

How do we assess musicians' musculoskeletal symptoms?: a review of outcomes and tools used

Jessica STANHOPE^{1*}, Dino PISANIELLO¹, Rebecca TOOHER¹ and Philip WEINSTEIN²

¹School of Public Health, The University of Adelaide, Australia

²School of Biological Sciences, The University of Adelaide, Australia

Received March 20, 2018 and accepted November 30, 2018

Published online in J-STAGE December 14, 2018

Abstract: Recent reviews of musicians' musculoskeletal symptoms (MSS) have reported heterogeneity in the outcomes reported and data collection tools used, making it difficult to compare and synthesise findings. The purpose of this present review was to improve the consistency of future research, by documenting the outcomes reported in recent studies of musicians' MSS and the data collection tools used. All English language, peer-reviewed studies, published 2007–2016 that reported musicians' self-reported MSS outcomes were identified. Details of the types of outcomes reported and the tools used were extracted, and synthesised descriptively. A range of MSS outcomes were reported, including MSS with a temporal relationship to activities performed, and the consequences of symptoms. Only 24% of studies used standardised questionnaires, with the Nordic Musculoskeletal Questionnaire (NMQ) being the most commonly used. To improve the homogeneity of outcomes and data collection tools when investigating musicians' MSS, we recommend using the NMQ, where appropriate. Recall periods of 12-months and 7-d are the most appropriate for prevalence, and 7-d recall periods for ratings. Importantly, outcomes and the tools used to collect data should be reported in sufficient detail to ensure that the study can be replicated, critiqued, and accurately interpreted.

Key words: Musicians, Outcomes, Measures, Rating scales, Questionnaires, Musculoskeletal, Pain, Review

Background

Musculoskeletal symptoms (MSS) include pain, stiffness, weakness, numbness, and loss of control in soft tissue, peripheral joints and the axial spine^{1,2}. When assessing MSS, there are a number of parameters that need to be considered. These parameters include the MSS quality (e.g. pain, tingling), intensity, location, and frequency of symptoms, and temporal relationship of MSS to a particular activity, as well as activity and participation limitations due to MSS, and whether MSS are perceived to be due to a

particular factor (e.g. resulting from work). The variability in the assessment of each of these parameters (e.g. which scale was used to measure MSS intensity), the potential combination of parameters, and the recall periods of interest (e.g. last 12-months, current) result in a seemingly endless range of potential outcomes relating to MSS.

Recent systematic reviews of various occupational groups^{3–7}, including musicians^{8–14}, have identified inconsistencies in the case definitions used for MSS, the specific outcomes of interest, and the methods of data collection (e.g. questionnaires). In the first systematic review¹² of musicians' MSS, published in 1998, the authors recommended that clear case definitions be used and reported, and that these allowed for comparison with other studies. Despite this recommendation, issues remain^{8–11, 13, 14}.

*To whom correspondence should be addressed.

E-mail: Jessica.stanhope@adelaide.edu.au

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Recently there have been calls for guidelines regarding the data collection tools used to assess musicians' MSS¹⁴. One of the potential barriers to improving the consistency of terminology and case definitions is that there has not been a comprehensive investigation of the outcomes and tools used for studies examining musicians' MSS. The present review builds on previous systematic reviews regarding the prevalence^{8–12} and incidence of^{11, 12}, or risk factors for^{8, 13, 14} MSS in musicians, by looking specifically at the types of outcomes reported and the data collection tools used, rather than focusing on study findings. Additionally, the present review considers types of studies which have not been addressed in existing reviews (e.g. interventions) and includes a broader range of outcomes (e.g. symptom intensity, seeking treatment). In addition, we include all types of musicians, making this review the most comprehensive examination of the topic to date, and providing the foundation for the suggested guidelines regarding future data collection tools to assess musicians' MSS¹⁴.

We aimed to improve the consistency of research regarding musicians' MSS, by reviewing the reported outcomes (e.g. recall periods, severity), and data collection tools used (e.g. questionnaires, rating scales). By doing so, future research can be designed to ensure that findings can be compared and/or synthesised with the existing literature, thus improving the overall evidence base for developing and testing appropriate strategies to reduce the burden of MSS for musicians.

Methods

A broad systematic search was first performed to identify any studies regarding musicians' MSS (including reviews). Studies were identified through a systematic search seven library databases, and screening of the table of contents and abstracts section of *Medical Problems of Performing Artists* to identify any studies regarding musicians' MSS (Appendix 1). The citation and reference lists of musicians' MSS were screened to identify additional potentially relevant studies. From the resultant list of studies, we included studies reporting self-reported MSS outcomes. Outcomes included, but were not limited to: MSS which were attributed to or aggravated by specific factors; the consequences of MSS (e.g. sick leave, consulting a health professional); MSS with a temporal relationship to an activity (e.g. MSS while playing); and more general outcomes, which were reported as the presence or absence of an outcome, and ratings of frequency or intensity. Stud-

ies were only eligible if they were published in English language, within peer-reviewed journals from 2007–2016. The first author determined study inclusion and exclusion, with another reviewer consulted where there was any uncertainty.

Extracted data included: the questionnaire(s) and ratings scales used (including scale type, rating type, scale length, anchors); body charts used; 'music-related' MSS terminology and definitions; MSS quality, recall-period, location, duration, severity, and frequency; MSS with a temporal relationship to activities; MSS resulting from perceived aggravating or risk factors; and MSS consequences (e.g. impact on playing, management strategies used). Data from included studies were manually extracted twice by one reviewer, and checked by another reviewer, with discrepancies resolved through discussion with a third reviewer, if required. Verification by a second reviewer is an accepted approach for systematic reviews¹⁵, with evidence suggesting that review findings do not differ whether there has been double extraction or single extraction with verification¹⁶.

Following the methods used by Smith *et al.*¹⁷, if the questionnaire was included in the appendix, or a published questionnaire was cited with no mention of any modifications having been made, the data extracted were checked against the questionnaire used, to fill in gaps from the text and to identify discrepancies. If the modifications made to questionnaires were described, it was assumed that other elements of the questionnaire remained the same and thus these questionnaires were also checked. If papers reported on the same study, it was assumed the same questionnaire was used.

Data were reported descriptively, and in tabulated form. Outcomes were only reported where the recall-periods were clearly stated, as this is integral to defining outcomes. The outcomes were classified as temporal relationship of MSS to an activity, MSS with perceived aggravating or risk factors, the consequences of MSS (including management strategies), and MSS in general. The latter category included outcomes where the term music-related or similar (e.g. playing-related) was used, but not defined in such a way that the relationship between MSS and musical activity could be determined.

Because we were interested in describing the types of outcomes and the tools used to collect the data, rather than the findings of the included studies per se, we did not assess methodological bias, as is typical of reviews of this nature (e.g.^{18–26}).

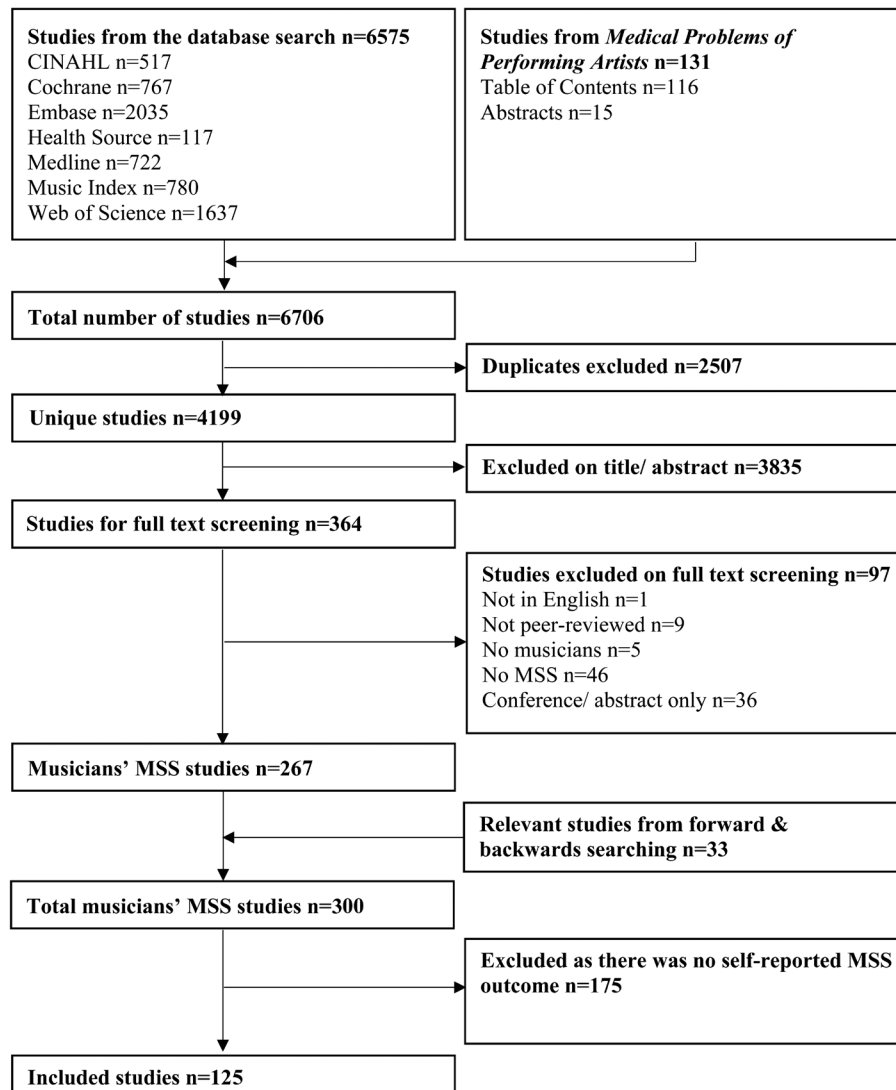


Fig. 1. Flow chart of study inclusion/exclusion.

CINAHL: Cumulative Index to the Nursing and Allied Health Literature; MSS: Musculoskeletal symptoms.

Results

A total of 125 articles met the inclusion criteria (Fig. 1). Of these articles, there were 110 unique studies, with some articles reporting on the same dataset^{27–50}. Values reported throughout this review refer to the 110 unique studies, unless otherwise indicated.

Questionnaires used

Few studies (24%) used existing standardised questionnaires that have been used with the general population; however, there appears to be an increase in their usage with 33% of studies published from 2012 onwards us-

ing such questionnaires. The most commonly used questionnaires (including translations) were the Nordic Musculoskeletal Questionnaire (NMQ, also known as the Standardised Nordic Questionnaire)⁵¹, the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire⁵², and the Neck Disability Index^{53–55} (Table 1). Of note, while there was no mention of modifications to the NMQ there appear to have been some discrepancies in the symptoms reported^{43, 44, 56, 57}, recall periods^{58, 59}, and the body regions⁶⁰ in some studies.

In addition to the published modifications of the NMQ (Table 1), seven studies reported modifying the NMQ. Kaufman-Cohen and Ratzon⁷⁵ added additional up-

Table 1. Published questionnaires used

Questionnaire	Studies
Nordic Musculoskeletal Questionnaire (NMQ) ^{51, 61, 62)}	43, 44, 56, 57, 60)
Portuguese translation ^{63–65)}	58, 59, 66)
Extended version ⁶⁷⁾	68)
Engquist <i>et al.</i> 's ⁶⁹⁾ modification for musicians	70)
Paarup <i>et al.</i> 's ³³⁾ modified version ^a	32, 33)b
Dutch Musculoskeletal Questionnaire (which includes the NMQ) ⁷¹⁾	72)
Disability of the Arm, Shoulder and Hand Questionnaire ^{52, 73)}	74, 75)
Turkish version ⁷⁶⁾	77)
Spanish version ⁷⁸⁾	68)
Disability of the Arm, Shoulder and Hand Questionnaire: Performing art/sports module ^{52, 73)}	79, 80)
Turkish version ⁷⁶⁾	77)
Spanish version ⁷⁸⁾	68)
Quick Disability of the Arm, Shoulder and Hand Questionnaire ^{81, 82)}	83)
Quick Disability of the Arm, Shoulder and Hand Questionnaire: Performing arts/sports module ^{81, 82)}	83)
Brief Pain Short Form ⁸⁴⁾	85)
West Haven Yale Multidimensional Pain Inventory ⁸⁶⁾	87)
McGill Pain Questionnaire Short Form ⁸⁸⁾	89)
Neck Disability Index ^{53–55)}	83, 90–94)
Spanish version ⁹⁵⁾	68)
Shoulder Disability Questionnaire ^{96, 97)}	98)
Shoulder Pain and Disability Index ⁹⁹⁾	94)
Research Diagnostic Criteria for Temporomandibular Disorders ¹⁰⁰⁾	101)
Temporomandibular Joint Disorder questionnaire ¹⁰²⁾	103)
Fonseca Anamnestic Questionnaire	
Portuguese version ^{104–106)}	107)
Temporomandibular Joint Disorder screening questions ¹⁰⁸⁾	109, 110)
Brief Illness Perceptions Questionnaire ¹¹¹⁾	
Dutch version	42)
Patient Specific Functional Scale ¹¹²⁾	91)
Health-Pain-Injury Inventory ^{a113)}	113)
Ranelli's ¹¹⁴⁾ modification of the Young People's Activity Questionnaire ^{a115)}	27–29, 45, 46, 116)b
Musculoskeletal Pain Intensity and Interference Questionnaire for professional orchestra musicians ^{a117)}	118)
Musculoskeletal Pain Questionnaire for Musicians ^{a119)}	120)
Musician Injury Survey ^{a121)}	121)
Physical Discomfort Questionnaire for Traditional Korean Instrument (Gukakgi) Players ^{a39)}	38, 39)
Marching Unit Incident Report Form ^{a122)}	122)
Ackermann & Driscoll's ¹²³⁾ questionnaire ^a	34–37, 124)
Allsop & Ackland's ¹²⁵⁾ questionnaire ^a	125)
Hatheway & Chesky's ¹²⁶⁾ questionnaire ^a	126)
Kava <i>et al.</i> 's ¹²⁷⁾ questionnaire ^a	127)
Stanhope <i>et al.</i> 's ¹²⁸⁾ questionnaire ^a	128)
Steinmetz <i>et al.</i> 's ¹²⁹⁾ questionnaire ^a	129)
Steinmetz <i>et al.</i> 's ¹³⁰⁾ questionnaire ^a	130)
Woldendorp <i>et al.</i> 's ¹³¹⁾ questionnaire ^a	131)
Wood's ¹³²⁾ questionnaire ^a	133)

