Why do we need to investigate non-classical musicians to reduce the burden of musicians’ musculoskeletal symptoms?

Jessica STANHOPE¹* and Philip WEINSTEIN²

¹School of Public Health, The University of Adelaide, Australia
²School of Biological Sciences, The University of Adelaide, Australia

Abstract: Musculoskeletal symptoms (MSSs) are common among professional musicians; however, most of the research has focused on orchestral/classical musicians. In some countries orchestral and classical musicians are in the minority; hence targeting research towards these specific sub-groups of musicians is unlikely to address the overall burden of musicians’ MSSs, unless the research is generalizable to other types of musicians. This multidisciplinary narrative review seeks to answer the question: “why do we need to examine the MSSs of non-classical groups of performing musicians in order to reduce the burden of musicians’ MSSs?”. There are differences in the education, posture, tasks (e.g. military training for military band musicians, dancing for those in musical theatre), venues and management of MSSs for different types of musicians. Future research should compare classical and non-classical musicians in order to determine which specific sub-groups (e.g. military band musicians) have the greatest MSS burden, such that further research into the risk factors of and interventions for MSSs can be targeted towards the sub-groups of musicians with the greatest MSS burden. In doing so, we maximise the likelihood of being able to introduce interventions, policies and practice that reduce the burden of musicians’ MSSs.

Key words: Musician, Jazz, Opera, Military band, Musical theatre, Orchestra, Pain, Musculoskeletal

Introduction

Musculoskeletal symptoms (MSSs) may include ache¹, discomfort¹, pain¹–³, weakness², tingling², numbness², stiffness³, and lack of control³ in soft tissue, peripheral joints and the axial spine³. There is a high prevalence of MSSs in professional musicians⁴ which is reportedly higher than that of the general workforce⁵. Furthermore, musculoskeletal disorders account for 70% of all workers’ compensation claims made by employed musicians⁶. Musculoskeletal symptoms may have a range of consequences for musicians, including having to take time off from work⁵–⁸. Research into musicians’ MSSs is therefore warranted in order to ultimately reduce the burden of musicians’ MSSs.

There is a relatively large body of evidence recently published regarding professional musicians’ MSSs, however 69% of these studies were of orchestral musicians, with fewer than five studies each investigating military band musicians, choristers, opera singers and Cuban band musicians⁹. Orchestral musicians form a minority of professional musicians in many countries. For instance, in Australia orchestral musicians are estimated to account...
or less than 10% of professional musicians\(^9\); and 64% of instrumentalists and singers predominantly work in contemporary musical genres\(^10\). To address the burden of musicians’ MSS these other groups of musicians should therefore be investigated.

Our recent systematic mapping review\(^9\) of the musicians’ MSS literature did not identify any studies comparing professional musicians working in different genres, and only two studies\(^11, 12\) that have compared different ensemble types. One of these two studies compared the prevalence of MSS outcomes in musicians in different types of orchestras (stage only, pit only, stage/pit\(^12\)), and the other different groups within military bands (blues, concert, ceremonial and chorus\(^11\)). These comparisons, while useful, do not assist in determining the generalisability of research on orchestral musicians, to other types of professional musicians.

This review answers the question “why do we need to examine the MSSs of non-classical groups of performing musicians in order to reduce the burden of musicians’ MSSs?”. We focus on popular, rock, jazz, and traditional (e.g. Irish folk) music as examples of non-classical musical genres, and musical theatre, concert, marching, brass, and stage bands as examples of non-classical ensembles.

To answer this question we examined the characteristics of classical and non-classical musicians, and orchestral and non-orchestral ensemble musicians.

**Genres**

The main musical genres in Western music are classical, jazz, contemporary (e.g. rock, popular), and folk music. Musical theatre may also be thought of as a musical genre; however musical theatre will be discussed in the Ensembles section of this review. These musical genres typically have different types of instrumentalists (Table 1), and musicians might not restrict themselves to one genre\(^13, 14\), particularly for singers and those playing instruments which may cross multiple genres. Beyond the differences in instruments, there are differences in the training of musicians, in the playing settings and personality differences, that may be associated with MSS outcomes\(^15\).

**Education and focus**

The education and focus of skills development differs between classical and non-classical musicians (summarised Table 2). Irish traditional musicians have also reported that classical musicians focus on perfection, while in traditional music the focus is on learning a tune as soon as possible, with little consideration for musical literacy and posture\(^16\).

**Repertoire**

Classical music is arguably the most structured genre, where musicians follow what is written on the score, emulating the composers’ intentions; the music cannot simply be modified to suit the musicians’ abilities. There are two main exceptions to this. The first exception is the ornamentation to Baroque music. The compositions are typically less technically demanding than compositions of later periods, and musicians can select ornamentation within their technical capabilities. The second exception is cadenzas, which are improvised passages, typically in concertos, where musicians have control over what they perform: this is the soloists’ opportunity to show off their technical capabilities; hence they may choose to push their technical limits.

Non-classical music is often technically easier than classical. For Irish traditional musicians however, like Baroque music, the music requires ornamentation, selected by the musician. For Irish traditional musicians, the speed of the music has been identified as a problem\(^16\), where reels will be repeated, at an increasing tempo\(^16\), which may push the musicians’ technical capabilities. For jazz musicians, there is an emphasis on improvisation. Improvised passages, like cadenzas in some classical solo works, allow musicians to display their technical capabilities, but have the advantage of allowing musicians to play
Table 1. Types of musicians typically involved in each genre, and ensemble type

| Genres     | Types of musicians typically involved                                                                                                                                                                                                 |
|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Classical  | Vocalists, and violin, viola, cello, double bass, harp, flute, oboe, bassoon, clarinet, saxophone, trumpet, cornet, trombone, French horn, euphonium, tuba, percussion, piano, harpsichord, pipe-organ, classical guitar players. |
| Jazz       | Vocalists, and saxophone, trumpet, trombone, double bass, acoustic guitar, electric guitar, bass guitar, keyboard, piano, and percussion players, and sometimes flute, clarinet, banjo, and electric organ players.                                             |
| Rock/popular | Vocalists, and acoustic guitar, electric guitar, bass guitar, piano, keyboard, and percussion (generally drum kit) players, and sometimes saxophone, trumpet, trombone, and double bass players.                                      |
| Folk       | Depends on the type of folk music, but in Western folk music instruments may include tin whistles, fiddles, acoustic guitar, banjo, concertina, bag pipes and percussion players.                                    |

