An epidemiological investigation into Musculoskeletal pain in Kwa Zulu-Natal orchestral musicians

By

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Dissertation submitted in partial compliance with the requirements for the

Master's Degree in Technology: Chiropractic

Durban University of Technology

I, Linley Muhondo, do declare that this dissertation is representative of my own work in both conception and execution (except where acknowledgements indicate to the contrary)

27 March 2024

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27 March 2024

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27 March 2024

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Dedication

To you, my family. I would not be here without your innumerable sacrifices, prayers and constant encouragement and boundless love for me.

To Daddy, who prayed for me incessantly, taught me to work hard daily at home and disregard listening to the sometimes misleading examples of others. Thank you for leading me by example.

To Mommy, who literally picked me up off the floor and dusted me off, prayed with me, dried my tears, did a lot of thesis work, hugged me and kept me going. Your strength and incredible kindness and warmth through the years gave me the ability to keep going.

To John-D, my beautiful baby brother. I am so proud of you and your work ethic, which also inspired me to work hard. Your unexpected hugs, calls and visits kept me going through the long, late nights more than you know. I love you measurelessly.

To my extended family from church, non-blood family and my closest friends- You are literal lifesavers. I would know –you've saved mine often.
And most importantly, To my Heavenly Father. Yahweh, words cannot describe my gratitude. You placed me here and promised that You would be with me every step of the way, and You were. No words are sufficient to declare my love for You, so to You I quote:

"Could we with faith the oceans fill,
And were the skies of parchment made.
Were every stalk on Earth a quill,
And every man a scribe by trade.
To write the love of God above
Would drain the oceans dry!
Nor could the scroll containment hold,
Though stretched from sky to sky."

Acknowledgements:

My most sincere gratitude and admiration goes out to:

My supervisors Dr Thandar and Dr Kell. Thank you so much for being with me through both of my research topics these last few years. Thank you for the track changes, whatsapps and emails. Your guidance through this process and your frank advice is deeply appreciated. God bless you both richly.

My contacts at DCO, Wesley and Tatum Paed: Wes, for being so willing to help with both my pilot study and with my data collection. You really went above and beyond for me. Tatum for being the patient in-road that I needed to help me contact Wesley and the rest of the orchestra. Thank you!

Dr David Plank: For answering my numerous calls and emails, doing my pilot and being my contact to the PCO. Thank you!

To Keegan Hughes and the rest of the PMB GHS Music Department: For letting me come home, giving me a chance to tell my story, cheering me on and even letting me touch a trombone again. Thank you!

To the PCO and DCO: This literally wouldn't have been possible without your willingness and kindness to let me interrupt your precious practice time. Thank you for hearing me out and increasing the knowledge we have on this topic. I can't thank you enough.

My tech support: Uncle Mwenecho, Thabo Mafoyane and John-D Muhondo. As well as mom, my tech lady. Technology is reliable until you have to type a dissertation. Thank you for sharing your technology with me so readily in my moments of dire need.

My loved ones who transported me to my research venues: Jessica Lin, Amal Deodutt, Shannon Fisher and John-D Muhondo. Thank you for making the time to take me to my research obligations and making sure I was safe and on time.

The Squad. Mary and Shannon especially, as well as my beloved Sihle and Matty: For all the trips you took me on, the research help, dinner-dates, birthdays, late night movies, coffee on the beach, unexpected calls, expected love and craziness – words will never be enough. I pray that we're together often and always. I love you.

“My gang of best and oldest friends”: Particularly Shane, Lerato, Wabo and Bernie. A person couldn’t hope to be surrounded by a better group of people, you are the quintessential “tribe” that people are always searching for. The Bible talks about there being a ‘friend who sticks closer than a brother’. That’s you, you are those people; my family from another mother. I love you.

My church family: You watched me grow and prayed with me every step of the way. I know I am here today because a lot of you silently fasted and prayed for me. So I want to loudly declare my love and gratitude toward you – Thank you! I love you. God bless you.

My music teachers and conductors throughout the years, especially Mr van Rooijen, Miss van Rooijen, Mr Dipenaar and Mrs Vermaak: Thank you for feeding the flames of the fiery passion that I have for music and giving me a structured and safe place to be challenged and grow with my chosen disciplines.

My Conductors, Lyk Temmingh and Cathy Burns, as well as my KZNPO family: Being under your batons was an immense honour and pleasure. Thank you for acknowledging, and allowing me to pursue my love for music.

To all my Chiro, WCCS and Homoeo mates: Thank you for laughing with me when we felt like crying and walking with me on this long and winding road. Thank you for finding me, in unexpected ways and places, and for being my very real family. May you continue to richly bless others the way you have blessed me. I love you.

The National Research Fund: Thank you very much for providing me with a stipend for part of my Masters.

Professor Tonya Esterhuizen: Thank you very much for processing my stats so quickly and doing it in a way that made sense. I really appreciate it.

To my clinicians and lecturers: Thank you for all the pearls of wisdom and examples that I will carry with me going forward. I will surely never forget.

Now that the prelude is over, let the concerto begin.

Abstract

Background

Non-communicable diseases pose a significant health threat worldwide. Of those diseases, musculoskeletal diseases are most responsible for a significant portion of occupational injuries in all job-sectors, including the musical sector. Musicians are prone to suffering from musculoskeletal injuries, more so than other populations. These injuries are termed playing-related musculoskeletal diseases (PRMDs). There are several risk factors associated with acquiring PRMDs including being of the female gender, age, and the type of instrument played. While most literature on musicians' has been documented in countries abroad, there is a paucity of literature looking at the risk factors and attributes of African, and specifically South African, musicians. This is notable, as African musicians may have different characteristics to their international counterparts. The aim of this research was to examine orchestral musicians in Kwa Zulu-Natal from all sections of the orchestra to determine the prevalence of musculoskeletal injuries and the potential risk factors for these injuries, as well as their musculoskeletal injury profile.

Methodology

This study was a quantitative, cross-sectional descriptive study based on a self-administered questionnaire. The questionnaire was piloted electronically and the necessary alterations were made. The final questionnaire was administered to members of 2 orchestras in Kwa Zulu-Natal, namely the Pietermaritzburg City Orchestra (25 members) and the Durban City Orchestra (30 members), making the targeted sample 55 musicians in total. All musicians who met the inclusion criteria were invited to participate in the study. The anonymously completed questionnaires were placed into marked boxes after completion to ensure musician anonymity. The data was analysed using IBM SPSS version 28. Association between specific risk factors and 12-month prevalence of MSK was assessed using Fisher's exact 2-sided tests for categorical risk factors, and t-tests for continuous risk factors. A p-value of <0.05 was taken as statistical significance.

Results

Of the 55 musicians targeted, 30 of them participated, resulting in a response rate of 54.5%. Majority of the respondents were female (n=20). The data showed that the annual prevalence of PRMDs in the two orchestras was 46.7%. The point and one month prevalence were both 40%. The most injured section of the orchestra were the strings, followed by the woodwind section. The string section also reported the highest number of average affected areas in the orchestra (n=4). The most frequently injured anatomical sites of the body were the shoulders and wrists. There was no statistical significance found between the risk factors and injuries acquired. However, the results showed that females were injured more than the males (55%). Most of the respondents that reported musculoskeletal injury fell within the 18-24 age range and majority of the injured musicians fell in the overweight BMI body category. Most of the music teachers and the single career musicians in the study reported suffering from PRMDs and playing instruments for more than 16 hours a week on average.

Conclusion

The prevalence of playing-related musculoskeletal disorders among musicians was relatively high among the orchestral musicians in Kwa Zulu-Natal. Though not statistically significant, factors such as instrument played, age, and female gender were the factors that had the greatest influence on injury rates. The pain experienced was mild in nature and felt worse after playing their instruments. While the pain did not affect their activities of daily living, it did cause a few to change their way of playing or stop playing entirely for a period of time due to their pain. Majority of the players were aware of musician's playing related health problems, and acknowledged that they are a problem, but none of them had received formal methods of education regarding them. The COVID-19 pandemic was a phenomenon that also affected the musicians in various ways.