^ahave only been used by those who developed the questionnaires. ^bRanelli *et al.*^{27–29)} reported the use of a modification of the Young People's Activity Questionnaire¹¹⁵⁾ but did not cite the modification¹¹⁴⁾ however it is assumed that this modification was used as the articles^{27–29)} appear to report on the same project as two later articles^{45, 46)} which cite the modification¹¹⁴⁾. Paarup *et al.*³²⁾ did not cite the modified Nordic Musculoskeletal Questionnaire used, but appears to report on the same study³³⁾ where the questionnaire was published. ^cLima *et al.*⁸⁵⁾ also referred to it by its former name the Wisconsin's Pain Inventory.

per limb regions, while Leaver *et al.*¹³⁴⁾ added a 4-wk recall period and also added items regarding ‘disabling pain’, which they defined as ‘pain in the past 12 months present for at least a month which prevented attendance at work for at least 1 d’⁷⁵⁾. Similarly, Kok *et al.*⁷⁹⁾ and Bruno *et al.*¹³⁵⁾ integrated Zaza *et al.*’s²⁾ definition for playing-related musculoskeletal disorders into the NMQ, although different variations of the definition were used, as will be discussed below. Bruno *et al.*¹³⁵⁾ also changed the time period to 4-wk, and both studies^{79, 135)} appear to have changed the body regions. Changes made to the NMQ were reported, but not described, in three studies^{32, 136, 137)}. Regarding Paarup *et al.*’s³²⁾ study, it is possible that the changes to the NMQ were using a rating scale for MSS in the last 7-d rather than a dichotomous response, as this modification was published in their other article³³⁾, which appears to report on the same study.

To guide the collection of data for specific body regions, 14 studies reported using a body chart^{27–30, 33, 35, 38, 39, 43–46, 56, 66, 68, 74, 80, 89, 131, 138)}, six studies including the body chart within the article^{33, 80, 89)}, or the questionnaire in the appendix^{39, 131, 138)}. While 11 studies did not specifically report that a body chart was used^{31, 32, 34, 36, 37, 57–60, 72, 116, 118, 124)}, they reported using questionnaires that include body charts^{30, 33, 51, 64, 71, 114, 117, 123)}. Based on the questionnaire¹²³⁾ used in one study^{34–37)} a body chart was only used for current pain, with lifetime prevalence determined without a body chart. Assuming no changes were made to the questionnaire body charts, nine studies used blank body charts^{27–29, 34–37, 45, 46, 80, 89, 116, 118, 124, 131, 138)}, and 11 used body charts with the regions marked^{30–33, 38, 39, 43, 44, 57–60, 66, 68, 72)} (10 of which used the NMQ body chart^{33, 43, 44, 56–60, 66, 68, 72)}). While Bragge *et al.*’s¹³⁸⁾ questionnaire had a blank body chart, the body chart reported included the regions marked; hence the reader can ascertain how the authors defined each body region.

Music-related terminology

‘Music-related’ terminology refers to the use of terms such as ‘playing-related’, ‘performance related’ and ‘associated with playing’. There were 53 studies (49%)^{27–31, 34–39, 43, 45, 46, 49, 50, 57, 60, 75, 77, 79, 80, 89, 91–93, 113, 116, 118, 120, 121, 124, 125, 127, 128, 133, 135, 136, 138–161)} that used ‘music-related’ MSS terminology in the title or aim of the study, for inclusion into the study, and/or to describe a MSS outcome. The terms ‘non-playing-related problems’^{147, 162)}, work-related^{56, 85, 163, 164)}, ‘relative to profession’⁷⁰⁾, or education-related¹⁶⁵⁾ were also used, and while it could be argued that work or education was music-related, because

this remained uncertain, these outcomes have not been reported further within this section.

The specific musical tasks reported were: playing^{27–29, 38, 39, 43, 45, 46, 49, 50, 57, 60, 75, 79, 80, 91–93, 116, 118, 120, 121, 125, 128, 135, 136, 138, 142–145, 147, 149–153, 155, 157, 159)}, performance^{30, 31, 34–37, 77, 127, 133, 140–142, 146, 148, 154, 156, 158, 160)}, practice/performance¹³³⁾, marching¹⁴⁰⁾, drum-corp¹⁴⁰⁾, instrument¹³⁵⁾, flute^{148, 150)}, trombone⁸⁹⁾, piano¹⁶⁶⁾, and ‘voice usage’¹⁶¹⁾. Two studies used the term ‘music-related’^{113, 139)}. Some terms were used interchangeably^{133, 135, 140, 142, 146, 148, 150)}, although in the case of Wood¹³³⁾ the author made it clear that the term performance-related musculoskeletal disorders included both practice and performance. A further study¹²⁴⁾, reported ‘PRMD’ without indicating what this stood for, however the questionnaire used¹²³⁾ indicates that this referred to ‘performance-related musculoskeletal disorders’.

‘Music-related’ and more generic terminology, e.g. pain or injuries, appear to have been used interchangeably in 25 articles (21 studies)^{34–39, 43, 50, 57, 60, 75, 80, 89, 118, 121, 124, 136, 138, 140, 142, 146, 150, 151, 161, 166)}. How musical activity and MSS were related was not clear in 31 studies^{34, 38, 39, 43, 46, 50, 57, 60, 75, 77, 89, 91, 92, 113, 120, 121, 125, 139–142, 145–151, 157–159, 162)}. A total of 17 studies defined ‘music-related’ MSS as MSS that interfered with musical activity^{27–31, 35–37, 45, 46, 79, 93, 116, 118, 124, 128, 135, 136, 138, 143, 153, 154, 156, 160)} (all but one,¹⁴³⁾ using Zaza *et al.*’s^{2, 167, 168)} definition of playing-related musculoskeletal disorders (‘any pain, weakness, numbness, tingling or other physical symptoms that interfere with your ability to play your instrument at the level you are accustomed’²⁾) or a slight variation thereof). ‘Music-related’ MSS were also defined as MSS attributed to musical activity^{80, 133, 155)}, or MSS with a temporal relationship with musical activity^{27–29, 45, 46, 116, 127, 143, 144, 161, 166)}, with one additional study¹⁵²⁾ defining ‘music-related’ MSS as MSS that were caused by or affected performance. One study¹²⁷⁾ stated defining ‘performance-related musculoskeletal disorders’ according to Zaza *et al.*’s²⁾, stating this term referred to ‘neuromusculoskeletal disorders that develop from playing an instrument, rather than problems that may interfere with playing’¹²⁷⁾, which is in contrast with Zaza *et al.*’s²⁾ definition. The authors¹²⁷⁾ later went on to state with regards to data collection that pain while playing was deemed a symptom associated with performance-related musculoskeletal disorders, again citing Zaza *et al.*²⁾. This example highlights the need to clearly state the definition used.

Two studies^{27–29, 45, 46, 116)} used the term playing-related MSS to refer to symptoms that had a temporal relationship

with musical activity, and playing-related musculoskeletal disorders to refer to MSS that impaired musical activity; these were collectively referred to as playing-related musculoskeletal problems. Yoshimura *et al.*¹⁴³) used the term 'playing-related pain' as an over-arching term to encompass questions regarding pain when playing, pain after playing, pain that stopped the pianist from playing and how much playing was affected.

Steinmetz *et al.*⁴⁹) stated that the term 'playing-related musculoskeletal disorders' was used as an umbrella term encompassing both musculoskeletal pain and disorders, contrasting their definition with that of Zaza *et al.*¹⁶⁷), suggesting that within their study⁴⁹) playing-related musculoskeletal disorders simply refer to MSS experienced by musicians. It is possible that this interpretation is also the case in the studies that did not state how musical activity and MSS were related, however unlike Steinmetz *et al.*⁴⁹) the definition was not made clear.

In some studies^{27–29, 35, 36, 43, 45, 46, 57, 60, 80, 124, 161}), where the questionnaire used was reported, we were unable to find corresponding questionnaire items for some or all of the reported 'music-related' MSS outcomes, even where the author had indicated the items specifically related to the corresponding outcome⁸⁰). Additionally, two articles^{43, 44}) reported one study, with many of the same outcomes, however one reported the same MSS finding as 'playing-related'⁴³) while the other did not⁴⁴).

'Music-related' terminology referred to MSS which: impaired musical activity; were attributed to musical activity; and/or had a temporal relationship with musical activity; or were not clear in their relationship with musical activity. Notably, not all outcomes where musical activity was in some way related to MSS (e.g. impaired musical activity) used 'music-related' terminology, instead describing the outcome. The outcomes described in the following sections relate to the type of outcome reported (e.g. temporal relationship between MSS and an activity), irrespective of whether the authors of the included studies used 'music-related' terminology, or not.

Outcomes reported

Of the included studies, only 35 had all outcomes extracted^{27, 28, 32, 33, 38, 39, 45, 46, 56, 58, 59, 66, 75, 79, 103, 116, 118, 122, 126, 134, 135, 138–140, 142, 145, 152, 154, 160, 166, 169–175}), 42 had some^{29, 34–37, 40–44, 49, 50, 57, 60, 68, 70, 72, 74, 77, 80, 83, 89, 91, 93, 94, 98, 120, 121, 124, 128, 130, 131, 133, 137, 149–151, 153, 159, 177, 178}), and 44 had no outcomes extracted^{30, 31, 47, 48, 85, 87, 90, 92, 101, 107, 109, 110, 113, 125, 127, 129, 136, 141, 143, 144, 146–148, 155–158, 161–165, 180–192}) as the recall periods could not be determined.

Temporal relationship to activity

MSS with a temporal relationship to musical activity were reported in 10 studies^{27–29, 37, 45, 46, 116, 121, 126, 130, 139, 145, 149, 166}), and non-musical activities in three studies^{46, 74, 116}) (Table 2). A total of 10 of these studies reported MSS during specific activities^{27–29, 37, 45, 46, 74, 116, 121, 126, 139, 145, 149, 166}), while others reported MSS before¹⁴⁵), or after the activity^{121, 126, 145}), or reported combinations of before, during and after activity^{145, 166}). Four reports of one study^{27–29, 46}) indicate that playing-related musculoskeletal symptoms referred to symptoms during and after, while another report of the same study referred to during or after playing⁴⁵). However, the questionnaire¹¹⁴) used only asked about symptoms during playing; hence we have classified the outcome as symptoms during playing only. With the exception of two studies^{126, 166}), all reported the percentage of participants who had experienced MSS while doing the specified activity. Three studies^{28, 46, 126}) reported the frequency of MSS^{46, 126}), and another¹⁶⁶) reported the intensity of pain, and tension while playing (Table 2).

In addition to the abovementioned outcomes, Damian and Zalpour⁹⁴) reported the mean rating from the pain subscale of the Shoulder Pain and Disability Index⁹⁹), which includes items relating to pain during certain activities combined with pain at its worst, which will be reported in full in the other outcomes section.

Symptoms attributed to an activity

The prevalence of MSS aggravated by¹⁴⁵), or caused by^{35, 36, 121, 133, 138, 178}) various factors were reported in six studies. The MSS types were injury¹³³), pain or injuries³⁵), musculoskeletal problems¹⁴⁵), lip pain¹⁷⁸), playing-related symptoms¹²¹), in the last 12-months^{121, 178}), and over the musicians' lifetime^{35, 133, 145}). In one study¹³⁸) the participants were asked an open-response question, and in another³⁵) participants were asked to rate the effect of each factor on an 11-point numeric rating scale (NRS) "no effect at all" to "greatest effect of all", reporting the percentage who endorsed each factor, and the percentage who indicated that the factor was "important"; however cut-point for this classification was not reported³⁵). In the remaining studies, participants appear to have been asked to endorse each factor. In two of the studies where the questionnaire was published^{35, 121}), there were discrepancies with the questionnaires used^{121, 123}).