| Ensemble types | Symphony orchestra | Conductor, and violin, viola, cello, double bass, harp, flute, oboe, bassoon, clarinet, trumpet, cornet, trombone, French horn, euphonium, tuba, and percussion players, and sometimes saxophone, cornet, piano, harpsichord, and pipe-organ players. Soloists may include any type of instrument, as well as vocalists. |
|----------------|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                | Chamber orchestra  | Violin, viola, cello, and double bass players, and sometimes flute, oboe, trumpet, harpsichord players.                                                                                                                                                                           |
|                | Concert band        | Conductor, and flute, clarinet, oboe, bassoon, saxophone, trumpet, trombone, French horn, euphonium, tuba, and percussion players, and sometimes cornet, double bass and piano players.                                                                                                                                                   |
|                | Marching band        | Drum major, and piccolo, clarinet, oboe, saxophone, cornet, trombone, French horn, euphonium, tuba/ sousaphone, and percussion players.                                                                                                                                                                                                  |
|                | Brass band           | Cornet, tenor horn, euphonium, and trombone players.                                                                                                                                                                                                                                                                                  |
|                | Big band/ stage band | Saxophone, trumpet, trombone, electric guitar, bass guitar, piano, and percussion players, and sometimes the saxophone player will ‘double’ on flute and/or clarinet.                                                                                                                                                              |
|                | Musical theatre      | Musical director, vocalists and an orchestra with variable instrumentation depending on the musical.                                                                                                                                                                                                                                     |
|                | Opera                | Musical director, vocalists and an orchestra similar to a symphony orchestra.                                                                                                                                                                                                                                                         |
|                | Choristers           | Conductor, and vocalists                                                                                                                                                                                                                                                                                                             |

Small groups e.g. jazz combos, rock groups, folk groups, chamber music ensembles have not been included above, but include various combinations of instruments from the abovementioned genres. Variations of the instruments (e.g. piccolo, tenor saxophone) have not been included.

Table 2. Summary of the characteristics of classical and non-classical musicians regarding education

|                      | Classical musicians | Non-classical musicians                                                                                                                                                                                                                                                                       |
|----------------------|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Start age            | Typically start music earlier than non-classical musicians\(^{17, 18}\)                                      | Typically start learning music later than classical musicians\(^{17, 18}\)                                                                                                                                                                                                                   |
| Education strategies | Long tradition of formal education\(^{18}\)  
Focus on solo work\(^{17, 18}\)  
Practice is high priority\(^{17}\)          | Non-classical music programs have been introduced to universities more recently\(^{17, 19}\), but non-classical musicians are more autonomous\(^{18}\).  
Non-classical musicians spend more time networking\(^{17, 18}\), engaging in mental rehearsal\(^{17}\), playing with others\(^{17, 18}\), and engaging in professional conversations\(^{17, 18}\), than classical musicians  
Jazz/contemporary musicians specifically learn through attending gigs, listening to music and memorising or transcribing it, networking with more experienced musicians, and jamming with friends\(^{18}\).  
Irish traditional musicians have a strong oral-aural learning culture\(^{16, 20}\), learning through listening and participating in playing sessions\(^{20}\).  
Even when taught by a teacher, traditional Irish musicians learn through imitation\(^{16, 20}\). |
| Valued skills        | Technical proficiency\(^{17, 18}\)  
Sight reading\(^{18}\)  
Control and quality of tone\(^{18}\)  
Notation-based skills\(^{17}\)  
Musical analysis\(^{17}\)  
Musicality\(^{17, 18}\) | Memorization\(^{17, 18}\)  
Improvisation\(^{17, 18}\)  
Collaboration\(^{18}\)                                                                                                                                                                                                                                                                       |
within their technical limits. It has, however, been argued that jam sessions, and ‘cutting contests’ require musicians to compete and therefore push their technical limits, which may lead to MSSs.

**Posture**

Here, we are not discussing the postures required to play different instruments, which may be more important in some musical genres than others (Table 1); we instead focus on the differences in posture required to play the same instrument; in this case violin/fiddle as an example. It has been reported that there is little consideration for posture in the Irish traditional music culture, which may account for the differences in posture and hand position assumed by classical violinists compared with Irish fiddle players. This is one example of where our understanding of MSSs for one type of instrumentalists is not necessarily generalizable across musical genres; therefore, there is support for the need to undertake research into non-classical musicians.

**Technique**

Technique may also differ between genres, despite playing the same instrument. These differences are both related to the repertoire and the technique required to play in a manner characteristic of their genre. For guitarists, the different picking techniques may alter the MSS risk, while the fast, repeated passages typical of jazz piano playing differ from those generally performed by classical musicians, and may increase the risk of MSSs.

**Venues**

While classical musicians typically perform in concert halls and churches, non-classical musicians will often perform in less formal venues, such as pubs and clubs, with larger concert venues reserved for musicians with large fan bases. Unlike concert halls, pubs and clubs are not generally designed for performance, and sometimes have health and safety issues. The potential differences in rehearsal and performance venues across different musical genres means that research might not be generalizable from one group to another; hence the need for research into the MSSs of specific sub-groups of musicians is supported.

**Movement on stage**

Rock and popular music performers are more mobile on stage compared with other musicians (with the exception of opera and musical theatre performers, described in the Ensemble types section), which could arguably result in a higher or lower risk of MSSs, depending on the type of movement engaged in on stage. Potentially the most dangerous aspect for some contemporary musicians is ‘head-banging’, particularly common in heavy metal band performances. Head-banging may lead to head and neck injury. A number of professional contemporary musicians have reportedly given up performing because of health problems associated with head-banging.