Key Terms: Musculoskeletal injury, playing-related musculoskeletal disorders, musician's injuries, overuse injury

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List of Abbreviations:

- BMI: Body Mass Index
- CDC: Centers for Disease Control and Prevention
- DCO: Durban City Orchestra
- DUT: Durban University of Technology
- IBM SPSS: Statistical software suite by IBM
- IREC: Institutional Research Ethics Committee
- Kg: Kilograms
- Mm: Millimetres
- MPQIIM: Musculoskeletal Pain Intensity and Interference Questionnaire for Musicians
- MSK: Musculoskeletal
- MSDs: Musculoskeletal Disorders/Diseases
- n: Sample number
- NMQ: Nordic Musculoskeletal Questionnaire
- *p:* Probability value of statistical significance
- PCO: Pietermaritzburg City Orchestra
- PRMDs: Playing Related Musculoskeletal Disorders
- SA: South Africa
- TOS: Thoracic Outlet Syndrome
- WHO: World Health Organisation

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List of Definitions

Arpeggio: The notes of a chord played one after another instead of simultaneously, in which the pitch of the notes can be ascending or descending (Barbancho *et al.* 2018)

Bowing: In bowed string instruments, sound is usually produced by moving the bow continuously across the string with the right arm. Stringed instrument bowing is a complex sensorimotor skill, involving fine regulation of bow orientation and motion relative to the string (Verrel *et al.* 2013)

Brachial plexus: The brachial plexus is a plexus of nerves formed mainly by five roots, five spinal nerves, three trunks, six divisions, three cords and numerous terminal branches in a complicated anatomic arrangement (Chuang 2008)

Conductor: The leader of a musical ensemble who indicates through gestures or conducting patterns how the music should be interpreted by the musicians. The musical director of an orchestra or chorus (FreeMusicDictionary.com 2019)

Embouchure: The way in which a player uses their lips and face muscles to produce sound from a brass or wind instrument (*Cambridge Dictionary* 2023)

Ensemble: A group of music with a simple arrangement of various music instruments (Pangesti and Wadiyo 2021)

Lower strings: Cello and double bass players (Scotland 2016)

Micro-trauma: An injury resulting from repetitive stress to tissues, characterised by an insidious onset of symptoms (Donatelli *et al.* 2004)

Mouthpiece: The part of a wind instrument into which the performer directs his breath in order to induce the regular series of vibrations to which musical sounds are due. The mouthpiece is either taken into the mouth or held to the lips (*Encyclopedia Britannica 1911* 2018)

Movement: A movement refers to independent sections of classical music that are part of a larger composition (Hub 2023)

Non-communicable disease: A noncommunicable disease (NCD) is a medical condition or disease that is by definition non-infectious and non-transmissible among people (Kim and Oh 2013)

Non-instrumental musician: Not relating to, composed for, or performed on musical instruments. This can include musicians such as singers, sound engineers etc. (*Merriam-Webster* 2023)

Orchestra: A group of instrumentalists, especially one combining string, woodwind, brass and percussion sections. (*Oxford South African Concise Dictionary Second Edition* 2010)

Plucked: To pull and then release the strings of a musical instrument with a finger to play notes (*Cambridge Dictionary* 2023)

PRMDs: Any pain, weakness, numbness, tingling or other physical symptoms that interfere with the ability to play an instrument at the level to which one is accustomed. This definition does not include mild transient aches or pains (Ackermann and Driscoll 2010)

Quaver: A musical note that is half as long as a crotchet; an eighth note (*Cambridge Dictionary* 2023)

Repertoire: All the music or plays, etc. that you can do or perform or that you know (*Cambridge Dictionary* 2023)

Tremolo: Either tremolo con l'arco, "tremble with the bow" which means to draw (the bow) back and forth rapidly, or tremolo col strumento "tremble with the instrument" (for example when done by trombone or bassoon) (Carter 1991)

Trigger point: Hyperirritable spots in skeletal muscle that are associated with a hypersensitive palpable nodule in a taut band (Dommerholt, Mayoral del Moral and Gröbli 2006)

Tutti: A direction in music meaning "with all voices or instruments performing together" (*Merriam-Webster* 2023)

Upper strings: Violin and viola string players (Scotland 2016)

1 CHAPTER ONE: INTRODUCTION

This chapter will include the background, rationale, aims and objectives of the study.

1.1 INTRODUCTION

Jobs which combine frequently repeated movements, high physical demands and psychosocial stress are often associated with musculoskeletal conditions (Cruder *et al.* 2020). While music is commonly employed as a relaxation method, musicians themselves are subject to higher-than-normal stress and competition levels, over and above the levels of the general workforce (Holst, Paarup and Baelum 2011; Cruder *et al.* 2019). The work environment of orchestral musicians is characterised by rigorous demands for high levels of technical skills, strict discipline and requiring an orchestral performance depending on high collaborative skills (Holst, Paarup and Baelum 2011). Professional musicians greatly rely on their physical and mental health, but even minor complaints can impact the precision with which their instrument is played or their musical technique (Rotter *et al.* 2020).

The learning and playing of a musical instrument requires fast, repetitive, asymmetrical and complicated moves of the arms, hands and fingers. Previous studies have concluded that taking the typical position required to play an instrument causes unfavourable postures (Ohlendorf *et al.* 2018). It has been reported that musicians can spend 1300 hours or more annually in non-ergonomic postures (Kochem and Silva 2018). Schalow (2020) stated emphatically that studies correlating the impact of musicians' postural distortions or spinal structural anomalies on their health do not currently exist. As in sport, the region of injury reflects the physical demands indicative of that sport (Chan and Ackermann 2014). The constant spinal pressures typical for musicians' body postures can be up to five times higher than that of an average person (Jacukowicz 2016). This can lead to future problems such as degeneration of the spine or other structures. Players' symptoms could also be secondary to poor positioning of the instrument, incorrect ergonomics between the player and the instrument, and supporting the weight of the instrument (Abréu-Ramos and Micheo 2007).

Musicians are a highly specialised group (Stanhope, Pisaniello and Weinstein 2021). They have characteristics that are unique to them, such as the young age that they usually start playing their instruments at, their tendency to become moulded to their instrument, and, since they are highly motivated by their projects, performing very often takes precedence over maintaining their physical health (Abréu-Ramos and Micheo 2007). Furthermore, musicians have less hand asymmetry, most probably related to their early musical training. As specialised as musicians are, similarities have been drawn to groups such as athletes and soldiers, in that they are also an elite occupational group with specific physical demands in their work (Paarup *et al.* 2011; Quarrier 2013). Steinmetz *et al.* (2015) conducted a study that highlighted the need for therapeutic interventions tailored to musicians' ailments. To reach the epiphany of the music profession, these meticulous and artistic athletes persist with practice and work at a heightened level of physical stress, making them highly susceptible to neuromusculoskeletal injuries (Chan and Ackermann 2014).

Musculoskeletal (MSK) injuries have been noted as common in European orchestral music students where Cruder *et al.* (2020) found that almost two thirds of experienced painful MSK conditions in the preceding 12 months. The results from Sousa *et al.* (2017) showed that more than half of the musicians of Northern Portugal were actively playing with mild to moderate playing-related musculoskeletal disorders (PRMDs). These facts are rather unfortunate, as literature suggests that 50% of musicians' problems are preventable as they are caused by modifiable factors such as poor posture, technique, inadequate training or physical conditioning (Abréu-Ramos and Micheo 2007).

In addition to risk of physical injury, musicians also face intense psychological pressures that stem from performing under public scrutiny (Chan and Ackermann 2014). Because negative connotations of being technically inferior when suffering injury are aimed at musicians, injuries evoke feelings of shame or professional inadequacy (Chan and Ackermann 2014). This tends to lead to injury concealment behaviours that delay health care management (Rickert, Barrett and Ackermann 2013; Chan and Ackermann 2014).

Musicians have to perform with the highest possible accuracy and under enormous internal (personal) and external (e.g. colleagues, conductor, audience) pressures to achieve ultimate perfection (Steinmetz *et al.* 2015). Performance anxiety has a considerable impact on playing-related musculoskeletal pain (Stanhope, Weinstein and Pisaniello 2020). While some studies have found a correlation between the impact of psychological factors and the tendency to express psychological distress through somatic symptoms, others have not reached this conclusion. Kenny and Ackermann (2015) stated that there are contrasting results that have been reported in the current literature regarding the relationship between the impact of psychological factors and the tendency to express their psychological distress through somatic symptoms. The results of their study showed, for the first time in musicians, that patients with a depressive and/ or anxiety disorder reported higher pain scores and pain chronicity. Jacukowicz (2016) astutely pointed out that musicians, unlike other professions, feel the immediate effects of their stress including: trembling hands, lips or legs, excessive perspiration, hot flashes, shortness of breath, impaired concentration and memory; these can all have a marked and detrimental effect on musicians. Gross and Musgrave (2016) conducted the world's largest known study into music and mental health, which revealed that the music community may be up to three times more likely to experience depression compared to the general public.

PRMDs are a direct threat to the career and income of a musician (Paarup *et al.* 2011; Steinmetz *et al.* 2015). Sousa *et al.* (2017) postulated that up to half of all musicians experience playing-related medical problems that could threaten or end their careers.

Many musicians believe that pain is inherent to the level of performance that they're trying to achieve and that pain can also be interpreted as the player being an inferior talent (Kok *et al.* 2013a). Their physical conditions are believed to come second to playing (Abréu-Ramos and Micheo 2007). The subsequent physical burdens exerted on the musicians bodies when playing are related to the playing of their chosen instrument (Ohlendorf *et al.* 2018). The achievement and improvement of skills in musical techniques to reach the highest levels of performance expose students to a wide range of PRMDs (Cruder *et al.* 2019). It was also stipulated that PRMDs as a

result of playing different instruments should be looked at individually as they are all diverse and are under-investigated (Stanhope *et al.* 2019).

