

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

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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, pain^{1–3}, weakness², tingling², numbness², stiffness³, and lack of control² 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 work-

ers' compensation claims made by employed musicians⁶. Musculoskeletal symptoms may have a range of consequences for musicians, including having to take time off from work^{5–8}. 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

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for less than 10% of professional musicians⁹); and 64% of instrumentalists and singers predominantly work in contemporary musical genres¹⁰. To address the burden of musicians' MSSs these other groups of musicians should therefore be investigated.

Our recent systematic mapping review⁹ 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 differences in the characteristics of classical and non-classical musicians, and orchestral and non-orchestral ensemble musicians.

Methods

This multidisciplinary, narrative review draws upon research from music education, psychology, military medicine, occupational health and safety, and performing arts medicine. The reported review was not a systematic review, owing to the complexity of the topic, drawing upon research in different disciplines. Relevant studies identified in the systematic mapping review⁹ of musicians' MSSs were supplemented by studies identified through more targeted searches for genre or ensemble-type specific literature, including screening of reference and citation lists to identify additional relevant material.

Results and Discussion

The results of the review are reported in two main sections. The first section describes and compares musicians working in different musical genres, while the second section describes and compares musicians in different types of ensembles.

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 outcomes¹⁵.

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 posture¹⁶.

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 problem²⁰, where reels will be repeated, at an increasing tempo¹⁶, 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

Types of musicians typically involved	
Genres	
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⁾

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 ¹⁶⁾	Instrument angled towards the floor ¹⁶⁾
Instrument positioned between the shoulder and chin ¹⁶⁾	Instrument held against the anterior trunk between the neck and shoulder ¹⁶⁾
Play sitting or standing ¹⁶⁾	Typically play sitting in a slouched position ¹⁶⁾
Left wrist in a neutral or flexed position ¹⁶⁾	Left wrist in an extended position ¹⁶⁾
Fingers on the right hand flexed with increasing flexion, particularly of the carpometocarpal joints towards the fifth digit	Fingers of the right hand flexed to approximately the same angle across digits 2–5

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 MSSs²¹⁾.

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^{16, 20)}, which may account for the differences in posture and hand position assumed by classical violinists compared with Irish fiddle players (Table 3). 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 risk²²⁾, while the fast, repeated passages typical of jazz piano playing differ from those generally performed by classical musicians, and may increase the risk of MSSs²¹⁾.

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^{16, 23)}. 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 performances²⁴⁾. Head-banging may lead to head and neck injury^{25, 26)}. A number of professional contemporary musicians have reportedly given up performing because of health problems associated with head-banging²⁵⁾.

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 up²⁰⁾, noting that classical musicians will prepare and warm up before performances, which is not typical of their traditions¹⁶⁾. Irish traditional musicians have reported that they do not take MSSs as seriously as classical musicians²⁰⁾, 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^{20, 27)}, playing through pain^{16, 20, 28, 29)}, getting caught up in the playing experience³⁰⁾, having difficulties in stopping playing when they notice MSSs^{20, 23, 27)}, not noticing symptoms until

Table 4. Summary of the type of musical work by ensemble types

Orchestras	Orchestral musicians typically perform Western classical music, within symphony or philharmonic orchestras, or chamber orchestras. The primary difference between these orchestras is that symphony or philharmonic orchestras are larger than chamber orchestras, with different instrumentation (Table 1). Orchestral musicians may also play within the ‘pit’ (an open space in front and/or below the stage) when accompanying ballets, operas and musicals. For ballets and operas, orchestras may be those who solely perform in these settings ¹¹ , or symphony orchestras who typically perform on stages also taking on these roles ^{11, 33} . Musicians who play in symphony orchestras in stage and pit settings have identified that when working in the pit, the rehearsal styles is different (e.g. few breaks) ³³ , and that concerts are closer together than their typical work ³⁴ .
Opera/musical theatre (stage performers)	Opera and musical theatre singers have physical demands that are quite different to those of other singers. Singers in both musical theatre and opera must act, however musical theatre may also involve acrobatics ³⁵ , dancing ³⁵ , stage combat ³⁵ , and puppetry ³⁶ .
Military bands	Military bands vary widely, internationally. For instance, in Australia the bands are concert bands, which also engage in marching in ceremonial parades, as well as forming smaller groups including contemporary rock groups, and big bands ³⁷ , whereas some military bands in the United States also have string players ^{38, 39} and singers ^{12, 38} , with blues ^{12, 38} , chorus ^{12, 38} , chorale ³⁸ , strings ³⁸ , concert ^{12, 38} , and ceremonial units ^{12, 38} . Concert bands (which may be part of a military band) are similar to symphony orchestras in that musicians typically sit while playing, however there are differences in the instrumentation (Table 1), and the repertoire.