Perceived risk/causative factors (Table 3) were grouped as musculoskeletal, playing-related, work environment and psychosocial, based on Chimenti *et al.*'s¹²¹) study. Bragge *et al.*¹³⁸) (who used open response categories) also

Table 2. Temporal relationship between activity and symptoms

Activity, temporal relationship & symptoms	Time period	Scale (if appropriate)	Questionnaire references	Reported as	Studies
Musical					
Pain or discomfort when playing	Lifetime Current Lifetime	NA NA NA	NR NR NR	Percentage Percentage Percentage	139) 139) 145)
Musculoskeletal symptoms before, during, after, before and after, during and after, and before, during and after playing	Lifetime Last month Last month	NA NA “none”, “once a month”, “once a week”, “two to three times a week” or “daily”	114) 114) 114)	Percentage Percentage Percentage for any, & each frequency	27–29, 45, 46) 27–29, 45, 46, 116) 28)
Soreness while playing ^a	Last month	“none”, “once a month”, “once a week”, “two to three times a week” or “daily”	114)	Percentage for any, & each frequency	46)
Soreness while playing in the neck, right shoulder, left and right hand ^b	Last month	“none”, “once a month”, “once a week”, “two to three times a week” or “daily”	114)	Percentage for any, & each frequency	46)
Pain during and/or after practice/performance	Current	NA	130)	Percentage	130)
Pain during a practice session	Current	NA		Percentage	149)
Pain during performance ^b	Current	NA	123)	Regression outcome only	37)
Playing-related symptoms that occur while playing ^c	Last 12-months	NA	121)	Percentage	121)
Playing-related symptoms that persist for <15 min after playing ^c	Last 12-months	NA	121)	Percentage	121)
Playing-related symptoms that persist for >15 min after playing ^c	Last 12-months	NA	121)	Percentage	121)
Rating of the frequency of pain during marching rehearsal ^d	Current semester	Horizontal 100 mm VAS from “never” to “always”	126)	Mean	126)
Rating of the frequency of pain after marching rehearsal ^d	Current semester	Horizontal 100 mm VAS from “never” to “always”	126)	Mean	126)
Rating of the frequency of pain during non-marching playing ^d	Current semester	Horizontal 100 mm VAS from “never” to “always”	126)	Mean	126)
Rating of the frequency of pain after non-marching playing ^d	Current semester	Horizontal 100 mm VAS from “never” to “always”	126)	Mean	126)
Number of body regions affected by pain during marching band ^d	Current semester	NR	126)	Mean	126)
Intensity of pain while playing	Standardized task	10 cm VAS (anchors NR)	NR	Mean	166)
Intensity of tension while playing	Standardized task	10 cm VAS (anchors NR)	NR	Mean	166)
Non-musical					
Soreness while writing	Last month	“none”, “once a month”, “once a week”, “two to three times a week” or “daily”	114)	Percentage for any, & each frequency	46)
Soreness while doing intensive hand activity	Last month	“none”, “once a month”, “once a week”, “two to three times a week” or “daily”	114)	Percentage for any, & each frequency	46)
Soreness while watching television/videos	Last month	“none”, “once a month”, “once a week”, “two to three times a week” or “daily”	114)	Percentage for any, & each frequency	46)
Soreness during vigorous physical activity	Last month	“none”, “once a month”, “once a week”, “two to three times a week” or “daily”	114)	Percentage for any, & each frequency	46)
Soreness while using electronic games	Last month	“none”, “once a month”, “once a week”, “two to three times a week” or “daily”	114)	Percentage for any, & each frequency	46)
Soreness during non-musical activities ^e	Last month	“none”, “once a month”, “once a week”, “two to three times a week” or “daily”	114)	Percentage for any, & each frequency	116)
Upper extremity pain during an activity	Last 7-d	Likert: “none”, “mild”, “moderate”, “severe”, “extreme”	52, 73)	Mean	74)

NA: not applicable; NR: not reported; VAS: visual analogue scale. ^aThe questionnaire states “soreness while playing”¹¹⁴⁾ however the two studies^{27–29, 45, 46, 116)} each report different definitions. ^bThere was no related question in the questionnaires. ^cThe authors¹²¹⁾ combined this outcome with consequences of MSS such that the categories were exclusive (more information is presented in the Other Outcomes section). ^dThere was a discrepancy between the article and questionnaire, with the tabulated information reflecting that of the questionnaire. ^ereported as ‘non-music musculoskeletal soreness’ without explanation, however based on the questionnaire¹¹⁴⁾ it appears to relate to soreness while writing, doing intensive hand activities, watching television/videos, doing vigorous physical activity or using of electronic games.

Table 3. Perceived aggravating or risk factors for musculoskeletal symptoms

	Studies
Playing-related factors	
Practice or performance	133)
Long sessions of playing	121)
Long practice sessions	35)
Particular repertoire or a difficult piece	121)
Repertoire scheduling	35)
Increase in playing difficulty	145)
Sudden increase or decrease in playing hours	121)
Increase in rehearsal time	145)
Sudden increase in playing	35)
Increase in playing	145)
Change in practice routine	138)
Musculoskeletal factors	
Too much/excess muscle tension	35, 121)
Playing when physically exhausted	121)
Muscle fatigue	35)
Lack of endurance or strength	121)
Lack of fitness	35)
Lack of flexibility	35)
Poor/bad posture	35, 121, 145)
Insufficient warm-up	35, 121)
Insufficient rest	35)
Too few breaks during playing	121)
Poor technique/technical flaws	35, 121)
Mouthpiece pressure	177)
Poor injury management	35)
Work environment factors	
Chairs of improper or invariable height	121)
Cramped playing conditions	121)
Carrying instrument or other equipment	121)
Temperature	121)
Lighting	121)
Variations in the functioning and/or malfunction of the instrument	121)
Instrument set-up	35)
Touring	35)
Psychosocial factors	
Emotional problems	145)
Stress and/or anxiety	121)
Stress	35)
Depression	121)
Performance anxiety	35)
Time pressure/practicing with a deadline	121)
Feelings of inadequacy	121)
Job dissatisfaction	121)
Lack of support from management/conductor	121)
Conductor approach	35)
Lack of social support	121)

reported that ‘muscle tension’, ‘practice time’, ‘technique’, ‘posture’ and ‘stress’ were the top five perceived risk factors.

In addition to the outcomes reported in Table 3, two reports of the same study, reported the current prevalence of pain/injury attributed to work³⁵⁾ and playing³⁶⁾; however neither outcome matches the questionnaire items¹²³⁾. Grier *et al.*¹⁷³⁾ reported an outcome that combined MSS being attributed to band activities, and the impact on daily life, hence this combined outcome will be reported in detail in the Other Outcomes section.

Consequences outcomes

Impact on musical activity

The prevalence of MSS that influenced musical activity was reported in 18 studies (Table 4). Eight studies^{27–29, 45, 46, 79, 116, 118, 128, 135, 138, 153)} used Zaza *et al.*’s^{2, 167, 168)} definition of playing-related musculoskeletal disorders, or slight variations thereof.

In addition to the outcomes summarised in Table 4, one study¹⁵³⁾ reported the prevalence of current MSS that impaired playing for periods of >7 d, <4 wk, 4–12 wk, and ≥3 months, and another¹³⁸⁾ reporting the prevalence of MSS in the last 7-d that impaired playing, for 1–7, 8–30 and ≥30 d duration.

Berque *et al.*¹¹⁸⁾ also reported the percentage of musicians reporting one, two or three or more body regions affected by symptoms that impaired playing, during the last 7-d (reported as ‘current’), and Bruno *et al.*¹³⁵⁾ reported the percentage of participants who reported MSS that impaired their playing in more than one body region in the last 4-wk. What defined a region was not clear from the paper.

The lifetime prevalence of self-reported carpal tunnel syndrome, hypermobility, tendinitis, and scoliosis that affected playing were also reported in one study, as well as the lifetime prevalence of ‘temporomandibular joint’ affecting playing¹⁵¹⁾; presumably referring to MSS in this region.

Six studies used the performing arts module from the Disability of the Arm Shoulder and Hand (DASH) questionnaire⁵²⁾, to provide a measure of musical disability in the last 7-d. Two studies^{68, 80)} reported the percentages for each response category (Table 4), while others reported the overall mean^{77, 83)} or median score⁷²⁾, or were unclear as to whether the mean, median, or another statistic was reported⁷⁹⁾.

The Patient Specific Functional Scale¹¹²⁾ was used by Steinmetz *et al.*⁹¹⁾ to collect data regarding the musical

impairment from pain. Participants are asked to “rate any reduced function due to pain in up to three issues related to playing their instrument”⁹¹⁾, with these issues nominated by the participant. The degree of impairment on the day of data collection was rated on a scale from 0 “unable to perform activity” to 10 “able to perform activity at the same level as before”¹¹²⁾. It was not specified whether these ratings were for the impairment at its worst, on average, or its least.

The degree or frequency of musical impairment outcomes for the remaining four studies are reported in Table 5, where three used Zaza *et al.*’s^{2, 167, 168)} definition, or a slight variation thereof^{153, 154, 160)}. Although Árnason *et al.*¹⁵³⁾ reported that the career rating was for the worst playing-related musculoskeletal disorder (using Zaza *et al.*’s^{2, 167, 168)} definition) experienced, they did not specify whether this rating was for the disorder at its worst, on average, or at its least. Similarly, the other studies reporting the degree of musical impairment failed to report this detail. Finally, the mean number of days off playing due to MSS in the last 12-months was also reported in one study¹³⁷⁾.

Non-musical consequences

The impact of MSS on daily life was reported in 10 unique studies^{32, 68, 72, 74, 75, 77, 83, 94, 98, 126)}, five studies^{32, 35, 36, 68, 121, 134)} reported consequences related to work, seven studies^{32, 40, 68, 121, 131, 145, 150)} reported the management strategies used, and one²⁸⁾ combined impairment of musical activity and management strategies used (Table 6). For consequences, the percentage of affected participants were reported, with the exception of two studies^{36, 75)} that used the number of days off from work as an outcome in a regression analysis only. For the interference of MSS on general life, ratings were reported as the mean and/or median.

Ratings of interference tended to have a 7-d recall period, while the prevalence of MSS consequences was most commonly reported over a 12-month period (Table 6).

Chimenti *et al.*¹²¹⁾ also reported the 12-month prevalence of playing-related symptoms that influenced daily activities, as part of a broader scale. Similarly, Grier *et al.*¹⁷³⁾ reported an outcome that combined consequence on daily life and attribution of MSS to band activities. Both combined outcomes will be reported in the Other Outcomes section.

Symptoms in general

This section includes outcomes that did not have a

Table 4. Prevalence outcomes of musical consequences due to musculoskeletal symptoms

Consequence	Time periods	Body regions (if specified)
Unable to play at usual level	Lifetime ^{118, 128}	Jaw ¹²⁸ , L & R sides of the jaw ¹²⁸ , neck/shoulder ¹²⁸ , L & R sides of the neck ¹²⁸ , upper limb ¹²⁸ , L & R shoulders ¹²⁸ , L & R arms ¹²⁸ , L & R wrist/hand/fingers ¹²⁸ , back ¹²⁸ , L & R sides of the upper back ¹²⁸ , L & R sides of the middle back ¹²⁸ , L & R sides of the lower back ¹²⁸
	Career ¹⁵³	
	12-months ¹¹⁸	
	1-month ^{27-29, 45, 46, 116, 135}	Mouth ²⁷ , neck ^{27, 135} , L & R shoulder/arm ²⁷ , shoulders ¹³⁵ , upper arms ¹³⁵ , L & R elbow/hand ²⁷ , elbow ¹³⁵ , forearms ¹³⁵ , wrists ¹³⁵ , hands/fingers ¹³⁵ , upper back ¹³⁵ , middle back ²⁷ , lower back ^{27, 135} , L & R lower limb ²⁷ , hip ¹³⁵ , foot ¹³⁵
	7-d ^{79, 118, 138}	Head/face/lips ¹¹⁸ , anterior head ¹³⁸ , neck ¹¹⁸ , anterior neck ¹³⁸ , posterior neck ¹³⁸ , L & R shoulder/upper arm ¹¹⁸ , anterior L & R shoulders ¹³⁸ , posterior L & R shoulders ¹³⁸ , L & R forearm/elbow ¹¹⁸ , anterior L & R elbows ¹³⁸ , posterior L & R elbows ¹³⁸ , L & R wrist/hand ¹¹⁸ , anterior L & R wrist/hand ¹³⁸ , posterior L & R wrist/hand ¹³⁸ , sternum ¹³⁸ , abdomen ¹³⁸ , upper/middle back ¹³⁸ , upper back ¹¹⁸ , lower back ^{118, 138} , lower limb ¹¹⁸ , anterior L & R hip/thigh ^{118, 138} , posterior L & R hip/thigh ^{118, 138} , anterior L & R knee ¹³⁸ , posterior L & R knee ¹³⁸ , anterior L & R ankle/foot ¹³⁸ , posterior L & R ankle/foot ¹³⁸
	Point ¹²⁸	Jaw ¹²⁸ , L & R sides of the jaw ¹²⁸ , neck/shoulder ¹²⁸ , L & R sides of the neck ¹²⁸ , upper limb ¹²⁸ , L & R shoulders ¹²⁸ , L & R arms ¹²⁸ , L & R wrist/hand/fingers ¹²⁸ , back ¹²⁸ , L & R sides of the upper back ¹²⁸ , L & R sides of the middle back ¹²⁸ , L & R sides of the lower back ¹²⁸
Affected playing ability	Lifetime ¹⁴⁵	
Affected performance	Lifetime ¹⁴⁵	
Influenced performing ability	Career ⁷⁰	
Change or impaired playing	12-months ³²	Neck/back/upper extremity ³²
Distracted from performing	Lifetime ¹⁵⁰	
Interfered with playing or rehearsals or performances	Lifetime ⁶³⁵	
Change in technique	Lifetime ¹⁴⁵	
Trouble using your usual technique ^d	7-q ^{68, 80}	Shoulder/arm/hand ^{68, 80}
Trouble playing the musical instrument ^d	7-q ^{68, 80}	Shoulder/arm/hand ^{68, 80} , neck/back ⁸⁰
Trouble playing as well as you want to ^d	7-q ^{68, 80}	Shoulder/arm/hand ^{68, 80}
Trouble playing the instrument for the time usually devoted to it ^d	7-q ^{68, 80}	Shoulder/arm/hand ^{68, 80}
Affect playing time	Lifetime ¹⁴⁵	
Decrease playing	Lifetime ¹⁴⁵	
Cannot play	Lifetime ¹⁴⁵	
Paused from practice alone	12-months ³²	Neck/back/upper extremity ³²
Paused from rehearsal	12-months ³²	Neck/back/upper extremity ³²
Omitted playing at concerts	12-months ³²	Neck/back/upper extremity ³²
Warm-up	Lifetime ¹⁴⁵	
Time off from playing	Lifetime ¹⁵¹	
	12-months ⁸⁹	
Missed at least 1 rehearsal, but no competitions	Previous summer ¹⁴⁰	
Missed 1-3 rehearsals, & 1 competition	Previous summer ¹⁴⁰	
Missed 4-7 rehearsals, & > 1 competition	Previous summer ¹⁴⁰	
Missed > 7 rehearsals, & > 1 competition	Previous summer ¹⁴⁰	