1.2 AIMS OF THE STUDY

The aim of this study was to determine the epidemiology of performance-related MSK disorders in professional orchestral musicians in Kwa Zulu-Natal.

1.3 OBJECTIVES OF THE STUDY

This study had three objectives.

Objective One: To determine the point, one month and 12 month period prevalence of MSK injuries among orchestral musicians in Kwa Zulu-Natal from all sections of the orchestra.

Objective Two: To identify selected risk factors (sex, age, number of years playing, type of instrument, financial income, stress and performance anxiety) for those MSK injuries present among orchestral musicians in Kwa Zulu-Natal.

Objective Three: To evaluate the influence of selected risk factors on MSK injuries.

1.4 STUDY RATIONALE

Performing arts medicine is a relatively new field, having been recognised as a speciality from the 1980s (Kochem and Silva 2018). Despite there being a peer-reviewed journal, the *Journal of Medical Problems of Performing Artists*, dedicated to the problems of performing artists, musicians as a group remain under-investigated (Stanhope *et al.* 2019). One of the veterans in the field, Bronwen Ackermann, has demonstrated that the medical management of musicians is different from the management of the general populace (Ackermann 2019). Stanhope *et al.* (2019) pointed out that more than 85% of musical studies currently in existence have been conducted in high income countries. Hohls (2010) stated in his study that there is a

dearth of studies that have been done in this field in South Africa. Devroop (2014) concurred and furthermore directed attention to the fact that there are no specialised clinical settings that cater for the medical problems of performing artists in South Africa. This is of concern, as Ajidahun *et al.* (2017) pointed out that the risk factors and other information pertaining to South African musicians may be unique.

Literature suggests that PRMDs aren't sudden, and they develop slowly. They can start as early as pre-university stages of learning (Brandfonbrener 2003; Cruder *et al.* 2019). Longer hours of practising an instrument have been associated with increased risk of PRMDs (Cruder *et al.* 2020). Also, due to the modest income of musicians, some become teachers of music, or engage in other endeavours to supplement their income (Kochem and Silva 2018). Arts entrepreneur David Taylor blogged that musicians can even earn an extra income by playing online for paying patrons on websites such as Patreon (Taylor 2020). Increases in playing time are a significant risk factor for injury among musicians, and musicians are advised to decrease the amount they play once they are injured (Heming 2004; Abréu-Ramos and Micheo 2007; Gasenzer *et al.* 2017).

Kochem and Silva (2018) touched on the fact that conservatories and musical colleges need to encourage and educate musicians about early actions to prevent PRMDs and engender good habits to better prepare for professional demands, improve their performance as well as to protect them from further injuring themselves. Devroop (2014) has also highlighted the need for educational awareness to decrease the risk for long-term injury, especially in South Africa. One of the major challenges of managing the health of performing artists, as identified by Ackermann (2019) is 'a lack of training programs specifically targeting performing artists' healthcare'. Hohls (2010) noted in his research that the curricula of South African tertiary music institutes do not place enough focus on PRMDs and their prevention.

PRMDs might contribute considerably to performance disability, sick leave and the possibility of premature termination of a musicians' career (Paarup *et al.* 2011; Steinmetz *et al.* 2015). When considering musicians, Early injury management is still lacking, and this delays their return to work (Chan and Ackermann 2014). Devroop

(2014) intimated that interdisciplinary management of musicians' maladies is needed. PRMDs, being musculoskeletal in nature, fall into the scope of treatment of chiropractors and other physical practitioners. A 2020 case study on a soon-to-be retiring musician illustrated the potential for chiropractors to successfully treat and reverse the effects of PRMDs, in fact preventing the musician from retiring (Schalow 2020).

1.5 CONCLUSION

The myriad number of risk factors and the high prevalence of PRMDs amongst musicians underlines the need for more studies in this area. Over and above an increase in studies, Kochem and Silva (2018) have identified the need for methodological quality in the literature. The researcher has been unable to find studies demonstrating the prevalence of PRMDs in orchestral musicians in South Africa. This research therefore hopes to bridge the gaps in knowledge that exist in the available literature on South African orchestral musicians and the understanding of their injury profiles and risk factors. This will better equip chiropractors and other practitioners interested in treating injured musicians.

2 CHAPTER TWO: LITERATURE REVIEW

Chapter 2 presents the past and current literature on PRMDs. It also includes known risk factors and relevant information regarding the sections of the orchestra. Descriptions of various conditions experienced by musicians are also detailed.

2.1 PERFORMANCE-RELATED MUSCULOSKELETAL DISORDERS

When considering non-communicable diseases that affect most people at one point in their life or another, MSK disorders are in the forefront of that consideration (Briggs *et al.* 2016). This is because they are a well-established cause of severe, long-term pain and disability that affects a vast swathe of the global population (Akodu and Ashalejo 2019). On top of MSK disorders affecting the bulk of humanity, they are also under researched, with the WHO acknowledging that infectious diseases are more commonly studied. This is in spite of the fact that these disorders inflict a severe burden on people and economies (Parker and Jelsma 2010). In the general workforce, MSK disorders are the leading cause of disability worldwide (Mäntyniemi *et al.* 2012). Musicians comprise a specific portion of the work force. They have been shown to be prone to musculoskeletal ailments and dysfunctions which have been understudied and misunderstood for years. Available literature, though, shows that musicians may suffer from musculoskeletal conditions more than other people. For example, a study by Kok *et al.* (2013b) found that the prevalence of MSK disorders in musicians was higher than the general Dutch population. This was affirmed by Stanhope, Pisaniello and Weinstein (2021) who found rates of MSK injury to be higher in musicians than non-musicians.

Zaza, Charles and Muzynski (1998) were the first to define PRMDs, and defined them as “pain and other symptoms that are chronic, beyond your control, and that interfere with the ability to play your instrument at the usual level”. More recently, Ackermann and Driscoll (2010) redefined it to mean “any pain, weakness, numbness, tingling or other physical symptoms that interfere with your ability to play your instrument at the level you are accustomed”. This definition does not include mild, transient aches and pains (Cruder *et al.* 2019). As a group, musicians tend to strive towards perfectionism in their art. This drive to attain their desired level of playing can

cause them to adopt playing habits that are detrimental for them, which in turn predisposes them to correspondingly higher prevalence of injury (Rodríguez-Gude, Taboada-Iglesias and Pino-Juste 2022). In fact, musicians are faced with such intense demands and high expectations from their performances that they may actively ignore any discomfort they feel until after they have finished playing, and where acknowledged, are unlikely to seek medical help timeously (Kaufman-Cohen and Ratzon 2011; Yang, Fufa and Wolff 2021). Brusky (2009) declared that no instrumental musician has been found to be immune to developing PRMDs, and as a result of playing an instrument, up to 12% of musicians may be forced to retire earlier than they would like to due to their debilitating injuries (Abréu-Ramos and Micheo 2007).

The level that the musician is playing at seems to not matter in regard to PRMDs, as both music students and professional musicians have commensurate rates of PRMDs (Steinmetz *et al.* 2015). When surveyed, many musicians reported experiencing their first injury before even having graduated (Steinmetz *et al.* 2015). Indeed, Ajidahun *et al.* (2017) agreed with these findings when they reported that the prevalence of PRMDs is similar at all levels of proficiency, including music students and amateurs. Brandfonbrener (2009) found that 85% of 1st year music students surveyed had PRMDs, a majority of whom had first experienced those PRMDs before they were enrolled at college. This suggests that musicians are prone to playing their instruments while suffering from PRMDs for years on end, starting from younger ages as well.

The lifetime prevalence of PRMDs is high and was reported to be between 32-87% on average historically (Jacukowicz 2016). However, more recent studies have suggested rates of between 44.7%-93% (Kochem and Silva 2018). Not only are the rates of this MSK disorder higher than those of the general public in many cases Kok *et al.* (2013b), but Sousa *et al.* (2017) found that, in a study conducted in Northern Portugal, the majority of the musicians of the area (62.5%), were still actively playing in the orchestra despite reporting mild to moderate levels of pain.