**Preventing and managing musculoskeletal symptoms**

There are also differences between classical and non-classical musicians regarding the prevention and management of MSSs. For example, Irish traditional musicians hold that their traditional ‘identity’ does not include doing exercises or warming up, noting that classical musicians will prepare and warm up before performances, which is not typical of their traditions. Irish traditional musicians have reported that they do not take MSSs as seriously as classical musicians, although attitudinal difference has not been examined. How identity shapes behaviours and responses to MSSs should therefore be investigated across different sub-groups of musicians.

There appear to be a number of similarities in the management of MSSs by classical and non-classical (e.g. Irish traditional) musicians. These similarities include prioritising performance over their MSSs, playing through pain, getting caught up in the playing experience, having difficulties in stopping playing when they notice MSSs, not noticing symptoms until

---

**Table 3. Comparison of the playing posture/position of classical violinists compared with Irish fiddle players**

| Classical violin | Irish fiddle |
|------------------|--------------|
| Hold the instrument approximately parallel to the floor | Instrument angled towards the floor |
| Instrument positioned between the shoulder and chin | Instrument held against the anterior trunk between the neck and shoulder |
| Play sitting or standing | Typically play sitting in a slouched position |
| Left wrist in a neutral or flexed position | Left wrist in an extended position |
| Fingers on the right hand flexed with increasing flexion, particularly of the carpometacarpal joints towards the fifth digit | Fingers of the right hand flexed to approximately the same angle across digits 2–5 |
after they have stopped playing\textsuperscript{20, 27}, having a ‘culture of silence’ around MSS\textsuperscript{16, 29–31}, and a distrust of and negative experiences with health professionals\textsuperscript{2, 20, 28, 32}. These similarities indicate that non-classical musicians are likely to face some of the same challenges in managing MSSs as classical musicians, and non-classical musicians therefore also require research attention.

### Ensemble types

In this section we compare classical orchestral musicians, and musicians in other types of ensembles (i.e. pit orchestral musicians, opera and musical theatre stage performers, and military band musicians). Each of the ensemble types is summarised in Table 4, before comparisons between the ensemble types are made, regarding the venues, unique activities (e.g. marching), equipment, and management of MSSs reported, in that order, in the sections below.

#### Performance environment

Stages are the typical working environment for musicians, particularly orchestral musicians, and opera or musical theatre performers. Raked (angled) stages were constructed to improve the ability for the audience to view the performers, and are more common in older theatres\textsuperscript{36}, but may pose problems for the performers. Raked stages were reported as a problem related to MSSs by an opera singer\textsuperscript{40}, and performing on raked stages was associated with injury in musical theatre performers\textsuperscript{41}, particularly dancers\textsuperscript{42}.

Another working environment is the pit, where there are a number of unique issues faced by musicians. Specific issues identified by musicians include insufficient room (leading to musicians adopting uncomfortable positions)\textsuperscript{33, 43}, poor lighting\textsuperscript{43}, dangerous access to the pit\textsuperscript{43}, cables\textsuperscript{43}, and objects falling from the stage into the pit\textsuperscript{43}. Recent guidelines\textsuperscript{44, 45} have stipulated that covers should be over the pit to address the latter issue. The pit wall can also impose limitations on posture, particularly when ergonomics have not been considered, and when a musician is required to play multiple instruments (discussed further below).

Unlike most other musicians, military band musicians often perform outdoors. Playing outdoors may place additional stress on musicians’ bodies, particularly on windy days where the wind may place stress on larger instruments, and ultimately the instrumentalist. Cold or hot temperatures may also affect military band musicians when outside. For instance, in hot weather the instrumentalist may sweat, resulting in increased gripping of the instrument to stabilise it.

#### Equipment

The equipment needs of musicians include seating, music stands, props, costumes, and footwear. For opera and musical theatre performers, costumes, footwear, props and other issues have been identified as potential hazards, particularly in poorly lit back stage areas\textsuperscript{36}.

Opera singers have identified ill-fitting costumes as a problem\textsuperscript{40}, and recently the weight of costumes has been identified as a problem in musical theatre, with costumes weighing as much as 40 pounds (18 kg)\textsuperscript{36}. Similarly, some roles require performers to wear wigs and/or headpieces, that may be used to conceal microphone transmit-
Newer musicals also combine costumes and props\textsuperscript{36}. Morton\textsuperscript{36} recently described the physical requirements of playing Lumière (the candelabra) in \textit{Beauty and the Beast}, where the actor must support “the weight of two bags of sugar”, while maintaining the required positions, which was to have the elbows at right angles with hands at shoulder level, for up to two hours a night. The weight of costumes, as well as transmitter packs, may alter movement, and place additional stress on the performers’ body, thus contributing to MSSs. Opera singers have also identified ill-fitting shoes and costumes as a MSS issue\textsuperscript{40}, while changing shoes (from rehearsal to performance shoes) have been described as a problem for those in musical theatre\textsuperscript{36}, as well as high-heeled shoes, for female musical theatre performers\textsuperscript{41, 42}.

Footwear is also a potential problem for military band musicians, with standard issue footwear. The footwear varies internationally, but has been shown to alter biomechanics\textsuperscript{46}, which may lead to MSSs. Grier \textit{et al.}\textsuperscript{12} investigated new improved dress shoes for military bands in the United States of America, in response to issues identified in previous work with this population\textsuperscript{47}, however the new shoes did not alter the incidence of injuries for which musicians sought care at the military clinic\textsuperscript{12}. Grier \textit{et al.}\textsuperscript{12} also looked at whether self-reported acceptability of the shoe heel fit, width, toe room, cushioning, breathability, and durability were associated with foot MSSs which limited daily activity and was perceived to be caused by band activities in the previous 12-months. Grier \textit{et al.}\textsuperscript{12} found an association between shoe cushioning and this MSS outcome, in the multivariate analysis. Having standard issue footwear may lead to MSSs for some musicians, but has not adequately been investigated to date.

