount of time spent playing or practicing one's musical instrument seems to be related to the presence of pain.[50] As reported by Ranelli et al,[35] an increase of 1 hour in a musician's training causes a 5% to 7% rise in the PRMD OR of lifetime prevalence ($P = .014$) and monthly prevalence ($P = .001$).

An important source of bias among the included articles was the response rate, which ranged from 23% to 90.4%. Studies with low response rates are prone to selection bias, resulting from the fact that musicians who have experienced

PRMD are more interested in taking part than asymptomatic musicians. Because of the absence of a gold standard method for diagnosing PRMD, and because of the considerable variability of musicians' age and occupation, it is hard to compare the results found in the included studies. Because cross-sectional studies only make associations between associated factors and outcomes and no causal inferences can be drawn, they should be interpreted with caution.

Limitations

The search strategy used may not have retrieved all relevant papers. To minimize this potential source of bias, searches were conducted in multiple databases, with thorough hand-searching and checking reference lists. Another limitation concerns the language in which the articles were published. This systematic review included studies in 5 languages, but relevant publications in German, Croatian, and Dutch languages may have been discarded because the authors were not fluent in these languages.

Another significant limitation of this systematic review concerns the level of evidence from included studies. Only cross-sectional studies were eligible for this review because these are the most appropriate study designs to report the prevalence of a health condition. In the cross-sectional study design, data concerning each participant is recorded at 1 point in time, often from a questionnaire. Thus, the prevalence of the outcome can be established, and some associations might be observed.[52] However, according to Krithikadatta[53] and Melnyk and Fineout-Overholt,[54] descriptive studies have a low level of evidence. McNair and Lewis[52] affirm that the "information gained from the cross-sectional study is often a starting point that provides the impetus to use a more powerful design to substantiate the initial findings." Including only cross-sectional studies has provided a better comparison between them, and the most common biases found in prevalence studies can be observed. Future research should be conducted using reliable and validated measurement instruments, identifying and avoiding sources of bias (mainly low response rates), and using appropriate statistical tests. Thus, preventive actions and therapeutic methods focused on musicians will be designed and performed.

Conclusion

Musicians are workers who are subject to development of PRMDs, especially string players. The PRMD prevalence rate is high, ranging from 44% to 90.3%. These impairments are associated with intrinsic musician factors, such as sex, age, and psychosocial characteristics, or are related to extrinsic factors, such as work environment and instrument shape. However, there is still a lack of high-methodological-quality studies about performing arts medicine.

Funding Sources and Conflicts of Interest

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Contributorship Information

Concept development (provided idea for the research): F.B.K., J.G.S.
Design (planned the methods to generate the results): F.B.K., J.G.S.
Supervision (provided oversight, responsible for organization and implementation, writing of the manuscript): F.B.K., J.G.S.
Data collection/processing (responsible for experiments, patient management, organization, or reporting data): F.B.K., J.G.S.
Analysis/interpretation (responsible for statistical analysis, evaluation, and presentation of the results): F.B.K., J.G.S.
Literature search (performed the literature search): F.B.K., J.G.S.
Writing (responsible for writing a substantive part of the manuscript): F.B.K., J.G.S.
Critical review (revised manuscript for intellectual content, this does not relate to spelling and grammar checking): F.B.K., J.G.S.

Practical Applications

- String players are workers who are subject to development of playing-related musculoskeletal disorders.
- The prevalence of these disorders is high among musicians.
- There is a lack of high-methodological-quality studies about performing arts medicine.

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