Stanhope *et al.* (2019) suggested a possible geographical bias regarding the countries from which the bulk of musicians' literature emanates from. With 85% of existing literature coming from high-income countries, it is important to consider that low to middle-income countries may experience differences in terms of education, customs, working conditions, policies for health and safety at work, and accessibility to healthcare and medical advice, that could influence the prevalence and impact of MSK conditions (Stanhope *et al.* 2019). In South Africa, work-related MSDs challenge the health system, leading to disability and compensation claims. The risk factors of the work-related MSDs are similar to risk factors for PRMDs in musicians (Redivo and Olivier 2021). Yongolo *et al.* (2022) surveyed the general public in Tanzania and found that joint disease and related conditions were likely a pressing health problem in the community and that further research on specific MSK disorders needed to be undertaken both in Tanzania and in Sub-Saharan Africa. While MSK issues are being investigated abroad and in other African countries, the impact and prevalence of MSK conditions in the SA workforce, as well as the effect on the health system, are not as well documented (Parker and Jelsma 2010; Carpenter, Nyirenda and Hanass-Hancock 2021). That being said, a study conducted at a Cape Town clinic found the prevalence of MSK disorders to be over twice the estimated prevalence rate in Sub-Saharan Africa at 362/ 100 000 people (Parker and Jelsma 2010). Kwa-Zulu Natal has been noted to be the province with the highest prevalence of chronic lower back pain at 18% (Kahere and Ginindza (2021). In addition to the higher prevalence rate, the number of years living with disability in South Africa are higher than those in Sub-Saharan Africa since 1997 (Carpenter, Nyirenda and Hanass-Hancock 2021). Unfortunately, South Africa doesn't have sufficient resources to fund enough research into MSK conditions due to an overwhelmed public healthcare system and burden of communicable diseases like Tuberculosis and HIV (Kahere and Ginindza (2021).

2.2 THE ORCHESTRA, ORCHESTRAL SECTIONS AND PERFORMANCE-RELATED MUSCULOSKELETAL DISORDERS

An orchestra, as defined by the Oxford Dictionary, is "a group of instrumentalists, especially one combining string, woodwind, brass and percussion sections" (*Oxford*

South African Concise Dictionary Second Edition 2010). The *Dictionary of Music Education* further defines an orchestra to be: “a large ensemble of instruments (which is distinct from small ensembles – one player to a part), divided into four main sections- strings, woodwinds, brass and percussion” (Collins 2013). Instruments in the orchestra vary in type, from what the body of the instrument is made of, to their colour and weight. For example, there are wooden instruments like the violin and oboe which are on the lighter end of the weight spectrum, to brass instruments like the trombone and tuba which are on the heavier end of the spectrum. Heavier still, are instruments like the harp, which is a string instrument. Just as their phenotypical aspects vary, the distinctive body postures that musicians are trained to assume vary and play an important role in the development of injuries (Maric *et al.* 2019). The instrument a musician plays is a factor that influences both the prevalence of injury and also the area in which those injuries occur (Barton and Feinberg 2008; Maric *et al.* 2019; Yang, Fufa and Wolff 2021). While PRMDs can consist of disorders such as neck and back pain, inflammatory conditions etc, they can also consist of more worrisome conditions. Chesky, Devroop and Ford (2002) detailed that the blowing pressure from playing brass instruments may cause conditions such as glaucoma, respiratory problems, orofacial damage, cardiac arrythmias, tooth displacement and orbicularis oris muscle damage, while Glória *et al.* (2018) found that playing wind instruments was associated with a spectrum of injuries from lip numbness and calluses to bacterial infections. Findings like these show that playing instruments for a living may have knock-on consequences that can affect the player’s everyday life.

2.2.1 STRING SECTION

A string instrument, as defined by the Hutchinson pocket dictionary, (*Hutchinson pocket dictionary of classical music,* 2005) is “A musical instrument that produces a sound when a stretched string is made to vibrate. Presently the strings are made of gut, metal and nylon or Pearlon (a type of plastic). Types of string instruments include: **bowed**, e.g.: the violin family; **plucked**, like the guitar, ukulele, lute, sitar, harp, banjo and lyre, **plucked mechanically**, the harpsichord; **struck mechanically**, the piano and clavichord and **hammered**, the dulcimer.” The string section of most orchestras consists of violins, violas, violoncellos, (cellos for short), and double bass.

This being said, for the purposes of this study, only the bowed string instruments will be considered. The four bowed instruments that have been considered are not only the most commonly encountered and frequently played in orchestras, but are all also played in the most similar manner, namely they are all ‘bowed’ and played with a horsehair bow. They are not plucked like the guitar, harp or harpsichord, nor are they percussed like a piano or harpsichord.

The orchestral section that has been seen as most affected by musculoskeletal complaints, in the majority of musicians’ literature, is the string section (Sousa *et al.* 2017). This is also the section that has the greatest number of MSK complaints in different areas on the musicians bodies (Holst, Paarup and Baelum 2011; Moraes and Antunes 2012; Steinmetz *et al.* 2015; Sousa *et al.* 2017).

While the string section may all play their instruments in a similar, bowed manner, the playing of each instrument is actually a nuanced endeavour. Of note are the “upper strings” that consist of the violin and viola. Upper string instruments are played in a seated position, while being held aloft for long periods of time (Stanhope, Pisaniello and Weinstein (2021). This forces cervical spine rotation (Yang, Fufa and Wolff (2021) and extreme shoulder rotation coupled with elevated arms and sustained maximum supination of the left forearm (Moraes and Antunes 2012). Although the two instruments may appear extremely similar to most people, there are differences between the two instruments. For example, the viola is heavier and slightly longer than a violin, producing a deeper sound as a result. In terms of repertoire, the 1st and 2nd violins play more music and have a heavier workload and are more technically involved musically than violas and the other string players (Holst, Paarup and Baelum 2011).

The asymmetrical posture that is a distinguishing factor of the upper strings, is a known risk factor for PRMDs (Nyman *et al.* 2007; Moraes and Antunes 2012; Sousa *et al.* 2017; Rotter *et al.* 2020), so much so that in their study of neck and shoulder pain within the orchestra, Nyman *et al.* (2007) found it more useful to classify the musicians according to posture rather than the more traditional classification of instrument families. Instrumentalists that played with elevated arm postures were

twice as likely to suffer from shoulder pain than instruments who played in a more neutral, natural position, such as the piano which has the arms closer to the body and held at more natural angles. Those musicians were also more prone to suffering from chronic pain in the shoulder and back (Gasenzer *et al.* 2017). Rodríguez-Gude *et al.* (2022) found that instrumentalists that played with both arms raised to one side had rates of injury at slightly more than 50%.

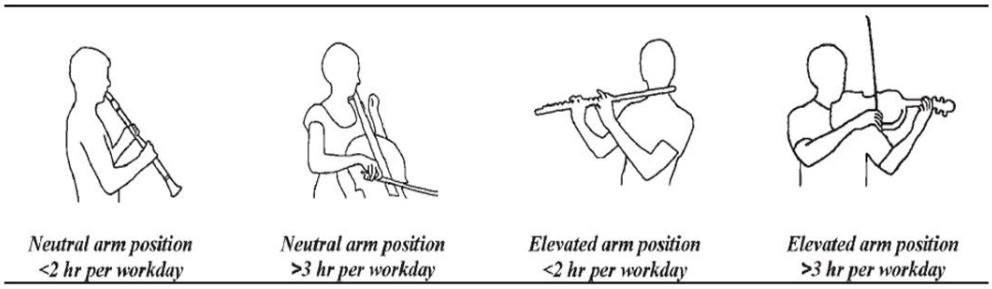


Figure 2.1 Showing neutral playing positions vs elevated, asymmetrical playing positions

(Nyman *et al.* 2007)

Kaufman-Cohen and Ratzon (2011) reported that 68% of those who complained of upper limb pain in an orchestral setting were from the string section. This is similar to the prevalence found in Sousa *et al.* (2017) of 67% and Gembris, Heye and Seifert (2018) of 62% of the complaints coming from the string section. Steinmetz *et al.* (2014) found that the highest prevalence of pain for the neck, left shoulder and left wrist areas belonged to the strings, particularly the upper strings. Likewise, Sousa *et al.* (2017) found that the number of complaints per musician were also highest in the string section when compared to the winds, at 1.2 and 0.9 complaints per musician respectively. Furthermore, string instrumentalists were the most prone to reporting more than 5 regions of pain on their body according to Steinmetz *et al.* (2015). The rating of the pain has also been found to be highest in string players, as well as the amount that their lives are affected by PRMDs as measured by their difficulty in performing tasks at home (Paarup *et al.* 2011; Maric *et al.* 2019). In African countries, the rates of injury have been found to be even higher. A South African study by Ajidahun *et al.* (2017) of 114 professional and amateur string instrumentalists found that 77% of the participants had musculoskeletal problems in one or more areas. Furthermore, Victor *et al.* (2016) concluded that their results may indicate that PRMDs may be a more serious problem amongst Nigerian string players than

previously thought, especially when considering that their 12-month prevalence was found to be at 82.4%.

Multiple possible explanations have been proposed to explain the increased prevalence of MSK injuries in this section of the orchestra. Along with their native posture and unnatural playing position, musicians in this section of the orchestra start playing their instruments at a younger age than average when compared to other musicians (Steinmetz *et al.* 2015). This could cause injuries associated with their young starting age. For example, a possible knock-on effect of starting young may be that the bones in the hands and wrist might not be fully ossified when they start intense practising, and this may predispose string musicians to deformity, malalignment and dysplasticity as those bones aren't ossified until approximately the age of 20 (Heming 2004).