Unlike orchestral musicians, military band musicians are often required to set-up and pack-up equipment for rehearsals and performances, including chairs, music stands, and amplifiers, which anecdotally leads to MSSs, although this is yet to be examined in epidemiological studies. Considering the evidence for the general working population, for manual material handling (including lifting and carrying) the evidence is conflicting for lower back pain in general\textsuperscript{48–51}; however there is consistent evidence for lower back pain and lifting more than 25 kg\textsuperscript{50}. There is also conflicting evidence of an association between lifting, and neck and shoulder pain\textsuperscript{48, 52}, and reasonable evidence of an association between lifting, and hip and knee pain\textsuperscript{48}. Nonetheless, the manual materials handling remains a difference between orchestral and military band musicians, which warrants further investigation regarding MSSs.

\textbf{Differences in the tasks performed}

\textbf{Sitting or standing}

Musicians within different ensemble types may be required to engage in prolonged sitting (typically symphony/philharmonic/pit orchestral musicians, concert band and some big band musicians), while others engage in prolonged standing (most musicians in chamber orchestras, military bands). Both prolonged standing and sitting have been proposed as risk factors for MSSs, particularly for lower back pain, however the evidence is scant, with mixed results\textsuperscript{48, 52–55}. For musicians within military bands there was a statistically significant association between standing time and foot symptoms (foot pain, discomfort, soreness, weakness, numbness, tingling which was believed to be due to band activities, and which limited daily activity). This association was, however, no longer statistically significant after adjusting for confounders\textsuperscript{12}. The musculoskeletal risks imposed by prolonged sitting or standing in specific types of musical ensembles therefore remain unclear, but might potentially lead to differences in the prevalence and profile of MSSs between musicians in different ensemble types.

\textbf{Marching}

Most military band musicians will have to march and stand on parade as part of their duties. It may be argued that marching limits sitting or prolonged static standing, potential risk factors for MSSs (despite conflicting evidence\textsuperscript{48, 52–55}). While it may be argued that marching is therefore a protective factor, the physical stress of marching may also theoretically lead to MSSs. Only one study\textsuperscript{12} has examined marching time as a risk factor for foot MSSs (pain, discomfort, soreness, numbness, weakness, tingling which impaired daily activity and which was believed to be due to band activities). The authors identified an association in the bivariate analysis, but not the multivariate analysis. However, it is not just the marching movement that may be problematic, but also playing instruments in a different way. For instance, drums are typically on stands when playing, however while marching a harness must be used for the musician to carry the drums, placing the musician under significant physical stress. There are also some more subtle changes, for instance piccolo players not rotating through the cervical and thoracic spine to the left as they would typically do, instead maintaining alignment of the shoulders and pelvis, thus altering the biomechanical stress on the body. Additionally, where music is read while playing, a lyre (small music stand) is used, which may be attached to the instrument or the player, thereby
altering positioning. For example, the piccolo player will usually play with the elbow held across the musician’s body, close to the abdomen, however when a lyre is used the elbow must be held in front of the musician, almost in line with the shoulder, so that the lyre is at eye-level. Marching while playing applies unique stress on the body of military band musicians, which may change their risk of MSSs, when compared with other types of musicians.

**Multi-instrumentalists**

Both military band musicians and orchestral musicians for musical theatre are often required to be multi-instrumentalists, particularly woodwind players. For example, Leonard Bernstein’s *West Side Story* requires one musician (Reed 3) to play the piccolo, flute, B-flat clarinet, bass clarinet, oboe, English horn, tenor saxophone, and baritone saxophone. Whether playing multiple instruments increases the risk of MSSs or not remains under-investigated, with only two studies published on the topic. One, a study of child instrumentalists, revealed a protective effect, while another, of professional bassists, found no association. It may be argued that learning and maintaining skills in additional instruments is likely to require additional total time spent playing, however as some skills are likely transferable between them, it could be argued to reduce the time exposed to particular biomechanical factors, and therefore reduce the risk of MSSs.

Multi-instrumentalists in pit orchestras for musicals have additional stressors, in that that have to swap between instruments, sometimes quickly. There are times when a woodwind player may have a saxophone hanging, otherwise unsupported around their neck, while playing another instrument, which limits their ability to maintain a good posture, in addition to having the weight of the instrument placing stress on their neck as it is not supported with the hands as would typically be done while playing. Keeping instruments on stands around the multi-instrumentalist also takes up limited room in the pit, reducing the available space to maintain a good posture, both for that musician and for others. For musicians carrying multiple instruments into venues, there may also be manual handling issues.

**Physicalization**

Musical theatre performers have arguably the most physical musical performance tasks off all musicians. Singers in both musical theatre and opera must act, however musical theatre may also involve acrobatics, dancing, stage combat, and puppetry. Two retrospective studies were conducted of performers in Broadway and West End musicals. Lower limb injuries were the most commonly affected areas for both those in predominantly acting or dance roles. The same was true of a small study of musical theatre students, where traumatic, lower limb injuries were the most common, which is typical of dancers’ MSSs. This differs from what has been reported in other types of musicians, where upper limb MSSs are more common, and the onset tends to be gradual, and described as being atraumatic. To our knowledge, there have not been any epidemiological studies of opera singers MSSs, however the prevalence of MSSs for actors (in general), is similar to that of musicians.

Physical tasks, unique to musical theatre, that have been identified by musical theatre students as risk factors for or activities leading to MSS, include jumping off, landing jumps, dance partners (e.g. lifting a partner or being carried), and performing small dance steps. An emerging issue for MSS in musicals is that of stunts. For example, in the Broadway production of *Spider-Man* injuries included fractures (wrist, feet, ribs, arms, scalpula, vertebra and skull), in addition to concussions, herniated discs, bruised lungs, and internal bleeding. While not all were related to the musculoskeletal system, they show the severity of the incidents, which included being hit by a rope, falling incorrectly in a ‘sling shot’ stunt, falling 20–30 feet from a platform into the pit where the tether was not correctly attached, and hitting the head and face into a wall. One cast member also had his leg caught in a hydraulic trap door. The reported injuries involved eight cast members, and were described as being different to the injuries which were expected by dancers and other stage performers, including sprains, muscle strains and digit fractures. The MSS of singers involved in musical theatre are likely to be different from other types of musicians, in terms of location, and type of onset (e.g. sudden or gradual onset).