L. left; R. Right. ^aone study²⁸ reported the outcome as the lifetime prevalence, however according to the questionnaire¹¹⁴ used and other reports^{27, 29, 45, 46} of the same study this should have been the prevalence in the last month. ^breported as point prevalence^{79, 118}. ^creported as career prevalence, but the questionnaire¹²³ asks about musculoskeletal symptoms during their lifetimes. ^dfrom the Disability of the Arm, Should and Hand (DASH) performing arts module⁵² and reported for the response categories “no difficulty”, “mild difficulty”, “moderate difficulty”, “severe difficulty”, or “unable”.

Table 5. Measures of the degree and frequency of musical impairment from musculoskeletal symptoms

	Time period	Outcome	Scale	Anchors	Reported as	Study
Degree	Lifetime	Affected performance	Likert-style	“entirely”, “partially”, “not at all”	Percentage	172)
	Career	Impaired playing ^a	100-mm VAS	NR	Mean	153)
	Current semester	Impaired marching	100-mm horizontal VAS	0% to 100%	Mean	126)
	Current semester	Impaired playing	100-mm horizontal VAS	0% to 100%	Mean	126)
	7-d	Impaired playing ^a	11-point ordinal	“nil” to “worst imaginable”	Mean	160)
	7-d	Impaired playing ^a	11-point VAS	“nil” to “worst imaginable”	Mean, median	154)
	Current	Impaired playing ^a	100-mm VAS	NR	Mean	153)
	Current	Affected performance	Likert-style	“entirely”, “partially”, “not at all”	Percentage	172)
Frequency	Career	Impaired playing ^a	100-mm VAS	“never” to “all the time”	Mean	153)
	Current semester	Stopping marching	100-mm horizontal VAS	“never” to “always”	Mean	126)
	Current semester	Stopping playing	100-mm horizontal VAS	“never” to “always”	Mean	126)
	7-d	Impaired playing ^a	11-point ordinal	“never” to “constantly”	Mean	160)
	7-d	Impaired playing ^a	11-point VAS	“never” to “constantly”	Mean, median	154)

VAS: visual analogue scale; mm: millimetres; NR: not reported. ^ausing Zaza *et al.*'s^{2, 167, 168)} definition or slight variations thereof.

temporal relationship to playing, were not necessarily perceived to have been the result of specific factors, or resulted in consequences (e.g. impact on musical activity, treatment sought). It also includes ‘music-related’ MSS outcomes, where the relationship between musical activity and MSS remained unclear.

How common these outcomes are

The majority of studies reporting outcomes in this section relate to the prevalence of general MSS^{32–36, 40–44, 49, 50, 56–60, 66, 68, 72, 75, 83, 103, 124, 134, 135, 139, 140, 142, 145, 150, 151, 170–172, 176–178)}. Exceptions were the episodic incidence of MSS¹²²⁾, the number of participants who had experienced MSS^{131, 152, 174, 177, 178)}, or where MSS outcomes were used only to investigate the association with other variables³⁷⁾. Of note, Chimenti *et al.*'s¹²¹⁾ report of the body regions where musicians experienced injuries, referred to the percentage of injuries in those body regions, rather than the percentage of affected musicians, while Heredia *et al.*¹⁵²⁾ reported the number of musculoskeletal complaints per musician. It is, however, unclear whether this outcome refers to the body regions affected, the quality of symptoms, or a combination.

Most studies used generic terms, like ‘injury’ or ‘symptoms’, or had more than three specific symptom qualities listed. In a number of studies there appeared to be interchangeable or inconsistent use of terms^{33–36, 43, 56, 83, 121, 124, 150, 151)}, including specific (e.g. pain) and more general (e.g. injury) terms^{34, 35, 43, 56, 150, 151)}, for these we extracted the most general term. When a specific symptom quality was considered, the most common was pain, with combinations of pain with ache, discomfort and/or tension

also being used commonly (Table 7). Only one of the eight studies⁶⁸⁾ that used the NMQ⁵¹⁾ reported the outcome as ache, pain or discomfort, as per the original questionnaire, with others reporting pain^{43, 44, 58–60)}, pain or ache⁵⁶⁾, or more general MSS terms^{57, 66)}. None of these studies reported modifying the NMQ, hence it is unclear whether the questionnaire was changed to reflect these reported outcomes, or whether the reporting did not match the data collection. It is therefore possible that additional studies reported ache, pain or discomfort outcomes.

The most commonly used recall periods were lifetime, 12-months, 7-d and current (Table 7). A wide range of body areas were investigated, with the most common being those that match the NMQ⁵¹⁾ body chart, with the laterality of MSS most commonly reported for the upper limbs (Table 8).

In addition to the outcomes reported in Tables 7 and 8, three studies reported the prevalence of MSS of various durations. Ackermann *et al.*³⁴⁾ reported the prevalence of those with current performance-related musculoskeletal disorders (a term used interchangeably with others) experienced for more than one week, and for at least three months. In another report of the same study³⁵⁾, the prevalence of current pain of <4-wk, 4- to 12-wk and >12-wk duration was reported. Paarup *et al.*³²⁾ reported the percentage of participants who had ache, pain or discomfort for more than seven days, and more than 30 d over the last 12-months, which was reported for the neck, upper back, lower back, left and right shoulder, left and right elbow, and left and right hand, and these regions combined (i.e. spine and upper limb).

Kok *et al.*⁴⁰⁾ reported the prevalence of current mus-

Table 6. Consequences of musculoskeletal symptoms

Consequence	Time period: symptom(s)	Questionnaire & scale (if appropriate)	Reported as	Studies
<i>General life</i>				
Degree of disability	Last 7-d: MSS in the arm, shoulder, and/or hand	DASH ^{52, 73)}	Mean	68, 74, 77)
	Last 7-d: shoulder pain	QuickDASH ⁸¹⁾	Median	68, 72)
	Last 24-h: MSS in the shoulder	Shoulder Pain and Disability Index ⁹⁹⁾	Regression only	75)
	Last 7-d: MSS in the arm, shoulder, and/or hand	Shoulder Disability Questionnaire ^{96, 97)}	Mean	83)
		DASH ⁷³⁾	Mean	94)
			Mean	98)
Degree of difficulty in opening a tight or new jar			Mean	74)
Degree of difficulty recreational activities which require some force or impact through the arm, shoulder or hand	Last 7-d: MSS in the arm, shoulder, and/or hand	DASH ⁷³⁾	Mean	74)
Degree of pain interference	Last 7-d: pain in any region	Berque <i>et al.</i> 's ¹¹⁷⁾ pain interference scale	Mean	118)
Frequency of pain interference with daily life	Current semester: pain in any region	NRS from 0 "does not interfere" to 10 "completely interferes" for the interference scale and 0 "no difficulty" to 10 "unable" for the playing items	Mean	126)
Functional limitations	Last 12-months: MSS in any region	Hatheway and Chesky's ¹²⁶⁾ questionnaire	Regression only	75)
Daily activities at home affected	Last 12-months: MSS in the upper limb	100 mm horizontal VAS from "never" to "always"	Regression only	75)
Leisure time activities affected	Last 12-months: ache, pain or discomfort in the neck/back/upper extremity	Modified NMQ	Percentage	32)
Sleep affected	Last 12-months: ache, pain or discomfort in the neck/back/upper extremity	Modified NMQ	Percentage	32)
	Last 12-months: ache, pain or discomfort in the neck/back/upper extremity	NR	Percentage	32)
<i>Work/study</i>				
Changes made to jobs/duties	Lifetime: MSS in the neck, shoulder, elbow, wrist/hand, upper back, lower back, hip/thigh, knee & ankle/foot	NMQ Extended version ⁶⁷⁾	Percentage	68)
Making a workers' compensation claim	Career ^b : playing-related symptoms ^a	Chimenti <i>et al.</i> 's ¹²¹⁾ questionnaire	Percentage ^a	121)
Prevented from doing normal work	Last 12-months: MSS in the neck, shoulder, elbow, wrist/hand, upper back, lower back, hip/thigh, knee & ankle/foot	NMQ Extended version ⁶⁷⁾	Percentage	68)
Number of days off from work	Last 18-months: physical pain or injury in any region	Ackermann & Driscoll's ¹²³⁾ questionnaire	Regression only	36)

Table 6 continued

Consequence	Time period: symptom(s)	Questionnaire & scale (if appropriate)	Reported as	Studies
Sick leave/time off from work or study	Last 18-months: physical pain or injury in any region	Ackermann & Driscoll's ¹²³ questionnaire	Percentage	35, 36)
	Last 12-months: MSS in the neck, shoulder, elbow, wrist/hand, upper back, lower back, hip/thigh, knee & ankle/foot	NMQ Extended version ⁶⁷	Percentage	68)
At least one day off from work	Last 12-months: ache, pain or discomfort in the neck/back/upper extremity	NR	Percentage	32)
	Last 12-months: pain of at least 1 month duration in the neck, shoulder, elbow, wrist/hand or lumbar spine	Modified NMQ	Percentage	134)
Number of missed services ^e	Last 12-months: playing-related symptoms in any region	Chimenti <i>et al.</i> 's ¹²¹ questionnaire	Percentage reporting 0, 1–9, 10–20, or >20	121)
<i>Management strategies</i>				
Taken medication	Lifetime: MSS in any region	NR	Percentage	145)
	Lifetime: flute playing-related pain in any region	NR	Percentage	150)
Taken NSAIDs	Last 12-months: MSS in any body region	NMQ Extended version ⁶⁷	Percentage	68)
	Lifetime: flute playing-related pain in any region	NR	Percentage	150)
Taken pain killers	Current: pain in any region	Woldendorp <i>et al.</i> 's ¹³¹ questionnaire	Percentage	131)
	Last 12-months: ache, pain or discomfort in the neck/back/upper extremity	NR	Percentage	32)
Taken over-the-counter pain killers	Lifetime: flute playing-related pain in any region	Not reported	Percentage	150)
Taken paracetamol	Current: pain in any region	Woldendorp <i>et al.</i> 's ¹³¹ questionnaire	Percentage	131)
	Current: pain in any region	Woldendorp <i>et al.</i> 's ¹³¹ questionnaire	Percentage	131)
Perform stretches	Lifetime: MSS in any region	NR	Percentage	145)
Change posture	Lifetime: MSS in any region	NR	Percentage	145)
Professional care	Career: playing-related symptoms in any region	Chimenti <i>et al.</i> 's ¹²¹ questionnaire	Percentage	121)
Consulted a health professional	Last 12-months: ache, pain or discomfort in the neck/back/upper extremity	NR	Percentage	32)
Consulted a doctor, physiotherapist, chiropractor or any such person	Last 12-months: MSS in the neck, shoulder, elbows, wrists/hands, upper back, lower back, hips/thighs, knees, ankles/feet	NMQ Extended version ⁶⁷	Percentage	68)
Medical care	Last 12-months & current ^d : MSS in the arm/neck/shoulder	NR	Percentage	40)