2.2.2 PERCUSSION

The *Music Dictionary* by Collins (2013) defines the percussion section as a "Generic name for instruments that are sounded by shaking, or by striking one object with another. In general classification of instruments, they are divided into 2 categories - membranophones and idiophones." The percussion section is an interesting section of the orchestra because the musicians can wear many hats. Unlike most other orchestral sections, percussionists are more likely to play multiple different instruments, even within one practice or performance. This increases the risk of injury as more potentially risky movements are made during each session (Yang, Fufa and Wolff 2021). Additional risk factors for injury in the section include asymmetric limb demands, poor sitting mechanics and poor trunk control (Yang, Fufa and Wolff 2021). When combined, these factors have resulted in up to two thirds of percussionists reporting musculoskeletal complaints that vary in nature and seriousness from bilateral tenosynovitis or muscle strain of the elbow to arthritis in the hands. These observations are supported by Papandreou and Vervainioti (2010), who found that the majority of the MSK complaints experienced by percussionists affected the upper limb. Researchers such as Llobet (2004); Mishra *et al.* (2013); Kok *et al.* (2016) and Azar (2020) are in agreement that percussionists are the population that are among

the highest, if not outright the most frequently injured population in an orchestra. Mishra *et al.* (2013) found percussionists to be at the highest risk for PRMDs in their study that looked at Indian percussionists, while a large-scale study by Azar (2020), conducted in 49 countries and with a sample size of 831 players, concluded that the percussionists in their study had a high lifetime prevalence for injury at 68%. The playing techniques of percussionists is a potential reason for the high lifetime prevalence of injury. Kick pedalling was also singled out as one of the percussionist-specific actions that leads to injuries (Stanhope, Pisaniello and Weinstein 2021). In addition, Rodríguez-Gude, Taboada-Iglesias and Pino-Juste (2022) found percussionists to be the group that reported the greatest amounts of pain in the orchestra.

2.2.3 WIND INSTRUMENTS:

The wind section consists of musical instruments that contain some type of resonator, in which a column of air is set into vibration by the player blowing into (or over) a mouthpiece set at the end of the resonator (Collins 2013). The main wind instruments are the brass instruments, with their sound produced by their lips coming together and vibrating. Examples of the brass section include trumpets, trombones and euphoniums. The remaining wind section is comprised of the woodwinds, with sound being made by blowing through one to two reeds, or blowing over a mouthpiece, to generate the necessary vibration and make sounds. Examples include the flutes, clarinets and oboes, with the oboe being an example of a double-reed instrument.

2.2.3.1 Woodwinds

The *Music Dictionary* defines this section as “A family of musical instruments within the more general category of wind instruments (Collins 2013). They consist of two main types of instruments: flutes and reed instruments (reed pipes). What differentiates these instruments is the way in which their sounds are made. As a general description, flutes produce sound by directing a focused stream of air across the edge of a hole in a cylindrical tube, while reed instruments produce sound by focusing air into a mouthpiece that then causes a reed, (or reeds), to vibrate.

Woodwinds span the musical range and can be soprano, alto, tenor or bass.” (Collins 2013).

Some wind instruments, (e.g. flutes and piccolos) require the musician to assume asymmetrical postures while many other woodwinds have more neutral playing postures, for example clarinettists and oboists. Studies conducted by Paarup *et al.* (2011) and Steinmetz *et al.* (2015) found that woodwinds were not only at a lower risk for MSK problems and their consequences, but they were also more likely to be least affected by PRMDs when compared to the string section. However, when they have pain, Rodríguez-Gude, Taboada-Iglesias and Pino-Juste (2022) found that their pain intensities surpassed that of the strings. Additionally, woodwinds also had a relatively high lifetime prevalence of injury at 62%. The high prevalence of injury was also coupled with playing-related injuries that lasted more than three months (Stanhope, Milanese and Grimmer 2014).

2.2.3.2 Brass

The brass section is a collection of brass or other metal-made musical instruments. Their sound is generated when the player's lips vibrate against the mouthpiece, causing the column of air inside the instrument to vibrate. The "natural horn" and "natural trumpet," signalling devices made of a single tube with no additional mechanism, are the ancestors of brass instruments used in orchestras. These instruments were limited to producing notes in their own harmonic series, with the player increasing lip strain to generate the higher notes of the series. Brass instruments could now play any note in their pitch range due to the development of the valve mechanism in the early 19th century. They generate tones with significant depth and resonance and are effective and strong sound generators. They do not include wind instruments that are made of metal, such as the saxophone or flute (*Hutchinson pocket dictionary of classical music,* 2005). Instruments like violins are supported by the player’s jaw or collarbone (Gasenzer *et al.* 2017). However most wind players must also use their fingers or thumbs to maintain the weight of the instrument (Heming 2004). This is significant as some brass instruments can be heavy. It is important to consider the size and weight of the instrument, particularly woodwind and brass instruments, as they can have a significant impact on the

emergence of chronic pain (Gasenzer *et al.* 2017). In Gasenzer *et al.* (2017) study, more than 300 of the participating artists associated their suffering with their instrumental performance and factors such as their instrument's weight. The body areas that are directly involved in maintaining their posture and playing their instrument are also the main body parts that are impacted by chronic pain.

Another condition related to playing the instrument includes dystonia, which is a condition that affects the muscles involved in their embouchure as well as the relationship of jaw, lip, and tongue to the instrument mouthpiece (Lederman 2003). As musicians of this section make music with their lips/ embouchure, fatigue of these muscles would render them unable to play their instruments, while after practices/ performances their calloused, sore lips and maybe even misshapen teeth would make tasks that involve their mouths more difficult to perform at home (Chesky, Devroop and Ford 2002; Steinmetz *et al.* 2015; Glória *et al.* 2018).

Chesky, Devroop and Ford (2002) conducted research on a brass population of 739, 61% of whom had experienced musculoskeletal difficulties in one or more areas. The notable brass instrument musicians included the trombone players (70%) and French horns, at 70% and 62% respectively, likely due to the asymmetry inherent in their playing technique. Unlike most instruments that utilise both arms equally or in a similar manner, the trombone and French horn cause similar asymmetry in that one hand is significantly more active than the other. Despite the previous research showing relatively high rates of injury, researchers like Cebriá i Iranzo *et al.* (2010) state that the brass section has some of the lowest rates of PRMD in all the orchestral sections.

2.2.4 MOST DIAGNOSED MSK DISORDERS IN THE ORCHESTRA

There are many ailments that afflict musicians. However, the characteristics of the ailments are often similar to each other and can therefore be organised into groups. While the manifestation of the injuries may be different, they are all similar in that none of these ailments are injuries that occur after a one-time event usually. They are all a result of cumulative trauma acquired from repetitive micro-injuries. The

injuries can manifest as overuse syndromes, nerve compression syndromes that differ in distribution (based on which nerve has been affected), inflammatory syndromes or focal dystonia.

2.2.4.1 Overuse Syndrome

Some often cited risk factors for musician injury are repeated movements over an extended period of time and increased intensity (Yang, Fufa and Wolff 2021). By the time the average musician plays in their first concert, they would have practised for an average of 10000 hours. They may also be practising pieces that call for playing pieces that can be as intense as 25 notes per second and 1200 movements every minute (Kaur and Singh 2016). In fact, it has been determined that during a performance of Handel's Messiah, violinists are bowing 740 times in two minutes (United States Department of Labour 2007). Thus, over an entire career, or even within a single season, musicians may push their anatomy past their physiological limits while performing usual musician activities (Larsen 2020). These tendencies can lead to overuse syndrome. Overuse is the main cause of instrumentalists' most frequent injuries (Wilke, Vleeming and Wearing 2019). Overuse syndrome is a term that has many different symptoms and is not seen as a distinct diagnosis, but rather is a consequence of repetitive movements done daily over a long time (Larsen 2020). Historically it has encompassed symptoms including pain and loss of function in muscle units, weakness, loss of control and agility, tightness in specific muscles and underuse in others; and was seen as another name for musculoskeletal complaints (Larsen 2020; Yang, Fufa and Wolff 2021).

In contrast to the claims of Yang, Fufa and Wolff (2021), who claimed that overuse syndrome is ill-defined, Lederman (2003) and Heming (2004) found overuse syndrome to be its own distinct condition. It has been defined as ‘‘A clinical entity in its own right, caused by overload or repetition of some movements giving episodes of micro-trauma to muscle and joint ligaments, resulting in chronic inflammation and fibrosis as connective tissue is slowly taken beyond its biomechanical and physiological limits’’. The insidiousness of the onset of symptoms may lead to permanent damage and scar tissue being laid down (Greer and Panush 1994).