**Military training**

A unique requirement of military band musicians is that they must undertake the same basic training and testing (including fitness) required of soldiers. Given the fitness requirements of military band musicians, it may be assumed that these musicians may have a lower risk of MSS compared with other musicians. The evidence of the association between fitness and physical activity, and MSSs is not convincing however. A recent study of military band musicians found that a range of fitness measures and engagement in physical training were not associated with...
foot MSSs that limited daily activity and was perceived to be caused by band activities in the previous 12 months\(^\text{12}\). Another study of military band musicians found that only self-rated physical activity was associated with injury (not just musculoskeletal) incidence\(^\text{38}\). A recent systematic review\(^\text{67}\) of university music students and professional musicians (excluding military band musicians), found no association between exercise or sports activities, and MSS. A comparison between military band musicians and other musicians would be required to determine whether military band musicians have a lower prevalence of MSS.

Basic military training ranges in content and duration internationally\(^\text{68–71}\), but typically involves theory sessions, fitness training, and weapons training. While MSS in military band musicians during basic training has not been examined, it has been for recruits in general. The prevalence of symptoms during basic training ranges from 13.9% to 48.65% (80 d to 26 wk of training)\(^\text{68, 69, 71}\), with an incidence of 17.4–17.8/100 people/100 d being reported\(^\text{71}\), as well as 18 injuries/100 people/month\(^\text{72}\). Injuries during basic training are most commonly in the lower limb\(^\text{68, 69, 73–75}\), and may include muscle strains\(^\text{68}\), plantar fasciitis\(^\text{68}\), medial tibial stress syndrome\(^\text{69, 75}\), sprains\(^\text{68, 69, 75}\), tendinitis\(^\text{68}\), arthritis\(^\text{68}\), and iliotibial band syndrome\(^\text{69}\). Injuries during basic training have been reportedly due to running, swimming, falling, walking, marching, performing sit ups, carrying equipment, unloading weapons, engaging targets, and making beds\(^\text{71}\). One of the risk factors for injury during basic training is poorer fitness\(^\text{73, 74, 76–78}\). While it has not been examined, it is hypothesised that musicians who are not preparing for combat roles, may enter basic training with a lower level of physical fitness than other recruits which may result in musicians having a higher risk of injury while training.

While lower limb injuries are unlikely to directly impair an instrumentalists' ability to play their instrument, lower limb injuries may prevent or make it difficult to play while standing or marching, or the symptoms of these injuries may distract the musician while playing. Lower limb injuries reportedly increase the risk of incident lower back pain, within the army\(^\text{79}\), and may therefore have a flow-on effect to other body regions. Similarly, for military band musicians specifically, injury in the previous year is associated with injury in the following year\(^\text{38}\), and a recent systematic review of MSSs in university music students and professional musicians (excluding military band musicians) revealed that previous MSSs was associated with future MSSs\(^\text{67}\). Injuries sustained during basic training may therefore impact upon a musicians’ work in the future.

Managing musculoskeletal symptoms

Musicians within symphony/philharmonic orchestras are impacted differently by MSSs, depending on the instrument they play. Within the orchestra the bowed string players have a number of musicians playing the same parts (e.g. violin 1, violin 2, viola, cello and double bass), and even when there is further division (divisi) such that half of each group playing the same part, there are still a number of musicians playing the same part. With the exception of principal players (who may have occasional solos, and who lead the sections) bowed string players have an advantage over the other musicians within the orchestra, as well as musicians in other ensemble types, as they can ‘fudge’ sections that could aggravate their MSSs, or skip these sections in rehearsals without it being as obvious as it would be for other musicians (who generally play their own individual part).

The other advantage that string players have, for the abovementioned reason, is that having time off has less of an effect on the ensemble, because casual musicians, brought in to replace missing musicians, do not have the same level of responsibility as a woodwind, brass or percussion instrumentalist, who is solely responsible for their own part. The differences between bowed string and other instrumentalists within the orchestra may explain the finding of some differences in the consequences of MSSs among different instrumentalists within professional orchestras. Paarup et al.\(^\text{5}\) found that a higher proportion of upper string players paused during practice or rehearsals, and omitted playing at concerts when compared with woodwind, and brass players, and a higher proportion of upper string players took sick leave when compared with woodwind players (there were no significant differences in these outcomes between upper and lower strings).

In pit orchestras for musical theatre, some musicals have multiple orchestrations, which may allow some musicians to have their parts covered by others within the orchestra; however this solution relies upon sight-reading or last minute changes. Nonetheless, this option provides orchestras with a strategy to manage MSSs within the ensemble.

As discussed above, military band musicians may be required to play multiple instruments, but unlike those in pit orchestras, they are generally not required to play multiple instruments within the same performance. The advantage of having multi-instrumentalists within a band is that missing musicians are more easily covered for, by someone already in the band, which is particularly important within reserve bands (where performances may be missed simply
due to having other commitments). Where the same bands are required to take on different functions, as is the case in Australia, multi-instrumentalists are important as they provide flexibility. In some instances, military band musicians may be required to play instruments they have not previously played. For instance, a bassoonist may play their bassoon in the concert band setting, however as bassoons are not part of the ceremonial marching band, the bassoonist may have to play a drum while marching, placing ‘unusual’ stress on their bodies.

In contrast to orchestras and military band musicians, singers in opera and musical theatre typically have ‘understudies’ or ‘covers’ who learn the part of a lead in the show, but will generally play another role in the performance, unless the lead cast member is unable to perform, and/or ‘alternatives’ or ‘standbys’ who do not typically perform, unless required to do so in the lead role. In some productions, these singers will perform in the lead roles for a certain number of performances per week. A ‘swing’ refers to a cast member who learns several roles usually filled by the main understudies, to cover for the understudy when the understudy is required to take the lead role. These contingencies are in place to minimise the disruption of a musician who is unable to perform, including those who take time off due to MSSs, which is not in place for other kinds of musicians. The implementation of these strategies may be due to the high physical and vocal demands, particularly of those in lead roles for musicals and opera.