Table 6 continued

Consequence	Time period: symptom(s)	Questionnaire & scale (if appropriate)	Reported as	Studies
Consulted a medical professional	Lifetime: MSS in any region	NR	Percentage	145)
Consulted a general practitioner	Last 12-months & current ^d : MSS in the arm/neck/shoulder	NR	Percentage	40)
	Last 12-months: ache, pain or discomfort in the neck/back/upper extremity	NR	Percentage	32)
Consulted a specialist	Last 12-months & current ^d : MSS in the arm/neck/shoulder	NR	Percentage	40)
	Last 12-months: ache, pain or discomfort in the neck/back/upper extremity	NR	Percentage	32)
Consulted a physiotherapist	Lifetime: MSS in any region	NR	Percentage	145)
	Last 12-months & current ^d : MSS in the arm/neck/shoulder	NR	Percentage	40)
	Last 12-months: ache, pain or discomfort in the neck/back/upper extremity	NR	Percentage	32)
Consulted an occupational therapist	Lifetime: MSS in any region	NR	Percentage	145)
Consulted a chiropractor	Last 12-months: ache, pain or discomfort in the neck/back/upper extremity	NR	Percentage	32)
	Lifetime: MSS in any region	NR	Percentage	145)
Consulted an alternative medicine therapist	Lifetime: MSS in any region	NR	Percentage	145)
	Last 12-months & current ^d : MSS in the arm/neck/shoulder	NR	Percentage	40)
Did Alexander technique	Lifetime: MSS in any region	NR	Percentage	145)
Did Feldenkrais	Lifetime: MSS in any region	NR	Percentage	145)
Hospitalised	Last 12-months: MSS in the neck, shoulders, elbows, wrists/hands, upper back, lower back, hips/thighs, knees, ankles/feet	NMQ Extended version ⁶⁷⁾	Percentage	68)
<i>Combined</i>				
Impaired musical activity and took medication	Last month: MSS in any region	Ranelli <i>et al.</i> 's ¹¹⁴⁾ questionnaire	Percentage	28)
Impaired musical activity and consulted a health professional	Last month: MSS in any	Ranelli <i>et al.</i> 's ¹¹⁴⁾ questionnaire	Percentage	28)

MSS: musculoskeletal symptoms; DASH: Disability of the Arm, Shoulder and Hand; VAS: visual analogue scale; NMQ: Nordic Musculoskeletal Questionnaire; NSAIDs: non-steroidal anti-inflammatory drugs. NR: not reported; NRS: numeric rating scale. ^athe percentage of injuries for which workers' compensation was claimed was reported for the head, neck, shoulder/upper arm, elbow/forearm, wrist/hand/fingers, upper back, lower back, hip/buttock/thigh, knee/lower leg, and ankle/foot/toes, ^bthere was no time period specified in the questionnaire¹²¹⁾, ^cdefined as 2–2.5 hours of playing, with a 15-minute break, ^dalso reported for those who have had their current musculoskeletal symptoms for at least 3-months.

Table 7. Recall periods and symptom quality of general symptom prevalence

	Lifetime	Career	18-months	12-months	6-months	Previous summer	3-months	1-month/ 4-wk	2-wk	1-week/ 7-d	Point/ current	All time periods
Symptoms ^a	5		1	6		1		1		3	6	16
Ache/pain/discomfort	1	1		2				1		1	1	3
Pain/discomfort/tension	1											1
Pain/discomfort									1	1	1	3
Pain/ache				1								1
Pain/soreness										1		1
Pain	5			7	2		3	2		3	8	21
Discomfort	1											1
Soreness											1	1
Tension	1										1	2
Clicking/popping	1											1
Crepitus	1											1
Tightness											1	1
Reduced range of motion	1											1
Loss of gross motor skill				1							1	1
Loss of fine motor skill				1							1	1
Involuntary movements	1											1
Power loss				1							1	1
Loss of control				1							1	1
Cramp	1			2							1	3
Muscle fatigue											1	1
Loss of speed				1							1	1
Loss of endurance				1							1	1
Swelling				3							1	3
Redness				1							2	2
Neuropathic symptoms	1											1
Burning				1								1
Numbness				2								2
Tingling				1								1
Weakness				2								2
Soreness				1								1
Stiffness				1								1
All symptom qualities	9	1	1	14	2	1	3	4	1	8	13	

^awhere more than three symptom types were specified these were classified only as symptoms. For references, refer to Appendix 2.

culoskeletal complaints, and pain, problems with gross motor skills, and fine motor skills, loss of speed, control, power and endurance, cramp, swelling and redness specifically, in the arm/neck/shoulder regions of at least 3-months duration. Woldendorp *et al.*¹³¹⁾ reported the number of participants who had experienced current pain for <3-months, and those reporting recurrent or continuous pain for >3-months duration.

Some authors reported the number of body regions/sites where symptoms were experienced as prevalence (e.g. percentage with ≥ 10 pain regions)^{35, 40, 75, 89, 124)}, or mean number of regions⁸⁹⁾, during the last 12-months^{40, 75, 89)}, or currently^{35, 124)}. None of the studies clearly reported

what constituted a region, although in some studies it was implied. In addition, McCrary *et al.*¹⁷⁴⁾ reported the number of participants with one, two, or three or more current symptoms, but it is unclear whether this refers to symptomatic body regions, or the quality of symptoms.

Additionally, the mean age when playing-related pain first appeared was reported by Ioannou and Altenmüller¹⁵⁹⁾, however the time from starting playing to the onset of playing-related pain was not included.

Symptom frequency

Two studies reported the frequency of MSS. One reported the prevalence of “rare”, “frequent” and “permanent”

Table 8 continued

	Lifetime Career	18-months	12-months	6-months	Previous summer	3-months	1-month/ 4-wk	2wk	1-week/ 7 d	Point/ Current	Any time period
Elbows	2		6			1	2		2	2	10
L/R elbow	3		3			1			2	4	9
Both elbows			1								1
L front elbow			1								1
L/R lower arm/wrist/hand/fingers/ thumb									1		1
Forearm										1	1
L/R forearm/lower arm	2								1	1	4
L front forearm			1								1
Wrist/hand/fingers			1								1
Wrist/hands	1		6			1	2		2	2	9
L/R wrist/hand			1						1	1	3
Both wrists/hands			1								1
Wrists	1									1	2
L/R wrist	2		1			1			1	4	6
L front wrist			1								1
L/R hand/fingers	1										1
Hands	1		1								2
L/R hand	1		2						2	2	5
L front hand			1								1
Palm										1	1
Fingers	1									2	3
L/R fingers	2					1				2	2
Thumbs										1	1
L/R thumb										1	1
Neck/back									1		1
L/R neck/back			1								1
Neck	5		11	1		3	2		4	6	20
Back/trunk										1	1
Chest/abdomen										1	1
L/R chest	1										1
Trunk										1	1
Back	2		1					1		1	4
Paravertebral region									1		1
Upper back/thoracic region	2		10			2	1		4	3	15
L/R upper back	1		1								2
Middle back	1									1	2
L/R middle back	1										1
Lower back/lumbar region	3		11			2	2		4	6	18
L/R lower back	1		1								2
Both lower limbs										1	1
L/R lower limb										1	1
Hip/buttock/thigh			1								1
L/R hip/thigh/femoral bone/knee									1		1
Hips/thighs	1		4			1	1		2	1	6
Groin										1	1
Hip/knees			1							1	1
Hips									1	1	2
L/R hip	1		1								2

Table 8 continued

	Lifetime Career	18-months	12-months	6-months	Previous summer	3-months	1-month/ 4-wk	2wk	1-week/ 7 d	Point/ Current	Any time period
Buttock/thigh			1								1
Thigh										1	1
Knee/lower leg			2								2
Knees	1		3			1	1		3	2	7
L/R knee	1		1								2
L/R shin/calf/ankle/heel/foot arch/ toes									1		1
Ankle/foot/toes			1								1
Feet/ankles	1		4			1	1		3	3	7
L/R foot/ankle	1										1
L/R ankle			1								1
Foot			1								1
L/R foot			1								1
Arms/hands/legs/knees/hips/joints								1			1
Unclear ^a			2						1	1	2

L: left; R: to right; L/R: the sides were reported separately. Numbers refer to the number of unique studies. ^aAppears an overall measure, but the studies focused on specific body regions (i.e. the upper limb⁸³) and the neck/shoulder/arm⁴⁰) so these values may relate only to these body region. For references, refer to Appendix 2.

pain over their careers⁴⁹), however the word “permanent” implies perceptions about the pain in the future, rather than pain frequency experienced in the past. The other study¹⁷⁷ reported the prevalence of reporting MSS as “often” or “always” during the last 3-months. The latter study¹⁷⁷ also reported the prevalence of “symptoms longer than three months ago”, however as this descriptor was used interchangeably with greater than three months; hence these outcomes are unclear. Both studies reported outcomes specific to body regions: teeth/jaw⁴⁹), temporomandibular joint⁴⁹), head⁴⁹), neck^{49, 177}), shoulder^{49, 177}), upper arm¹⁷⁷), elbows^{49, 177}), lower arm¹⁷⁷), wrists^{49, 177}), fingers^{49, 177}), back¹⁷⁷), upper back⁴⁹), and lower back⁴⁹), with all upper limb symptoms being reported separately for each side. Woldendorp *et al.*¹⁷⁷) also reported the median number of affected regions where MSS reportedly occurred often or always during the last 3-months.

Symptom intensity

The intensity of MSS was reported in 16 studies, with the most common time periods being current and 7-d (Table 9). Only two studies^{33, 93}) reported either within the article⁹³) or the questionnaire included in the appendix³³), sufficient detail of the MSS intensity rating (according to the criteria reported by Smith *et al.*¹⁷). For one study¹¹⁸), however, adequate details were included within the published questionnaire¹¹⁷).

In addition to the outcomes reported in Table 9, Kreutz *et al.*¹⁷²) reported the number of body regions (0, 1, 2, ..., 10, >10) for which pain ratings of 4–5, then 3–5 were made on a scale from 1 “non existent” to 5 “severe” pain in the last 7-d. The type of rating was not reported. The same scale was used by Ginsborg *et al.*¹⁷¹) where the number of body regions where the ratings were 2–5 was used as a regression outcome. Kreutz *et al.*¹⁷²) reported the maximum number of regions was 28, and asked participants to rate their pain in 30 regions, while Ginsborg *et al.*¹⁷¹) did not clearly report what constituted a region in their analysis (although it appears ratings were asked for 11 body regions).

Damian and Zalpour⁹⁴) reported the mean pain intensity from the pain sub-scale of the Shoulder Pain and Disability Index⁹⁹), which includes pain during certain activities, which is discussed in full in the next section.

Other outcomes

This section includes outcomes that did not fit into the above categories. The 12-month prevalence of musculoskeletal pain which was perceived to be caused by or which affected performance was reported by Heredia *et al.*¹⁵²), being a combination of consequences of MSS and musical activity-attributed MSS.

Chimenti *et al.*¹²¹) reported the 12-month prevalence for musicians who indicated that they had not had any

Table 9. Musculoskeletal symptom intensity rating scales

Time period	Symptoms	Rating type	Body regions	Scale: Anchors	Anchors	Reported as	Studies
Lifetime	Pain	NR	Overall	Type NR (0–10)	“without pain” to “worst imaginable pain”	Regression outcome	179
Current semester	Pain	NR	Overall	100 mm VAS	“none” to “extreme”	Mean	126
12-months	Symptoms	NR	Overall	NR	NR	Number with mild, moderate, severe ratings ^a	137
4-wk	Pain	On average	Neck, upper back, L & R shoulder, L & R elbow, L & R wrist, L & R thumb, L & R index finger, L & R middle finger, L & R ring finger, L & R little finger, lower back, hips, knees, ankles	VAS (length NR)	NR	Mean	68
7-d	Pain	NR	Overall	VAS ^b (length NR, reported as 1–10)	“minimal pain” to “intense or unbearable pain”	Mean	44
			Neck, shoulders, upper back, elbows, wrist/hand, lower back, hip/thighs, knees, ankles/feet	VAS ^c (length NR, reported as 1–10)	“minimal pain” to “intense or unbearable pain”	NR	43
			Back, neck, upper trapezius, shoulder, hand, face, jaw	11-point NRS	“no pain to “worst possible pain”	Median & percentage for each of the 11 points	175
			L shoulder, R wrist	11-point NRS	“no pain” to “worst pain”	Mean & percentage with 3 or less	177
			Neck, L & R shoulder	NR	NR	Median	59
			Shoulder, arm, hand	5-point Likert (from DASH ⁷³):	1 “none”, 2 “mild”, 3 “moderate”, 4 “extreme”, 5 “extreme”	Mean	74
			Overall (asked for 30 regions)	Type NR (1–5)	1 “non-existent” to 5 “severe”	Percentage rating 4–5	172
						Mean	171
	Pain or soreness ^d	Maximum	Neck, upper back, lower back, L & R shoulder, L & R elbow, L & R hand/wrist, hips, knees, ankles/knees	Bong’s CR10 scale ^e :	0 “no trouble”, 1 “very very mild”, 2 “very mild”, 3 “mild”, 4 “mild to moderate”, 5 “moderate”, 6 “moderate to severe”, 7 “severe”, 8 “very severe”, 9 “very very severe”	Sensitivity/specificity analysis (any, moderate or severe, less than severe, none/mild, none ^h)	33
	Stiffness	NR	Shoulder, arm, hand	5-point Likert (from DASH ⁷³):	1 “none”, 2 “mild”, 3 “moderate”, 4 “extreme”, 5 “extreme”	Mean	74
24-h	Pain	NR	Unclear. Study focuses on neck and shoulder	VAS (length NR, reported as 0–10)	NR	Mean	94
Current	Symptom	Current	R shoulder, R wrist	Type NR (0–10)	NR	Mean	174