Overuse injuries may be acute injuries, but are most often chronic ones (Yang, Fufa and Wolff 2021). Affected musicians may initially only experience symptoms of weakness, (which may or may not be reproduced during examination), pain and a loss of fine motor control. Left to continue, the musician may experience symptoms of swelling, tenderness at the muscle-tendon junction and a feeling of fullness in the area that lingers even after playing has ceased (Greer and Panush 1994). Kaur and Singh (2016) noted that some of the instrumentalists most vulnerable to overuse syndrome include pianists followed by violinists and guitarists. In terms of the prevalence of overuse injury, a study conducted on seven music schools in Australia found that the prevalence of overuse injury was between 13% and 21% (Chong *et al.* 1989).

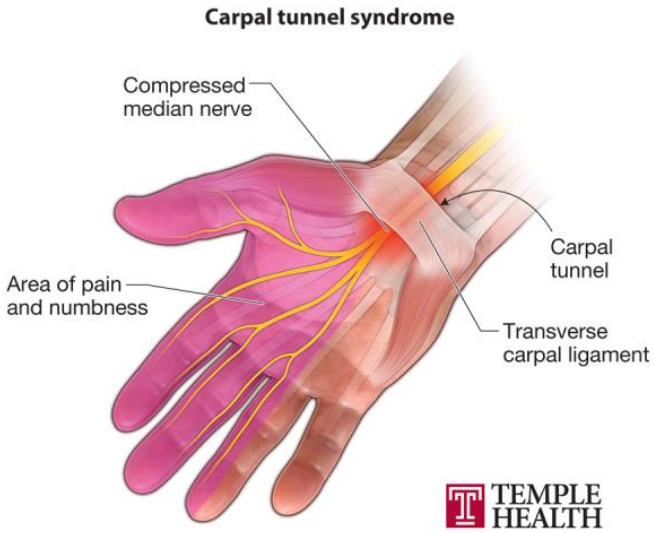
2.2.4.2 Nerve compression syndromes

"Nerve compression syndrome" is an umbrella name for the majority of nerve issues. The prevalent nerve conditions afflicting musicians include Carpal-tunnel syndrome, Cubital-tunnel syndrome and Thoracic-outlet syndrome.

Carpal-tunnel Syndrome: When considering the nerve compression syndromes that plague musicians, (Pratt *et al.* 2020) stated that carpal tunnel syndrome is one of the most prevalent, finding them to be more prone to the condition than non-musicians. Lederman (2003) and Júdez Torres (2019) concur and observe that entrapment of the median nerve, which occurs with highest frequency in the carpal tunnel, is the most prevalent peripheral neuropathy in musicians.

The gradual stress experienced by body parts when they are forced to do the same motions over and over again can lead to cumulative trauma (Jones Jr and Hernandez 2010). For example, excessive, repeated ulnar deviation can eventually lead to increased pressure in the carpal tunnel. This ulnar deviation has especially been detected in piano players, specifically during the playing of intense repertoires that use the centre of the keyboard (Yang, Fufa and Wolff 2021). Jones Jr and Hernandez (2010),however, have found brass players in general to be the population

with the highest risk of developing carpal tunnel syndrome in the orchestra. The most common symptoms associated with carpal tunnel include numbness, tingling and the loss of motion in the thumb, index and medial half of the middle finger (Lukomski 2004).



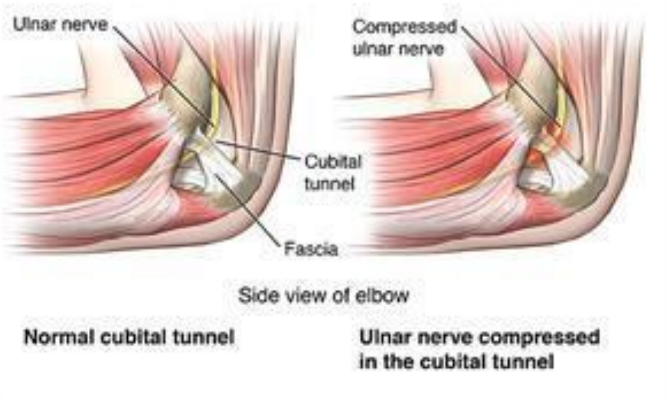
(Temple Health 2022)

Figure 2.2 Showing carpal tunnel syndrome and the affected area

Cubital Tunnel Syndrome: The ulnar nerve innervates nearly all intrinsic hand muscles, and is heavily utilised in music production (Rietveld 2013). As a result, the cubital tunnel syndrome is the second most common upper limb neuropathy affecting musicians Jones Jr and Hernandez (2010) and Júdez Torres (2019) and may account for up to nine percent of all instrumental injuries (Rietveld 2013; Júdez Torres 2019). Cubital tunnel syndrome, like carpal tunnel syndrome, is an upper-limb neuropathy characterised by inner elbow tingling and pain, especially when the elbow is bent and when there is elbow compression (Lukomski 2004). However, unlike carpal tunnel, which is a median nerve condition of the wrist, this is a neuropathy of the ulnar nerve that is compressed in the cubital tunnel at the elbow (O'Neill 2019). Normally, the ulnar nerve elongates by 5 mm in the cubital tunnel upon any elbow motions. When there is more than 90 degrees of elbow flexion, intraneural pressure increases by 600% while the shape of the cubital tunnel is changed into an ellipse from an oval shape, narrowing it by 55% (Júdez Torres 2019). The main mechanism of injury is from the compression, traction and friction of the ulnar nerve in the cubital

tunnel, which is located on the outer edge of the elbow (Jones Jr and Hernandez 2010; Júdez Torres 2019; O'Neill 2019). Some artists, such as those who play the double bass, harp, or guitar, have the ulnar nerve locally compressed by the sound-box of their instrument (Rietveld 2013).

The elbow is bent for an extended period of time in the normal playing of various instruments, such as the left arm in the cello, which stretches the ulnar nerve in the cubital tunnel (Rietveld 2013). Nerve injuries have a distinctive distribution that is affected by the injury, and symptoms of ulnar nerve compression can be identified by weakness in the little finger and the lateral aspect of the ring finger: due to damaged myelin sheaths causing inappropriate contraction of the affected muscles (Jones Jr and Hernandez 2010; O'Neill 2019). As time goes on, affected musicians will experience loss of grip strength, muscle loss and ‘claw hand’ which is an ulnar nerve deformity (O'Neill 2019).



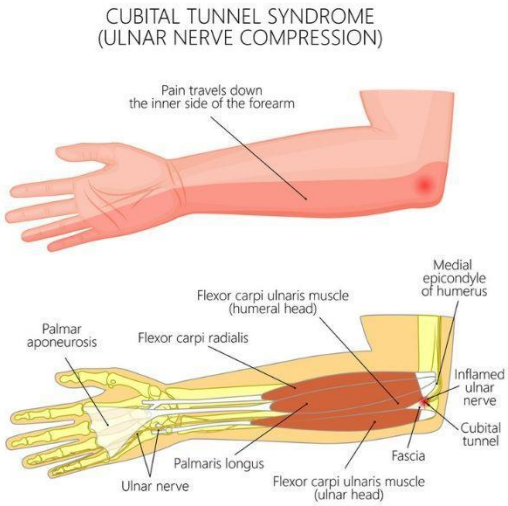
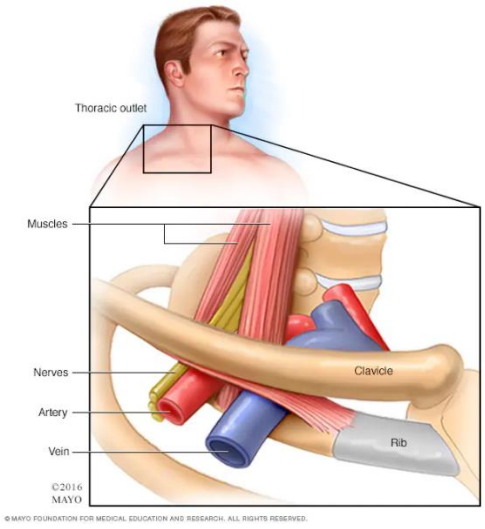


Figure 2.3 Showing the path of the ulnar nerve
Figure 2.4 Showing the distribution of cubital tunnel syndrome

(Institute of Regenerative Orthopaedics and Sports Medicine 2021), (Mazzara 2023)

Thoracic Outlet Syndrome: Thoracic outlet syndrome, (TOS), is yet another condition that falls under the umbrella of “nerve compression syndrome”, like Carpal and Cubital tunnel syndrome (O'Neill 2019). While studies do exist that state that Carpal and Cubital tunnel syndrome are most common, Lederman (2006) opined that TOS was actually the most prevalent neurological diagnosis, followed by carpal tunnel and cubital tunnel (Wilson, Watson and Lee 2014).The brachial plexus, which

originates in the cervical spine and runs through the thoracic outlet, can be irritated by certain habits and postures of musicians. Over time, the offending movements can lead to this condition (Rietveld 2013). An example of a habit that can aggravate this condition is when musicians unintentionally elevate their shoulders while playing in a concert or during a challenging section during practice or performance, which is a direct cause of brachial plexus entrapment (Rietveld 2013). “Rounded shoulder” posture, inappropriate breathing techniques, as well as having the head cocked forward, can also cause thoracic outlet symptoms. This is due to continuous compression of the neurovascular bundle as it travels under the pectoral muscle insertions and between the scalene muscles, which is especially noted in keyboard players (Chong *et al.* 1989). Likewise, violinists and violists are also at-risk players because of the constricted outlet caused by the raised and rotated left arm (O'Neill 2019).