One of the possible advantages of being a military musician is access to healthcare. Arrangements vary internationally, and depending on whether one is a member of the regular or reserves army. For instance, in Australia, regular army band musicians may access free healthcare37, however for reservists to have their healthcare funded, the incident must have occurred at work (similar to Workers’ Compensation in Australia). Early, affordable access to appropriate healthcare, may assist military band musicians in better managing their MSSs, minimising the duration and preventing recurrence, when compared with other types of musicians.

**Conclusion**

The MSS of non-classical (and non-orchestral ensemble) musicians need to be investigated to better target approaches to reducing the burden of musicians’ MSSs. There are differences in the characteristics between musicians working in different genres and ensemble types that may result in differences in the prevalence and profile of MSSs. As most of the research regarding musicians’ MSSs has been directed towards classical or orchestral musicians, there is a need to consider the unique needs of under-investigated groups of musicians. Future research should compare sub-groups of musicians to establish whether existing research is generalizable to these groups, and if not, what targeted strategies are required to reduce the burden of MSSs in specific sub-groups of musicians.

**Acknowledgements**

JS was 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.

**References**

1) Kuorinka I, Jonsson B, Kilbom A, Vinterberg H, Biering-Sørensen F, Anderson G, Jørgensen K (1987) Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. Appl Ergon 18, 233–7. [Medline] [CrossRef]

2) Zaza C, Charles C, Muszynski A (1998) The meaning of playing-related musculoskeletal disorders to classical musicians. Soc Sci Med 47, 2013–23. [Medline] [CrossRef]

3) Thom N, Ritchlin CT, Zhang X, Reveille J, Weisman MH (2015) Prevalence of chronic axial pain, inflammatory back pain, and spondyloarthritis in diagnosed psoriasis. Arthritis Care Res (Hoboken) 67, 829–35. [Medline] [CrossRef]

4) Kok LM, Huiss Steele BM, Voorn VM, Schoones JW, Nelissen RG (2016) The occurrence of musculoskeletal complaints among professional musicians: a systematic review. Int Arch Occup Environ Health 89, 373–96. [Medline] [CrossRef]

5) Paarup HM, Baclum J, Holm JW, Manniche C, Wedderkopp N (2011) Prevalence and consequences of musculoskeletal symptoms in symphony orchestra musicians vary by gender: a cross-sectional study. BMC Musculoskelet Disord 12, 223. [Medline] [CrossRef]

6) Stanhope J, Weinstein P, Pisansielo D (2020) What can musicians’ claims data reveal about their musculoskeletal conditions? Arch Environ Occup Health 75, 177–90. [Medline] [CrossRef]

7) Chimenti RL, Van Dilen LR, Prather H, Hunt D, Chimenti PC, Khoo-Summers L (2013) Underutilization of worker’s compensation insurance among professional orchestral musicians. Med Probl Perform Art 28, 54–60. [Medline]
8) Abréu-Ramos AM, Micheo WF (2007) Lifetime prevalence of upper-body musculoskeletal problems in a professional-level symphony orchestra: age, gender, and instrument-specific results. Med Probl Perform Art 22, 97–104.

9) Stanhope J, Tooher R, Pisanidlo D, Weinstein P (2019) Have musicians’ musculoskeletal symptoms been thoroughly addressed? A systematic mapping review. Int J Occup Med Environ Health 32, 291–331. [Medline] [CrossRef]

10) Throsby D, Petetskaya K (2017). Making art work: an economic study of professional artists in Australia. Australia Council for the Arts, Sydney.

11) Kenny DT, Driscoll T, Ackermann BJ (2016) Is playing in the pit really the pits? Pain, strength, music performance anxiety, and workplace satisfaction in professional musicians in stage, pit, and combined stage/pit orchestras. Med Probl Perform Art 31, 1–7. [Medline] [CrossRef]

12) Grier TL, Knapik JJ, Swedler D, Jones BH (2011) Footwear in the United States Army Band: injury incidence and risk factors associated with foot pain. Foot 21, 60–5. [Medline] [CrossRef]

13) Weekly EM, Lovetri JL (2009) Follow-up Contemporary Commercial Music (CCM) Survey: who’s teaching what in nonclassical music. J Voice 23, 367–75. [Medline] [CrossRef]

14) Vaag J, Gieever F, Bjerkeset O (2013) Specific demands and resources in the career of the Norwegian freelance musician. Arts Health 6, 205–22. [CrossRef]

15) Benedek M, Borovnjak B, Neubauer AC, Kruse-Weber S (2014) Creativity and personality in classical, jazz and folk musicians. Pers Individ Dif 63, 117–21. [Medline] [CrossRef]

16) Doherty L, Wilson IM, McKeown L (2013) Practicing safe trad: why existing approaches to playing-related musculoskeletal disorders may not help the Irish traditional music community. Med Probl Perform Art 28, 181–7. [Medline]

17) Creech A, Papageorgi I, Duffy C, Morton F, Hadden E, Potter J, De Bezenac C, Whyton T, Himonides E, Welch G (2008) Investigating musical performance: commonality and diversity among classical and non-classical musicians. Music Educ Res 10, 215–34. [CrossRef]

18) de Bezenac C, Swindells R (2009) No pain, no gain? Motivation and self-regulation in music learning. Int J Educ Arts 10, 16.

19) Welch G, Papageorgi I, Haddon L, Creech A, Morton F, de Bézéna C, Duffy C, Potter J, Whyton T, Himonides E (2008) Musical genre and gender as factors in higher education learning in music. Res Pap Educ 23, 203–17. [CrossRef]

20) Wilson IM, Doherty L, McKeown L (2014) Perceptions of Playing-Related Musculoskeletal Disorders (PRMD) in Irish traditional musicians: a focus group study. Work 49, 679–88. [Medline] [CrossRef]

21) Wood GC (2014) Prevalence, risk factors, and effects of performance-related medical disorders (PRMD) among tertiary-trained jazz pianists in Australia and the United States. Med Probl Perform Art 29, 37–45. [Medline] [CrossRef]

22) Rigg JL, Marrinan R, Thomas MA (2003) Playing related injury in guitarists playing popular music. Med Probl Perform Art 18, 150–2.