Table 9 continued

Time period	Symptoms	Rating type	Body regions	Scale: Anchors	Anchors	Reported as	Studies
	Pain	Current	Overall	Type NR (0–10)	“without pain” to “worst imaginable pain”	Regression outcome	179)
			Overall	10 cm VAS	NR	Mean	166)
			Shoulder, neck	11-point NRS (0–10):	“no pain” to “maximum pain”	Mean	93)
			Neck, back/trunk, shoulder, upper arm, elbow, forearm, wrist, palm, fingers, hips, thigh, knee, calf, ankle/foot ^f	Type NR (1–5)	“trivial pain” to “severe pain”	NR	38, 39)
			Neck/shoulder/between scapula	Likert (0–4)	0 “completely health”, 1 “a little pain, but no problem”, 2 “quite a bit of pain, but it is possible to play”, 3 “very much pain, have to avoid certain movements”, 4 “so much pain that I sometimes cannot work”	Percentage rating ≥ 2 / in ≥ 1 of the 3 regions	169)
		Current ^e	Upper extremity, neck, teeth/temporomandibular ^d	Likert (0–5)	“no pain”, “very weak”, “weak”, “medium”, “heavy”, “very heavy”	Mean	130)
Combined 4 scales (3 × 6 months & current)	Pain	Worst, on average, least (6 months), and current	Overall	Type NR (1–10)	NR	Regression outcome	120)
Combined 4 scales (3 × last 7-d & current)	Pain	Worst, on average, least (7-d), & current	Reported overall ^g	11-point NRS (0–10)	“no pain” to “pain as bad as you can imagine”	Mean	118)

VAS: visual analogue scale; NRS: numeric rating scale; CR10: Category Ratio 10; NR: not reported; L: left; R: right; DASH: Disability of the Arm, Shoulder and Hand.

^aranges for these classifications were not reported. ^balso reported as a “numeric scale”. ^calso described as a “numeric visual analogue scale”. ^dused a range of terminology in the report. ^ethe range and anchors are not the same as Borg’s CR10 scale, and Borg’s¹⁹³ instructions) were not used. ^fregions reported were different to the questionnaire. ^greported overall but according to the questionnaire¹¹⁷ participants were asked to rate the one region they perceived to be the worst. ^hPain ratings prior to treatment referred to the last 24 h; however, the recall period for the post-treatment (25-min treatment) was not reported. ⁱThe data were collected at follow-up for a treatment (mean 27 months), with current rating for the ‘post’ treatment rating, with the ‘pre’ treatment rating made retrospectively at follow-up with no time period specified. ^jratings were for the tooth, jaw, ear, head, neck, right shoulder, left shoulder, right elbow, left elbow, right wrist, left wrist, right fingers, left fingers, upper back, lower back and sciatica, and it was unclear how the regions were combined to produce the results for the three regions above.

symptoms related to playing, had symptoms after playing but not while playing, had symptoms that stopped within 15-minutes after stopping playing and while playing, had symptoms that persisted for more than 15-minutes after stopping playing and while playing, and those who had symptoms that make it difficult to perform daily activities, as well as symptoms while playing that persisted for more than 15-minutes after stopping playing¹²¹). These outcomes do not match what was asked in the questionnaire.

Ranelli *et al.*²⁸) reported a combined outcome, whereby the percentage of those with MSS that impaired their playing, who took medication, and who saw a health professional, during the last month. Similarly, Grier *et al.*¹⁷²) combined the attribution and consequences, such that their outcome was foot MSS within the last 12-months that impacted upon daily activities and that foot MSS was attributed to band activities.

The mean pain sub-scale ratings from the Shoulder Pain and Disability Index⁹⁹), was reported by Damian and Zalpou⁹⁴). The measure refers to pain at its worst and during specific activities during the last 7-d with responses given on 11 point numeric rating scales for each item, from “no difficulty” to “so difficult it requires help”, with an overall score produced⁹⁹).

One study³⁵) reported the lifetime prevalence of MSS among participants with a past injury who had recovered from it, reporting this for whole body, as well as the head/face/lips, neck, left and right upper limb, back, jaw, mid back, lower back, left and right shoulders, left and right elbows, left and right forearms, left and right wrists, left and right hands, left and right fingers, left and right hip, left and right knee, and left and right ankle/foot. Another article³⁴) from the same project reported this outcome only for the shoulder region, as well as the percentage of those with a history of playing-related injury who had recovered fully. These data were collected using a questionnaire developed specifically for that project¹²³), where participants were asked to rate the amount they had recovered from their injury on a NRS (0% not recovered at all to 100% fully recovered), in 10% increments. Because the time between the onset of symptoms, and data collection was not considered, this outcome is perhaps better described as the intensity of symptoms in relation to what they were when at their worst. There were inconsistencies in the terminology used between these two reports.

Discussion

This is the first targeted review of the types of outcomes

reported and data collection tools used in studies of musicians' MSS. We built on previous systematic reviews^{8–14}), that identified the heterogeneity of outcomes and data collection tools used, but have been limited in their inclusiveness of musical populations, in the types of studies (e.g. prevalence) covered, and in that they have focused on study findings, rather than an in-depth examination of outcomes and data collection tools.

Consistent with the existing systematic reviews^{8–14}), we found heterogeneity in the types of outcomes reported and the data collection tools used, limiting the opportunities for synthesis of findings or comparison of findings across studies. The most common outcome type was MSS in general, following by the musical impact of MSS; most frequently using Zaza *et al.*'s^{2, 167, 168}) definition of playing-related musculoskeletal disorders or slight variations thereof.

Questionnaires

Relatively few studies (24%) used existing, standardized questionnaires that had previously been used with the general population. The use of standardized questionnaires that had been used with the general population appears to be increasing, with 33% of studies published 2012–2016 using such questionnaires.

Where existing questionnaires were used, the most commonly used was the Nordic Musculoskeletal Questionnaire (NMQ)⁵¹). The NMQ is valid and reliable, in its original, translated and extended forms^{51, 61, 62, 64, 67}), and has been used in studies with a wide range of populations¹⁹⁴), including a national study of workers^{195, 196}). Thus, its use with musicians allows for comparison with other groups. The recall periods (7-d and 12-months), and the body regions from the NMQ were also commonly used, suggesting that NMQ is an appropriate tool for use in most studies, which would improve the consistency of outcomes.

For functional impairment, the Neck Disability Index^{53–55}) was also commonly used, however as the Index does not have a clear recall period, we do not recommend its use in future studies of musicians' MSS, unless a recall period is added.

One of the potential reasons for the large number of studies not using existing standardized questionnaires is the interest in music-specific outcomes. The DASH performing arts/sports module⁵²) was an existing measure for music-specific outcomes relating the upper limb disability due to MSS in the last 7-d. The performing arts module has only recently been investigated in terms of validity¹⁹⁷).

While the DASH performing arts module was found to have good construct validity, discriminative validity and internal consistency¹⁹⁷⁾, only traditional psychometric methods were used. Traditional psychometric methods, including Cronbach's alpha, are underpinned by Classical Test Theory, and both the Cronbach's alpha and Classical Test Theory have a range of limitations^{198–201)}. As with any measure where items are combined (e.g. summed, averaged), Rasch analysis should be used to examine the measures' utility^{202, 203)}. Further limitations of the DASH include that it focuses on the upper limb, and that it does not specify whether ratings relate to interference at its worst, on average or at its least, which may influence the validity of the scale. For studies of musicians, it may be important that the items reflect only musical activity, rather than "playing your musical instrument or sport"⁵²⁾, and to make this clear when reporting the study. The DASH performing arts module may be a useful tool for data collection when investigating musicians' MSS, however these limitations must be overcome.

Regarding the prevalence of music-specific outcomes, the approach taken by Kok *et al.*⁷⁹⁾ and Bruno *et al.*¹³⁵⁾ may provide a valid means of collecting these data, by substituting Zaza *et al.*'s²⁾ definition for playing-related musculoskeletal disorders, into the NMQ⁵¹⁾. An advantage of such an approach is that when used with the original NMQ⁵¹⁾, perhaps with the added regions, researchers can investigate the transition of MSS that do not impair musical activity to MSS which do impair musical activity. As this approach currently only has face validity, future research should investigate its validity and reliability.

There have only been two other questionnaires validated for use with musicians specifically^{117, 119)}. Both integrated modified items from the DASH⁵²⁾ sports/performing arts module, along with either the Brief Pain Inventory²⁰⁴⁾ or Chronic Pain Classification Scale²⁰⁵⁾. As with the DASH sports/performing arts module, testing of these scales^{117, 119)} did not use modern psychometric methods, like Rasch analysis, which should be considered in further testing of these scales.

We identified a range of discrepancies between reported outcomes and the questionnaires used. These may be due to inaccurate reporting of the outcomes, or modifications being made to the questionnaires without acknowledgement and description of these changes. Accurate reporting of data collection methods and outcomes is paramount in allowing for critique of the methods used, as well as replication of, or comparison between, studies.

Music-related outcomes

Almost half (49%) of the included studies^{27–31, 34–39, 43, 45, 46, 49, 50, 57, 60, 75, 77, 79, 80, 89, 91–93, 113, 116, 118, 120, 121, 124, 125, 127, 128, 133, 135, 136, 138–161)} reported on 'music-related' outcomes, with the relationship between musical activity and MSS being unclear in 58% of these studies^{34, 38, 39, 43, 46, 50, 57, 60, 75, 77, 89, 91, 92, 113, 120, 121, 125, 139–142, 145–151, 157–159, 162)}. This lack of clarity is a problem also present in qualitative studies (e.g.^{206–210)}, as well as studies where clinicians 'diagnose' 'music-related' MSS without reporting the diagnostic criteria (e.g.^{47, 48, 211)}).

Where the relationship between musical activity and MSS was clearly reported, it referred to MSS which impaired musical activity^{27–31, 35–37, 45, 46, 79, 93, 116, 118, 124, 128, 135, 136, 138, 143, 153, 154, 156, 160)}, with all but one of the studies¹⁴³⁾ using Zaza *et al.*'s^{2, 167, 168)} definition of playing-related musculoskeletal disorders. We therefore suggest that 'music-related' terminology be reserved for MSS that impair musical activity, using Zaza *et al.*'s^{2, 167, 168)} definition. As there are some discrepancies in the definitions reported by Zaza *et al.*'s^{2, 167, 168)}, the definition should still be stated to allow for accurate interpretation of the study findings. Zaza *et al.*²⁾ developed the definition and question regarding 'playing-related musculoskeletal disorders' through focus groups with professional musicians and health professionals, with the question posed as "do you have 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?"²⁾ We recommend this question be used in data collection, where appropriate. The applicability of Zaza *et al.*'s²⁾ definition of 'playing-related musculoskeletal disorders' to children should be examined.

A limitation of the term 'playing-related musculoskeletal disorder' and corresponding definition^{2, 167, 168)} is that it only relates to instrumentalists. Hence, where other musicians (e.g. singers, conductors) are being investigated the term 'music-related musculoskeletal disorders' may be more appropriate, and 'musical activities' substituted for 'playing'. We would caution against the term 'performance-related' which has been used in a number of studies^{30, 31, 34–37, 77, 124, 127, 133, 140–142, 146, 148, 154, 156, 158, 160)}, because it implies the symptoms relate to undertaking a public performance. However, where a definition was provided for these studies^{35–37, 124, 127, 133, 154, 156, 160)} it referred to playing, not performing *per se*, which may lead to confusion. Similarly, statements such as 'associated with playing' which was used in some studies^{121, 145, 155, 157)} should be avoided due to potential confusion with a statis-

tical association between playing and MSS¹⁷⁹).

Rating scales

Regarding the rating scales used, only two studies^{33, 93} reported the measure in sufficient detail to allow for accurate interpretation of the findings. The key problems were ambiguity in the types of scales being reported, not reporting of the scale length and anchors, as well as not reporting the type of rating made (e.g. at its worst, or on average). Such problems are not isolated to this group of studies. Smith *et al.*¹⁷ recently reviewed pain intensity ratings used in studies published in the three main pain journals and identified similar issues concerning reporting.

Both the VAS and NRS were used frequently, with no clear difference between the two regarding improving consistency. Looking at the broader literature, both the NRS and VAS have good reliability and validity²¹²), however the 11-point NRS is generally recommended, over the VAS^{212, 213}), as it is preferred by both respondents^{214, 215}) and researchers (given it has better compliance than the VAS^{212, 213, 215, 216}), and is considered easier to use²¹²). The NRS appears to be the most commonly used rating scale for pain intensity¹⁷), and it has also been deemed an appropriate measure of pain intensity for children and adolescents²¹⁷), potentially allowing for comparisons between child and adult musicians' MSS experiences.