(Mayo Clinic 2022)

Figure 2.5 Showing the thoracic outlet with accompanying vessels and nerves

The inflammatory conditions most experienced by musicians include tendonitis, tenosynovitis and epicondylitis.

Tendonitis: Tendonitis, or inflammation of a tendon, is highly associated with an increase in practice time and/or effort (Greer and Panush 1994). It is also incorrectly named when people are trying to describe tenosynovitis, peritendonitis, paratendonitis, tendonosis, and tendinopathy, on top of being misdiagnosed as tendinosis, which is degeneration of the tendon (Almekinders and Temple 1998;

O'Neill 2019). Tendonitis is a type of overuse syndrome seen in artists (Heming 2004).

Probably because of the fact that it can be aggravated by increases in practice time or effort, Stanhope (2018) found that two respondents with right arm tendonitis had been forced to stop playing their oboes permanently and had to play other instruments instead. Following their inability to play their original instruments, they were continually worried about getting injured on their new instruments. Kaur and Singh (2016) state that guitarists are particularly predisposed to tendonitis and nerve compression syndromes due to the placement of their upper extremities on their guitars during long-term practices or performances.

Tenosynovitis: Tenosynovitis, particularly De Quervain's tenosynovitis, is an overuse of soft tissue injury routinely found in musicians (Kaur and Singh 2016). De Quervain's is an inflammatory condition that affects the first dorsal compartment (Yang, Fufa and Wolff 2021). A particularly strenuous schedule, such as practising new techniques or a difficult performance can all aggravate this type of condition (O'Neill 2019). It can also be caused by direct irritation to the area, exacerbated by factors such as the position of the hand while playing an instrument, or the playing of particularly weighty instruments (Yang, Fufa and Wolff 2021). Usually, these injuries, (when acute), heal relatively quickly (O'Neill 2019). However, repetitive micro traumas to the tissue can cause derangement of the collagen there, leading to a frank injury. The recommended action is usually to stop doing the offending movement (O'Neill 2019). Percussionists are particularly plagued by tenosynovitis, as up to two thirds of them have been reported to have bilateral presentation of it (Yang, Fufa and Wolff 2021).

Epicondylitis: Epicondylitis is an inflammatory, chronic and aseptic overuse condition (O'Neill 2019; Karabinov and Georgiev 2022). There are 2 kinds of epicondylitis: lateral and medial. These conditions occur at either the lateral or medial aspect of the elbow. Both of them are aggravated by repetitive motions, especially where there are movements that are intense and carried out in an ungainly manner (Pascarelli and Hsu 2001; O'Neill 2019; Zięba, Zieliński and Ginszt 2019). The

precipitating actions surrounding epicondylitis are gripping activities, forced pronation and supination, and the overuse of the finger extensors (Çalisgan, Ünal and Burcu 2018; Parmar and Shukla 2020). Some studies have found lateral epicondylitis to be the most common cause of elbow pain in the general population, affecting up to 3% of the adult population each year (Parmar and Shukla 2020; Karabinov and Georgiev 2022). Also known as tennis elbow due to the high prevalence of this condition in tennis players, caused by gripping of the racquet, it can also be found in musicians, typists, carpenters and in various other professions (Pascarelli and Hsu 2001; Lukomski 2004; O'Neill 2019; Parmar and Shukla 2020). Factors that put musicians specifically at risk include over-training, progressing too quickly, poor technique and use of improper equipment (Parmar and Shukla 2020). All these factors lead to inflammation of the extensor compartment of the forearm and the origin of extensor carpi radialis brevis in particular (Parmar and Shukla 2020; Karabinov and Georgiev 2022).

Medial Epicondylitis, also known as golfer's elbow, is another common upper limb complication. Like lateral epicondylitis, the mechanism of injury is overloading of the upper limb and progressive injury caused by abnormal biomechanics and unnatural postures (Parmar and Shukla 2020; Mizrahi 2021). This condition worsens when musicians disregard the initial pain symptoms, leading to more damage of the tissues over time (Zięba, Zieliński and Ginszt 2019). Pascarelli and Hsu (2001) conducted a study on 485 patients with work related pain that included computer users, musicians and other professions with repetitive work. In their study they found medial epicondylitis to occur more frequently (60%) than lateral epicondylitis (33%) in their study with the musicians.

Both lateral and medial epicondylitis present similarly clinically, with pain in the area, loss of grip strength, loss of function, numbness and local weakness (Pascarelli and Hsu 2001; O'Neill 2019; Parmar and Shukla 2020). The gripping of the violin and bow, as well as the other string instruments, make them most susceptible to this condition (Çalisgan, Ünal and Burcu 2018). However, there have also been bilateral presentations of both of these conditions in drummers due to the bilateral gripping of drum sticks (Chong *et al.* 1989). Manual therapy for the affected regions have shown

that patients have increased and pain-free grip-strength, even from the first treatment (Karabinov and Georgiev 2022). This can be reassuring to patients, as the healing period of these conditions can vary from six months to two years (Parmar and Shukla 2020).

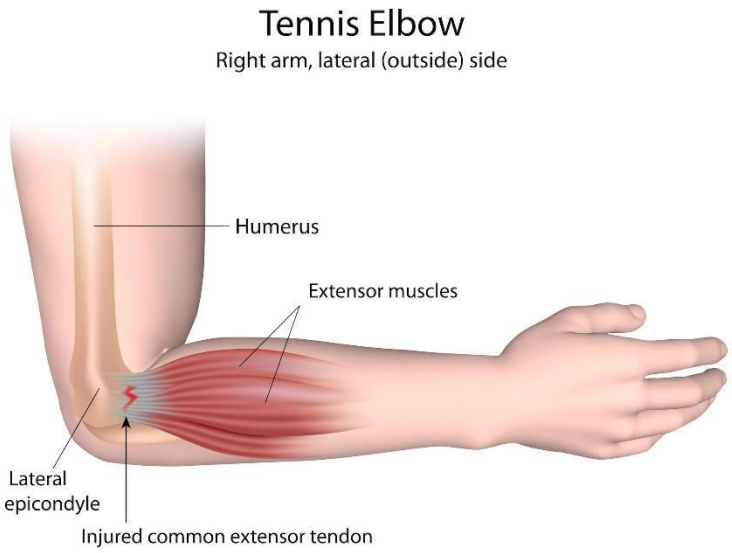
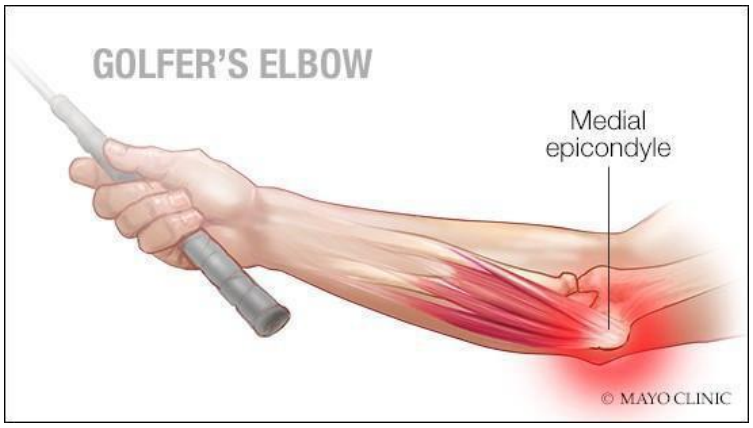


Figure 2.6 Showing the lateral epicondyle



(Marjoua 2023), (Mayo Clinic 2023)

Figure 2.7 Showing the medial epicondyle

2.2.4.3 Focal Dystonia

Focal dystonia is one of the more sinister conditions a musician can face, as it has been cited to be a potentially career-ending condition, with little known about what specifically causes it (Larsen 2020; Elam, Mowen and Jonas 2022). Also known as occupational palsy, idiopathic dystonia, writer's cramp or occupational cramp, it has

also been earmarked as one of the less understood overuse disorders (Greer and Panush 1994; Lukomski 2004). The known predisposing factors include heightened levels of anxiety, extended practice hours and repetitive motions. The anxiety specifically can be hard to escape for musicians especially when practising a particularly difficult passage, or considering a previous injury they may have suffered (Greer and Panush 1994; Larsen 2020; Yang, Fufa and Wolff 2021). Focal dystonia's distinguishing features include trouble maintaining motor control, painless incoordination of precisely controlled movement with no obvious cause, involuntary curling or extension of the fingers during technically challenging passages that require the fingers, as well as facial muscle incoordination leading to loss of embouchure or even pain, which is not the most striking feature of this condition (Greer and Panush 1994; Lukomski 2004). Symptoms begin with impairment, and progress to a total inability to perform smooth coordinated movements and use the affected muscles; translating to an inability to perform (Greer and Panush 1994).