23) McSharry J, Doherty L, Wilson IM (2015) Psychosocial risks in a unique workplace environment: safe trad and traditional Irish musicians. Eur Health Psychol 17, 174–8.

24) Egnor MR, Page LK, David C (1991) Vertebroepidural aneurysm—a unique hazard of head banging by heavy metal rockers. Case report. Pediatr Neurosurg 17, 135–8. [Medline] [CrossRef]

25) Patton D, McIntosh A (2008) Head and neck injury risks in heavy metal: head bangers stuck between rock and a hard bass. BMJ 337, a2825. [Medline] [CrossRef]

26) Foell J (2010) The bangover that did not stop: case report of neck weakness after headbanging at a rock concert, with later neck pain and upper limb paraesthesia. Int Musculoskelet Med 32, 133–7. [CrossRef]

27) Nygaard Andersen L, Roessler KK, Eichberg H (2013) Pain among professional orchestral musicians: a case study in body culture and health psychology. Med Probl Perform Art 28, 124–30. [Medline]

28) Park A, Guptill C, Sumson T (2007) Why music majors pursue music despite the risk of playing-related injuries. Med Probl Perform Art 22, 89–96.

29) Guptill C (2011) The lived experience of working as a musician with an injury. Work 40, 269–80. [Medline] [CrossRef]

30) Guptill CA (2011) The lived experience of professional musicians with playing-related injuries: a phenomenological inquiry. Med Probl Perform Art 26, 84–95. [Medline]

31) Bragge P, Bialocerkowski A, McMeecken J (2006) Understanding playing-related musculoskeletal disorders in elite pianists: a grounded theory study. Med Probl Perform Art 21, 71–9.

32) Chong J, Lynden M, Harvey D, Peebles M (1989) Occupational health problems of musicians. Can Fam Physician 35, 2341–8. [Medline]

33) Milanes S (2000) Provision of on-site physiotherapy services during the performance of Wagner’s Ring Cycle by the Adelaide Symphony Orchestra: a model of early intervention for playing-related musculoskeletal disorders. Med Probl Perform Art 15, 107–10.

34) Rickert DL, Barrett MS, Ackermann BJ (2013) Injury and the orchestral environment: part I. The role of work organisation and psychosocial factors in injury risk. Med Probl Perform Art 28, 219–29. [Medline]

35) Donahue EN, Leborgne WD, Brehm SB, Weinrich BD (2014) Reported vocal habits of first-year undergraduate musical theater majors in a preprofessional training program: a 10-year retrospective study. J Voice 28, 316–23. [Medline] [CrossRef]