The advantage of the NRS is that it is easy to comprehend²¹²), which may be more important in self-administered questionnaires where clarification of the instructions cannot be sought. As the VAS requires participants to indicate their level of pain on a 100 mm line, resulting in a 101-point scale, the VAS requires high levels of motor control to provide an accurate rating²¹²), which may be an important consideration when administering to people who may be experiencing upper limb symptoms. The NRS does not require this level of fine motor control. The NRS can also be completed verbally, allowing for data to be collected over the telephone²¹²).

The disadvantage of the NRS is that it might not have ratio properties²¹²). While it has been argued in the past that the VAS does²¹²), recent studies have questioned this^{218, 219}). Ordinal data should not be analysed using parametric statistics²⁰²), however we identified a number of studies^{68, 72, 74, 77, 83, 93, 94, 98, 118, 130, 160, 171, 177}) analysing ordinal data using parametric statistics. Ordinal data are inappropriate for longitudinal studies (e.g. intervention studies)²⁰²), however a number of included longitudinal studies reported changes in ordinal data^{94, 98, 130, 160}). Although the NRS appears to be the most appropriate

measure for rating the intensity and frequency of MSS and their consequences; the accurate and complete reporting of the scales and correct selection of statistical methods is vital, and for longitudinal studies aggregate scales should be used, so that the data can be transformed into interval level data, via Rasch analysis.

Few studies specified the type of intensity rating being made (e.g. at its worst or on average), which may influence the validity of the scales; an issue again evident in the broader literature¹⁷). There is evidence to suggest that aggregate measures²¹²), like those in the Brief Pain Inventory²⁰⁴), of pain at its worst, on average, at its least, and sometimes current pain improve the validity of the ratings^{220–222}), as was done in two studies^{118, 120}). This approach has not however been tested using modern psychometric methods, such as Rasch analysis; hence, it cannot be assumed a valid and reliable measure. Where only a single item is included, it has been recommended that participants be asked to rate the intensity of their MSS on average over specific time period²¹²), an approach which has been found to be valid²²³); however, the implications of using ordinal data must be considered. Caution should be exercised when asking participants about their current pain intensity, as pain intensity is susceptible to diurnal variation, as well as to changes in behaviour (e.g. medications, activities^{212, 221, 222}). As such, these factors should be controlled when current measures are taken. Regardless of the scales being used, future studies should refer to the recommendations made by Smith *et al.*¹⁷), to ensure that these scales are adequately reported.

We found little consistency in the anchors used for pain rating scales, which may impact upon findings²²⁴). For consistency, we recommend using “no pain” and “pain as bad as you can imagine”, which are the anchors from the Brief Pain Inventory²⁰⁴), that have been recommended for use to improve consistency for chronic pain trials²¹⁵).

Body regions

Regarding the body regions reported, the regions from the NMQ⁵¹) were most frequently reported, and the laterality of symptoms most commonly investigated in the upper limb, as per the NMQ⁵¹). As musicians have unique physical demands, other regions may be of interest. We have seen the diaphragm/abdominal muscle and lip/oral regions added in Engquist *et al.*'s⁶⁹) modified NMQ, while Kok *et al.*⁷⁹) added the head and jaw/mouth regions.

Few studies referred to using body charts, while others are likely to have used the body charts from the cited questionnaires. Body charts assist in terms of identifying

what is meant by terms like the 'arm' where in some cases this appears to be the area between the shoulder and wrist, while others may indicate that the arm includes the shoulder, wrist and hand. Body charts make this clearer both for the participants, and for the users of the research. Again clear reporting of the body regions, ideally with the aid of a body chart, is required to allow for synthesis and comparison of findings between studies.

Recall periods

The recall periods used were generally not reported clearly enough to allow meaningful data to be extracted. A total of 28 studies did not report recall periods for any outcome, and 32 did not do so for some outcomes. The lack of reporting regarding time periods has been identified in reviews of pain outcomes¹⁷⁾, and broader health issues in other groups^{225, 226)}, indicating that this is not an issue unique to the research of musicians' MSS, but rather a widespread issue which needs addressing.

The most commonly used recall periods identified in this review were lifetime, 12-months, 7-d, and current. There were a number of examples of recall periods being used interchangeably and/or not matching the recall periods used in the questionnaire^{28, 35, 57, 79, 83, 118, 121, 153)}. One of the most common problems was with use of the terms 'point prevalence' or 'current MSS' where this referred to recall periods as long as three months¹⁷⁷⁾. Furthermore, the studies^{34–37, 124)} using Ackermann and Driscoll's¹²³⁾ questionnaire have ambiguous estimates of current symptoms or the intensity of symptoms because the questionnaire specifies that these outcomes referred to current pain/injury as "pain or injury present, or that has been present for at least the past 7 d"¹²³⁾. Reference to this statement was not made in any of these studies^{34–37, 124)}. The terms current and point prevalence should be reserved for MSS at the time of data collection, consistent with normal epidemiological practice²²⁷⁾. As discussed earlier, data regarding current symptoms may be susceptible to diurnal variation and behaviours prior to data collection^{212, 221, 222)}; hence caution must be applied with these measures.

Both lifetime and career prevalence may be problematic given the differences in one's age or career duration; however career prevalence highlighted some additional concerns. For instance, Arnason *et al.*¹⁵³⁾ referred to career prevalence, however their population of interest was university students; hence this may indicate university career, or perhaps the time from commencing their musical studies. Regarding the selection of recall periods, it has been suggested that prevalence studies use recall periods of

12-months or less, to reduce the influence of memory decay²¹⁾. As the most common recall periods for prevalence of MSS were 12-months and 7-d, we suggest these recall periods be used in future studies.

Regarding the ratings of the intensity of MSS or their consequences, we saw that most studies used 7-d or current ratings. The 7-d recall periods for pain intensity are valid^{223, 228–230)} and reliable²²⁹⁾, and are not considered difficult for most people²²⁸⁾. The 7-d recall period is also in keeping with the recommendation that recall periods for pain intensity ratings be less than 3-months to maintain validity of the ratings²¹²⁾. While current ratings reduce recall bias, they are also susceptible to diurnal variation²¹²⁾; hence current pain ratings for research purposes may be inappropriate. Where these are used, there should be standardisation of the data collection methods to minimise the influence of potential confounders (e.g. time of day).

For ratings of MSS consequences, we found the most commonly used recall periods were 7-d. In other populations, it has been recommended that recall periods should not exceed one month²³¹⁾, with no significant differences in 1-, 3–7- and 28-d recall periods for pain interference²³¹⁾. Considering the findings of our review, and the broader literature, 7-d recall periods are therefore also recommended for ratings of the consequences of MSS.

Limitations

As outlined above, this is the first review to focus on the types of MSS outcomes reported in studies of musicians, and the data collection methods used, without restricting the review to a type of musician or type of study.

Given the broad nature of the review, and to maximise the relevance to future research, we focused on studies published in a 10 year period (2007–2016). While there may be other outcomes or data collection methods used in studies prior to 2007, if these have not been used more recently, the inclusion of earlier studies would not have altered the recommendations of our review.

Our review was restricted to studies published in English language, and we may therefore have missed some potentially relevant studies published in other languages; however, the addition of non-English studies would be unlikely to change the findings and recommendations of the present review. As recently discussed by Tsertsvadze *et al.*²³²⁾ excluding non-English studies in reviews does not tend alter the findings^{233–235)}, however this may depend upon the study topic^{234, 236, 237)}. It has been suggested that as the proportion of studies published in English increases, language biases decrease²³⁸⁾; hence our review is

unlikely to be impacted by such a bias. Further, two recent reviews^{9, 14} of musicians' musculoskeletal symptoms did not restrict the language of included studies, yet no non-English studies were included. Although these reviews^{9, 14} considered a narrower range of topics and musician types, this finding again indicates that the findings of the present review would not be expected to change.

The search, study selection and data extraction were carried out by one reviewer, with uncertainties regarding study selection checked by a second reviewer and data extraction performed twice by one reviewer and checked by another reviewer. With a comprehensive search strategy employed, involving searching databases, screening the titles of *Medical Problems of Performing Artists*, and screening the citation and reference lists of relevant studies it is unlikely that any relevant studies were missed. Regarding data extraction, evidence suggests that review findings do not change whether double extraction or single extraction with verification is performed¹⁶, and the latter is therefore deemed an acceptable approach¹⁵.

Summary of recommendations

Our recommendations regarding MSS assessment for musicians, based on the current evidence for both the types outcomes and data collection methods used, and on the broader literature around validity and reliability, are summarized in Table 10. Regardless of the MSS assessment tools used, these must be reported in sufficient detail to allow for replication (e.g. recall period, body regions, questionnaires used, the type and length of rating scales used).

Conclusion

We aimed to improve the consistency of reported outcomes and tools used in musicians' MSS research, by documenting and reviewing parameters from published papers. Based on the most common outcomes and tools used with musicians, and the broader literature, we developed recommendations, as summarised in Table 10, to improve the consistency of outcomes and data collection tools used in future studies of musicians' MSS. We also identified that there is a need for consistency and clear reporting of the tools used and outcomes reported for musicians' MSS research. Opportunities for future research into music-specific data collection tools, as well as validation of existing tools for use with musicians were identified. By improving this consistency, as well as developing valid tools of music-specific MSS outcomes, it is anticipated that the

quality and consistency of research into musicians' MSS will improve, along with opportunities for synthesis and comparison of research findings across studies. Strengthening the body of evidence around musicians' MSS should lead to improved recommendations for prevention and management of MSS for this population.

Acknowledgements

The authors would like to thank Maureen Bell (The University of Adelaide) for assisting with the development of the search strategy. JS is the recipient of an Australian Government Research Training Program Scholarship, and a SafeWork SA WHS Supplementary Scholarship (funded by the South Australian Government). SafeWork SA and the South Australian Government do not endorse the content of this material and the views expressed herein do not represent the views of SafeWork SA or the South Australian Government.

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Table 10. Summary of recommendations

Recommendation	Supporting evidence from the present review	Other evidence
<i>Questionnaire</i>		
For the prevalence of MSS the NMQ ⁵¹⁾ is recommended	Most commonly used standardised questionnaire	Valid and reliable ^{51, 61, 62, 64, 67)} Used with a range of populations ^{194–196)}
For MSS which impair musical activity the NMQ ⁵¹⁾ with Zaza <i>et al.</i> 's ^{2, 167, 168)} definition for playing-related musculoskeletal disorders ^a incorporated is suggested	Most commonly used standardised questionnaire Zaza <i>et al.</i> 's ^{2, 167, 168)} definition for playing-related musculoskeletal disorders is the most commonly reported definition of 'music-related' MSS outcomes	Zaza <i>et al.</i> 's ^{2, 167, 168)} definition of playing-related musculoskeletal disorders was developed through focus groups with musicians
<i>Rating Scales</i>		
NRS (11-point) is recommended	The 11-point NRS and VAS were often used	The NRS is preferred over the VAS ^{212–216)} Valid and reliable ²¹²⁾ Most commonly used rating scale for pain intensity ¹⁷⁾ Recommended for pain intensity ratings ²¹⁵⁾
For pain intensity, the anchors "no pain" to "pain as bad as you can imagine" should be used	Used in a study of pain intensity ¹¹⁸⁾ with similar anchors used in others ^{175, 177, 179)}	Recommended anchors for pain intensity ²¹⁵⁾
Multiple measures (e.g. worst, on average, least) should be considered, if this is not possible pain on average should be used (except in longitudinal studies)	Aggregate measures were used in two studies of musicians ^{118, 120)}	Aggregate measures to improve the validity ^{212, 220–222)} Ratings of pain intensity 'on average' are valid ²²³⁾
<i>Body regions</i>		
The body regions from the NMQ ⁵¹⁾ are suggested, along with the NMQ body chart	The NMQ ⁵¹⁾ is the most commonly used standardised questionnaire The NMQ body regions are the most commonly reported	Allow for comparison with a range of other populations ^{194–196)}
The addition of the head, orofacial and chest/abdomen regions should be considered	The head and orofacial regions have been investigated previously and added to the NMQ ⁷⁹⁾	These body regions may be of particular interest for wind instrumentalists, singers and upper string players
<i>Recall periods</i>		
For the prevalence of symptoms, we recommend recall periods of 12-months and/or 7-d	Most commonly used recall periods were 12-months, 7-d and current, however 'current' poses issues of validity and reliability Most commonly used standardised questionnaire	Recall periods for the prevalence of symptoms should not exceed 12-months to reduce memory decay ²¹⁾ Allow for comparison with a range of other populations ^{194–196)}
For ratings of MSS, we recommend a 7-d recall period	Most commonly used recall period for ratings are 7-d for MSS intensity and frequency, and MSS consequences intensity and frequency	7-d recall periods are valid ^{223, 228–230)} and reliable ²²⁹⁾ for MSS intensity, and valid for pain interference ratings ²³¹⁾ 7-d recall periods are not considered difficult by most people ²²⁸⁾ Recall periods for ratings of pain intensity should not exceed 3-months to improve validity ²¹²⁾ Recall periods for ratings of pain interference should not exceed 1-month to improve validity ²³¹⁾

NMQ: Nordic Musculoskeletal Questionnaire; MSS: musculoskeletal symptoms; VAS: visual analogue scale; NRS: numerical rating scale. ^athe definition may need to be modified for use with non-instrumental musicians, but should be clearly reported.