after they have stopped playing^{20, 27}), having a ‘culture of silence’ around MSSs^{16, 29–31}), and a distrust of and negative experiences with health professionals^{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 theatres³⁶), but may pose problems for the performers. Raked stages were reported as a problem related to MSSs by an opera singer⁴⁰), and performing on raked stages was associated with injury in musical theatre performers⁴¹), particularly dancers⁴²).

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)^{33, 43}), poor lighting⁴³), dangerous access to the pit⁴³), cables⁴³), and objects falling from the stage into the pit⁴³). Recent guidelines^{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 areas³⁶).

Opera singers have identified ill-fitting costumes as a problem⁴⁰), 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)³⁶). Similarly, some roles require performers to wear wigs and/or headpieces, that may be used to conceal microphone transmit-

ter packs³⁶). Newer musicals also combine costumes and props³⁶). Morton³⁶) recently described the physical requirements of playing Lumière (the candelabra) in *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 issue⁴⁰), while changing shoes (from rehearsal to performance shoes) have been described as a problem for those in musical theatre³⁶), as well as high-heeled shoes, for female musical theatre performers^{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 biomechanics⁴⁶), which may lead to MSSs. Grier *et al.*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 population⁴⁷), however the new shoes did not alter the incidence of injuries for which musicians sought care at the military clinic¹²). Grier *et al.*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 *et al.*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 general⁴⁸⁻⁵¹); however there is consistent evidence for lower back pain and lifting more than 25 kg⁵⁰). There is also conflicting evidence of an association between lifting, and neck and shoulder pain^{48, 52}), and reasonable evidence of an association between lifting, and hip and knee pain⁴⁸). Nonetheless, the manual materials handling remains a difference between orchestral and military band musicians, which warrants further investigation regarding MSSs.

Differences in the tasks performed

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^{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 confounders¹²). 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.

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^{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 study¹²) 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 saxophone⁵⁶). 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^{57, 58}), revealed a protective effect, while another⁵⁹), 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 they 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 of all musicians. Singers in both musical theatre and opera must act, however musical theatre may also involve acrobatics³⁵), dancing³⁵), stage combat³⁵), and puppetry³⁶). Two retrospective

studies were conducted of performers in Broadway⁴²) and West End⁴¹) musicals. Lower limb injuries were the most commonly affected areas for both those in predominantly acting or dance roles^{41, 42}). The same was true of a small (n=37) study of musical theatre students⁶⁰), where traumatic, lower limb injuries were the most common, which is typical of dancers' MSSs^{61, 62}). This differs from what has been reported in other types of musicians, where upper limb MSSs are more common⁴), and the onset tends to be gradual, and described as being atraumatic^{63, 64}). 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 musicians⁶⁵).

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 steps⁶⁰). 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, scapula, vertebrae 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 wall⁶⁶). One cast member also had his leg caught in a hydraulic trap door⁶⁶). 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 fractures⁶⁶). 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 MSS 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 months¹²). Another study of military band musicians found that only self-rated physical activity was associated with injury (not just musculoskeletal) incidence³⁸). A recent systematic review⁶⁷) 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^{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)^{68, 69, 71}), with an incidence of 17.4–17.8/100 people/100 d being reported⁷¹), as well as 18 injuries/100 people/month⁷²). Injuries during basic training are most commonly in the lower limb^{68, 69, 73–75}), and may include muscle strains⁶⁸), plantar fasciitis⁶⁸), medial tibial stress syndrome^{69, 75}), sprains^{68, 69, 75}), tendinitis⁶⁸), arthritis⁶⁸), and iliotibial band syndrome⁶⁹). 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 beds⁷¹). One of the risk factors for injury during basic training is poorer fitness^{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 army⁷⁹), 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 year³⁸), 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 MSSs⁶⁷). 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.*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.

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