36) Morton J (2015) Musical theatre: the hazards of the
performer’s workplace. Med Probl Perform Art 30, 1–7. [Medline] [CrossRef]
37) Australian Government Department of Defence (2016) Joining the Army Band. https://www.army.gov.au/our-work/community-engagement/the-australian-army-band/joining-the-army-band-0. Accessed May 5, 2019.
38) Knapik JJ, Jones SB, Darakjy S, Hauret KG, Nevin R, Grier T, Jones BH (2007) Injuries and injury risk factors among members of the United States Army Band. Am J Ind Med 50, 951–61. [Medline] [CrossRef]
39) Newmark J (2009) Military bands as a population for studying musicians’ health. Med Probl Perform Art 24, 50.
40) Cupido C (2016) Learning from experience: exploring the wellbeing of professional opera singers. Muziki 13, 80–107. [CrossRef]
41) Evans RW, Evans RI, Carvajal S (1998) Survey of injuries among West End performers. Occup Environ Med 55, 585–93. [Medline] [CrossRef]
42) Evans RW, Evans RI, Carvajal S, Perry S (1996) A survey of injuries among Broadway performers. Am J Public Health 86, 77–80. [Medline] [CrossRef]
43) Harper BS (2009) Health and safety in the classical music industry in the UK and Germany. Cult Trends 11, 43–91. [CrossRef]
44) Live Performance Australia (2019) Working at height hazard guide. Safety guidelines for live entertainment and events. Live Performance Australia.
45) Ontario Ministry of Labour (2012) Orchestra pits safety guideline for the live performance industry in Ontario. Ontario Ministry of Labour, Ontario.
46) Muniz AMS, Bini RR (2017) Shock attenuation characteristics of three different military boots during gait. Gait Posture 58, 59–65. [Medline] [CrossRef]
47) Knapik JJ, Jones SB, Ohlín DW, Canham-Chervak M, Darakjy SS, Goddard DE, Al E (2006) Injuries and injury prevention in the US Army Band. US Army Center for Health Promotion and Preventive Medicine, Aberdeen.
48) da Costa BR, Vieira ER (2010) Risk factors for work-related musculoskeletal disorders: a systematic review of recent longitudinal studies. Am J Ind Med 53, 285–323. [Medline]
49) Wai EK, Roffey DM, Bishop P, Kwon BK, Dagenais S (2010) Causal assessment of occupational carrying and low back pain: results of a systematic review. Spine J 10, 628–38. [Medline] [CrossRef]
50) Wai EK, Roffey DM, Bishop P, Kwon BK, Dagenais S (2010) Causal assessment of occupational lifting and low back pain: results of a systematic review. Spine J 10, 554–66. [Medline] [CrossRef]
51) Roffey DM, Wai EK, Bishop P, Kwon BK, Dagenais S (2010) Causal assessment of workplace manual handling or assisting patients and low back pain: results of a systematic review. Spine J 10, 639–51. [Medline] [CrossRef]
52) Mayer J, Kraus T, Ochsmann E (2012) Longitudinal evidence for the association between work-related physical exposures and neck and/or shoulder complaints: a systematic review. Int Arch Occup Environ Health 85, 587–603. [Medline] [CrossRef]
53) Roffey DM, Wai EK, Bishop P, Kwon BK, Dagenais S (2010) Causal assessment of occupational sitting and low back pain: results of a systematic review. Spine J 10, 252–61. [Medline] [CrossRef]
54) Roffey DM, Wai EK, Bishop P, Kwon BK, Dagenais S (2010) Causal assessment of occupational standing or walking and low back pain: results of a systematic review. Spine J 10, 262–72. [Medline] [CrossRef]
55) Coenen P, Willenberg L, Parry S, Shi JW, Romero L, Blackwood DM, Maher CG, Healy GN, Dunstan DW, Straker LM (2018) Associations of occupational standing with musculoskeletal symptoms: a systematic review with meta-analysis. Br J Sports Med 52, 176–83. [Medline] [CrossRef]
56) Bernstein L (1994) West Side Story. Boosey & Hawkes, London.
57) Ranelli S, Smith A, Straker L (2011) Playing-related musculoskeletal problems in child instrumentalists: the influence of gender, age, and instrument exposure. Int J Music Educ 29, 28–44. [CrossRef]
58) Ranelli S, Straker L, Smith A (2011) Playing-related musculoskeletal problems in children learning instrumental music: the association between problem location and gender, age, and music exposure factors. Med Probl Perform Art 26, 123–39. [Medline]
59) Woldendorp KH, Boonstra AM, Tijsma A, Arendzen JH, Reneman MF (2016) No association between posture and musculoskeletal complaints in a professional bassist sample. Eur J Pain 20, 399–407. [Medline] [CrossRef]
60) Wanke EM, Kunath EK, Koch F, Davenport J, Weisser B, Gronenberg DA, Mache S, Endres E, Vitzthum K (2012) Survey of health problems in musical theater students: a pilot study. Med Probl Perform Art 27, 205–11. [CrossRef]
61) Anand Prakash A (2017) Medical attention seeking dance injuries: systematic review of case reports. Phys Sportsmed 45, 64–74. [Medline] [CrossRef]
62) Jacobs CL, Hincapié CA, Cassidy JD (2012) Musculoskeletal injuries and pain in dancers: a systematic review update. J Dance Med Sci 16, 74–84. [Medline]
63) Lederman RJ (2003) Neuromuscular and musculoskeletal problems in instrumental musicians. Muscle Nerve 27, 549–61. [Medline] [CrossRef]
64) Stanhope J (2016) Physical performance and musculoskeletal disorders: are musicians and sportspersons on a level playing field? Perform Enhanc Health 4, 18–26. [CrossRef]
65) Engquist K, Ørbaek P, Jakobsson K (2004) Musculoskeletal pain and impact on performance in orchestra musicians and actors. Med Probl Perform Art 19, 55–61.
66) Day LB (2013) Turn off the danger: the lack of adequate safety incentives in the theatre industry. New York Univ Law Rev 88, 1308–47.
67) Baadjou VAE, Roussel NA, Verbunt JAMCF, Smeets RJEM, de Bie RA (2016) Systematic review: risk factors for musculoskeletal disorders in musicians. Occup Med (Lond) 66, 614–22. [Medline] [CrossRef]

68) Havenetidis K, Kardaris D, Paxinos T (2011) Profiles of musculoskeletal injuries among Greek Army officer cadets during basic combat training. Mil Med 176, 297–303. [Medline] [CrossRef]

69) Sharma J, Greeves JP, Byers M, Bennett AN, Spears IR (2015) Musculoskeletal injuries in British Army recruits: a prospective study of diagnosis-specific incidence and rehabilitation times. BMC Musculoskelet Disord 16, 106. [Medline] [CrossRef]

70) Henning PC, Khamoui AV, Brown LE (2011) Preparatory strength and endurance training for U.S. Army basic combat training. Strength Condit J 33, 48–57. [CrossRef]

71) Dawson GME, Broad R, Orr RM (2015) The impact of a lengthened Australian Army recruit training course on recruit injuries. J Mil Veterans Health 23, 14–9.

72) Wyss T, Roos L, Hofstetter MC, Frey F, Mäder U (2014) Impact of training patterns on injury incidences in 12 Swiss Army basic military training schools. Mil Med 179, 49–55. [Medline] [CrossRef]

73) Bedno SA, Cowan DN, Urban N, Niebuhr DW (2013) Effect of pre-accession physical fitness on training injuries among US Army recruits. Work 44, 509–15. [Medline] [CrossRef]

74) Hearn D, Rhon D, Goss D, Thelen M (2017) Evaluation of a novel field expedient musculoskeletal readiness screening tool in an army basic training population. Mil Med 182, e1862–8. [Medline] [CrossRef]

75) Brushøj C, Larsen K, Albrecht-Beste E, Nielsen MB, Løye F, Hölmich P (2008) Prevention of overuse injuries by a concurrent exercise program in subjects exposed to an increase in training load: a randomized controlled trial of 1020 army recruits. Am J Sports Med 36, 663–70. [Medline] [CrossRef]

76) Sefton JM, Lohse KR, McAdam JS (2016) Prediction of injuries and injury types in army basic training, infantry, armor, and cavalry trainees using a common fitness screen. J Athl Train 51, 849–57. [Medline] [CrossRef]

77) Hall LJ (2017) Relationship between 1.5-mile run time, injury risk and training outcome in British Army recruits. J R Army Med Corps 163, 376–82. [Medline] [CrossRef]

78) Wyss T, Von Vigier RO, Frey F, Mäder U (2012) The Swiss Army physical fitness test battery predicts risk of overuse injuries among recruits. J Sports Med Phys Fitness 52, 513–21. [Medline]

79) Seay JF, Shing T, Wilburn K, Westrick R, Kardouni JR (2018) Lower-extremity injury increases risk of first-time low back pain in the US Army. Med Sci Sports Exerc 50, 987–94. [Medline] [CrossRef]