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Appendix 1. Search strategy

Database search

Using the search terms reported in Appendix Table 1, seven databases (Web of Science Core Collection, Cochrane Library, EbscoHost Music Index, EbscoHost Health Source: Nursing and Academic Edition, EbscoHost Cumulative Index to Nursing and Allied Health Literature, Ovid Embase and Ovid Medline) were searched in January 2017. Where possible the search was limited to English language and the publication dates 2007–2016.

Titles of articles published in *Medical Problems of Performing Artists* from 2007–2016 were screened, as well as the Abstracts section of the journal. Any titles that reported performing artists or musicians, and health, medical or musculoskeletal conditions were added to the Endnote library.

Within the Endnote library, duplicates were removed, before the titles and abstracts were screened. At this stage any studies that were not published in English language, in full text, within peer reviewed journals (according to Ulrich's Web Serial Analysis System), from 2007–2016 were excluded, as were studies where musicians' musculoskeletal symptoms (MSS) were not reported, nor broader terminology (e.g. performing artists' health problems) which may have included musicians' MSS. Full texts were then screened using the same criteria, however at this stage they had to clearly report musicians' MSS. In addition, full text screening excluded studies that only reported symptoms during clinical examinations (e.g. trigger point pain) or musculoskeletal signs in the absence of symptoms. We also excluded correspondence, case reports, editorials and narrative reviews (i.e. reviews which did not meet the Preferred Reporting Items of Systematic Reviews and Meta-Analysis definition of a systematic review²³⁹); however these studies were retained for citation and reference list screening.

The citation lists (Google Scholar and Web of Science) and reference lists of included studies, and relevant narrative reviews, editorials, correspondence and case reports were screened for potential inclusion. The process continued until no additional studies were identified.

Appendix Table 1. Search terms

Title or keyword	musician* OR "music-related" OR "music related" OR conservatory OR conservatories OR conservatorium* OR conservatoire* OR woodwind* OR flute OR flutes OR flautist* OR flutist* OR clarinet* OR sax OR saxes OR saxophon* OR *bassoon* OR oboe* OR oboist* OR "double reed*" OR "Double-reed*" OR trumpet* OR trombon* OR tuba OR tubas OR tubist* OR bugle* OR cornet* OR euphonium* OR violin* OR violinist* OR viola OR violas OR violist* OR *cello OR *cellos OR *cellist* OR guitar* OR fiddle* OR banjo* OR baritone* OR piano* OR pianist* OR timpan* OR hornist* OR bassist* OR bagpipe* OR drummer* OR percussionist* OR harpist* OR harp OR harps OR harpsichord* OR organist* OR "church organ*" OR "pipe organ*" OR keyboardist* OR instrumentalist* OR vocalist* OR sing OR singer* OR singing OR choir* OR orchestra OR orchestras OR "playing-related" OR "performance-related" OR "playing related" OR "performance related" OR musical* OR (music near/3 (major* OR stud* OR teach* OR tuition OR training OR educat* OR school* OR perform* OR rehear* OR play* OR practi* OR concert* OR band* OR ensemble* or instrument*)) OR ((*wind* OR *reed* OR brass OR string* OR horn* OR bass* OR recorder* OR pipe OR pipes OR piper OR pipers OR drum* OR percussion* OR organ OR organs OR keyboard* OR vocal* OR voice) near/3 (major* OR stud* OR teach* OR tuition OR training OR educat* OR school* OR perform* OR rehear* OR play* OR practi* OR concert* OR band* OR ensemble* OR instrument* OR music* OR corp OR corps)) OR ("instrumental music*" OR ((band* OR ensemble*) near/3 (music* OR stage OR big OR folk OR country OR brass OR wind OR string OR percussion OR jazz OR baroque OR Dixieland OR traditional OR Irish OR march* OR military OR army OR defence OR navy OR force OR member*)) OR "marching art*" OR "performing art*" OR (conductor* near/3 (music* OR band* OR orchestra* OR ensemble*)) OR "musical director*" OR "drum major*" OR opera OR operas OR operatic
MeSH [^]	Musculoskeletal diseases OR pain OR "wounds and injuries"
Emtree [^]	Musculoskeletal disease OR pain OR injury
CINAHL subject heading [^]	Musculoskeletal diseases OR pain OR "wounds and injuries"
Health Source subject headings [^]	Musculoskeletal system – diseases OR pain or "wounds & injuries"

*indicates truncation, near/3 means 3 words between, ^ all terms were exploded where this was available in the database.

Appendix 2.

Appendix Table 2. Recall periods and symptom quality of general symptom prevalence

	Lifetime	Career	18-months	12-months	6-months	Previous summer	3-months	1-month/ 4-wk	2wk	1-week/ 7-d	Point/ current
Symptoms ^a	34, 35, 103, 139, 145, 177)		124)	40-42, 57, 83, 121, 137, 152)		140)		170)		57, 66, 83)	35, 36, 40, 41, 124, 139, 174, 178)
Ache/pain /discomfort	68)	70)		32, 68)				68)		32)	68)
Pain/discomfort/tension	151)										
Pain/discomfort									176)	72)	149)
Pain/ache				56)							
Pain/soreness										33)	
Pain	49, 50, 103, 142, 145, 151)			40, 43, 44, 60, 75, 89, 134, 152)	59, 120)		49, 50, 58, 59)	50, 134)		43, 59, 171)	34, 37-40, 50, 122, 131, 151, 178)
Discomfort	151)										
Soreness											122)
Tension	151)										178)
Clicking/popping	103)										
Crepitus	103)										
Tightness											122)
Reduced range of motion	103)										
Loss of gross motor skill				40)							40)
Loss of fine motor skill				40)							40)
Involuntary movements	145)										
Power loss				40)							40)
Loss of control				40)							40)
Cramp	145)			40, 152)							40)
Muscle fatigue											178)
Loss of speed				40)							40)
Loss of endurance				40)							40)
Swelling				40, 60, 152)							40)
Redness				40)							40, 178)
Neuropathic symptoms	145)										
Burning				60)							
Numbness				60, 152)							
Tingling				60)							
Weakness				60, 152)							
Soreness				60)							
Stiffness				60)							

^awhere more than three symptom types were specified these were classified only as symptoms.

Appendix Table 3. Prevalence period and body regions for studies reporting the prevalence of general symptoms

	Lifetime	Career	18-months	12-months	6-months	Previous summer	3-months	1-month/ 4-wk	2wk	1-week/ 7 d	Point/ Current
Any region	34, 35, 139, 142, 145, 151)	70)	124)	41, 42, 57, 60, 75, 89, 121, 137, 152)	120)	140)	49)	170)		57, 72, 171)	34–37, 41, 49, 122, 124, 131, 139, 150, 151, 174)
Back of head/neck/shoulders											178)
Head/neck										72)	
Head/face/lips	35)										35)
Head	49)			121)			49, 50)				49)
Face/jaw/temple/front of ear								50)			
Orofacial: head/sinuses/nose/ lips/teeth/tongue/jaw/throat/ face										171)	
Cheeks/jaw/temple	103)										
Face								50)			50)
Temporomandibular joint	49, 50, 103)						49, 50)				49, 178)
Jaw/mouth				41)							41)
Mouth	144, 178)			41, 152)							178)
Teeth/jaw	49, 50)						49, 50)				49)
Jaw	35, 151)			41, 89)							
Front tooth											178)
Back tooth											178)
Lips				89)							
Clavicle/pelvis										171)	
Neck/shoulders/upper back/ lower back				56)							
Neck/upper extremity/back				32)						32)	
Neck upper extremity/lower back				134)				134)			
Neck/shoulders/upper back				41, 42)							41)
Neck/upper trapezius											124)
Neck/shoulder									176)		
L/R neck/shoulder											35)
Neck/arm/shoulder				40)							40)
L/R neck/upper limb											35)
Shoulder/arm				152)							
Upper limbs				75)							
Both upper limbs											35)
L/R upper limb/arm	35)									66)	35)
Shoulder/upper arm				120)							34)
L/R shoulder/upper arm											35)
Arms	145)										
Shoulders	68, 145)			43, 44, 56, 68, 75, 134, 137)			58)	68, 134)		43, 72)	38, 39, 68)
L/R shoulder	35, 49)			32, 40, 41, 57)	59)		49, 50, 59)			32, 33, 59, 66)	34, 40, 49, 124, 174)
Both shoulders				57)							
L/R front shoulder	151)										
L front shoulder				89)							
L/R back shoulder	151)										
L back shoulder				89)							

	Lifetime	Career	18-months	12-months	6-months	Previous summer	3-months	1-month/ 4-wk	2wk	1-week/ 7 d	Point/ Current
L/R shoulder/upper arm/ elbow										171)	
Upper arm											38, 39)
L/R upper arm	151)										124)
L front upper arm				89)							
Elbow/wrist/hands				41, 42)							41)
Elbow/forearm				121)							34)
L/R elbow/forearm											35)
Elbows	68, 145)			43, 44, 56, 68, 134, 137, 152)			58)	68, 134)		43, 72)	38, 39, 68)
L/R elbow	35, 49, 150)			32, 40, 41, 57)			49, 50)			32, 33, 66)	40, 49, 124, 174)
Both elbows				57)							
L front elbow				89)							
L/R lower arm/wrist/hand/ fingers/thumb										171)	
Forearm											38, 39)
L/R forearm/lower arm	35, 151)									66)	124)
L front forearm				89)							
Wrist/hand/fingers				121)							
Wrist/hands	68)			43, 44, 56, 68, 134, 137, 152)			58)	68, 134)		43, 72)	34, 68)
L/R wrist/hand				57)						33)	35)
Both wrists/hands				57)							
Wrists	145)										38, 39)
L/R wrist	35, 49)			40, 41)			49, 50)			66)	40, 49, 124, 174)
L front wrist				89)							
L/R hand/fingers	151)										
Hands	145)			152)							
L/R hand	35)			32, 40, 41)						32, 66)	40, 124)
L front hand				89)							
Palm											38, 39)
Fingers	145)										34, 38, 39)
L/R fingers	35, 49)						49, 50)				35, 49)
Thumbs											34)
L/R thumb											35)
Neck/back										171)	
L/R neck/back				89)							
Neck	35, 49, 68, 145, 151)			32, 40, 41, 43, 44, 56, 57, 68, 75, 121, 134, 137, 152)	59)		49, 50, 58, 59)	68, 134)		32, 33, 43, 59, 66)	35, 38-40, 49, 68, 174)
Back/trunk											38, 39)
Chest/abdomen											35)
L/R chest	151)										
Trunk											35)
Back	35, 145)			137)					176)		35)
Paravertebral region										66)	
Upper back/thoracic region	49, 68)			32, 40, 41, 43, 44, 56, 57, 68, 75, 121, 137, 152)			49, 50, 58)	68)		32, 33, 43, 66, 72)	35, 49, 68)

	Lifetime	Career	18-months	12-months	6-months	Previous summer	3-months	1-month/ 4-wk	2wk	1-week/ 7 d	Point/ Current
L/R upper back	151)			89)							
Middle back	35)										124)
L/R middle back	151)										
Lower back/lumbar region	35, 49, 68)			32, 41, 43, 44, 56, 57, 68, 75, 121, 134, 137, 152)			49, 50, 58)	68, 134)		32, 33, 43, 66, 72)	35, 41, 49, 68, 124, 174)
L/R lower back	151)			89)							
Both lower limbs											35)
L/R lower limb											35)
Hip/buttock/thigh				121)							
L/R hip/thigh/femoral bone/ knee										171)	
Hips/thighs	68)			43, 44, 57, 68, 152)			58)	68)		43, 72)	68)
Groin											174)
Hip/knees				41)							41)
Hips										33)	38, 39)
L/R hip	35)			41)							
Buttock/thigh				137)							
Thigh											38, 39)
Knee/lower leg				121, 152)							
Knees	68)			43, 44, 57, 68)			58)	68)		33, 43, 72)	38, 39, 68)
L/R knee	35)			41)							
L/R shin/calf/ankle/heel/foot arch/toes										171)	
Ankle/foot/toes				121)							
Feet/ankles	68)			41, 43, 44, 57, 68)			58)	68)		33, 43, 72)	38, 39, 41, 68)
L/R foot/ankle	35)										
L/R ankle				41)							
Foot				152)							
L/R foot				41)							
Arms/hands/legs/knees/hips/ joint									176)		
Unclear ^a				40, 83)						83)	40)

L: left, R: right, L/R: the sides were reported separately. ^aAppears to be an overall measure, but the studies focused on specific body regions (i.e. the upper limb⁸³) and the neck/shoulder/arm⁴⁰) so these values may relate only to these body region.