For as yet unknown reasons, guitarists are particularly affected by this condition. Guitarists have been quoted as saying that they feel that when required to make highly controlled movements during music making only, and not during daily life, 'their fingers are too slow and lack control' (Rietveld 2013). Affected musicians may be symptomatic for months to years and are only relieved from the condition if they stop playing (Lukomski 2004). However, as most musicians need to keep playing to earn an income, this option is often cost prohibitive and may be the reason why it often signals the end of a musician's career.

2.3 GENERAL RISK FACTORS PREDISPOSING ORCHESTRAL MUSICIANS TO INJURY

Kochem and Silva (2018) explain that music brings out feelings of pleasure and wellbeing which may result in the difficulty of associating musicians with debilitating occupational hazards. However, musicians are susceptible to many known risk factors, both modifiable and non-modifiable. The most widely observed non-modifiable risk factors include being of the female gender, age and the instrument played. Modifiable ones include average number of hours played per week,

psychosocial aspects such as anxiety, ergonomics such as non-ergonomic instrument techniques, repertoire, lack of warming up, poor posture, use of excessive force and insufficient rest/breaks (Baadjou *et al.* 2016; Kochem and Silva 2018; Matei *et al.* 2018; Stanhope, Pisaniello and Weinstein 2021).

As stated previously, the available literature shows that no musicians are immune to developing PRMDs (Brusky 2009). PRMDs afflict not only professional players, but also musicians in the early stages of their music education (Cruder *et al.* 2019). Steinmetz *et al.* (2015) found that the prevalence of injury between students and professional players are similar. Brandfonbrener (2003) discovered in their study that 85% of 1st year music students that were surveyed had PRMDs, with the majority of those having first experienced those PRMDs pre-college. This demonstrates that they can happen at a wide range of ages and at almost every stage of a musician's career.

As has been noted, first world countries like the United States, Australia and European countries contribute the most to performing arts medicine literature. In these countries, preventative education about injuries that the musicians might face and PRMDs is mandatory at a tertiary level (Stanhope, Pisaniello and Weinstein 2020).

While the usual risk factors such as age, female gender and instrument played etc. have been cited in studies, recent systematic reviews Baadjou *et al.* (2016) and Stanhope *et al.* (2019) have suggested that due to poor research quality, known risk factors may not be as decisive as previously thought. As an example, female gender is believed to be a non-modifiable risk factor. However, studies have now been published that point to why the female gender may not be the gender more prone to PRMDs after all. For example, Baadjou *et al.* (2016) put forward two possible reasons for female gender not necessarily being a risk factor. Firstly, females were shown to be more likely than males to experience musculoskeletal diseases according to the results of multivariate only or univariate only analysis in cross-sectional research. As multiple variables were being considered and analysed, it may suggest that the correlation between gender and injury prevalence in this context may not be as strong as previously thought. Secondly, it has been demonstrated that

females are more likely to play the violin, an instrument known to cause PRMDs. This suggests that women are more likely to experience symptoms more often due to their instrument choice.

While current statistics reveal that up to 12% of musicians will be forced to prematurely end their careers due to PRMDs Abréu-Ramos and Micheo (2007), Sousa *et al.* (2017) postulate that almost half of musicians experience PRMDs that could threaten their careers or end them prematurely. To underscore that point, Sousa *et al.* (2017) discovered that more than half of the professional orchestral musicians in Northern Portugal are playing with mild to moderate pain. This suggests that musicians tend to disregard their own health in order to keep playing their instrument. All of this emphasises the requirement for future research on the perceived risk factors of musicians.

2.3.1 AGE

Existing information on age as a risk factor appears to be conflicting. While some literature supports findings that older musicians are more prone to injury (Baadjou *et al.* 2016; Kok *et al.* 2016), recent studies show compelling evidence that younger players may be more prone to PRMDs (Cruder *et al.* 2019; van Selms *et al.* 2020). Reasons for this include lack of proper playing techniques (especially as these are developed over time), pressure to play more frequently, and increasing levels of difficulty or intensity (Heming 2004; Baadjou *et al.* 2016; Gasenzer *et al.* 2017; Parmar and Shukla 2020). Frequent auditions both in university and at the beginning of a musician's career occur in a highly competitive environment, and may play a role in causing injuries in the younger population (Abréu-Ramos and Micheo 2007; Ascenso, Williamon and Perkins 2017; Cruder *et al.* 2019; Yang, Fufa and Wolff 2021). Older players, however, are usually more experienced in the field and may have had more time to learn to live with PRMDs and develop techniques to avoid acquiring them (Steinmetz *et al.* 2014).

Stanhope, Pisaniello and Weinstein (2021) asked musicians what they thought caused their injuries. They found that 14% of the injured musicians self-identified that

their pain may be due to age-related wear and tear. Abréu-Ramos and Micheo (2007) observed that the age groups that were associated the most with PRMDs were between the highest of the age groups, those of 50-60 years of age, as well as the lowest age range of 20-30; in fact, at 91% and 83% of those populations respectively. The reasons put forward for this bivariate finding were that those two groups played the most amount of music each week. The older group consisted of most of the section leaders who were responsible for duties such as demonstrating technical music to other players in their section and playing more notes than the rest of their section as a result. The younger groups may still be involved in university activities and studying their instrument as well as playing study-related music for recitals and exams outside of the orchestra. Those university activities translate to more playing time than their fellow orchestra members. This is probably also aggravated by their relative lack of experience, including lack of experience in preventing injuries.

Rodríguez-Gude *et al.* (2022) showed that older musicians were more predisposed to experiencing pain but were less impaired by that pain. Kenny, Driscoll and Ackermann (2012), found younger musicians were associated with higher pain ratings. Additionally, a younger age was also associated with more backache in percussionists and greater temporomandibular disorders in vocalists (Rodríguez-Gude, Taboada-Iglesias and Pino-Juste 2022). Recovery was found to decrease with increasing age (Rodríguez-Gude, Taboada-Iglesias and Pino-Juste 2022).

There is also literature that has found a lack of correlation between age (Nyman *et al.* 2007; Cruder *et al.* 2018; Glória *et al.* 2018) showed no evidence of relationship between age and the extent of pain, but the ages of people in the study reporting pain were higher than the ages of those not reporting pain. Furthermore, a systematic review by Baadjou *et al.* (2016) suggested that no conclusions can be drawn regarding the association of age and the number of years playing with PRMDs and also found that age was not a factor when considering the first episode of PRMD.

In conclusion, studies suggest that a greater number of higher quality analyses need to be undertaken to determine the effects of age on the incidence of PRMDs as the current results are contradictory.

2.3.2 GENDER

There appears to be a relative consensus that females are more prone to PRMDs (Rotter *et al.* 2020). This is likely multifactorial. Males are less likely to report their symptoms than females (Smith and Smith 2002). More importantly, due to the hormone relaxin, females have been found to be more prone to hyperlaxity than males (Em *et al.* 2015). Hyperlaxity is considered to be a major contributing factor to injury (Wolf, Cameron and Owens 2011). In addition, females are more prone to stress and anxiety, and are affected by adverse working conditions than men (Kenny and Ackermann 2015). This is noteworthy, as stress and anxiety are associated with increased susceptibility to injury, as well as a prolonged recovery time (Stanhope, Weinstein and Pisaniello 2020).

Females may be more prone to specific injuries than males. Steinmetz *et al.* (2014) reported that females experienced more embouchure problems than males and were almost twice as likely to experience cramping than males. Abréu-Ramos and Micheo (2007) observed that females had more tenderness and spasm, joint hyperlaxity, marked shoulder asymmetry and poorer posture than males; all of which are known risk factors associated with contracting musculoskeletal problems. They also found that there was an association between female gender and back pain, as well as hand neurological symptoms.

While the bulk of literature supports the view that female gender is a significant MSK injury risk factor, Baadjou *et al.* (2016) suggest that the instrument played by the musician is more significant to note when considering PRMDs than the gender of the player. They noted that more females played the violin, and they also had a higher probability of experiencing MSK symptoms from playing. A study that researched 40 orchestras in the US, UK and Europe looked at the distribution of the genders among the instruments of the orchestras. Their findings revealed that men were the

predominant gender in general in the orchestra (Sergeant and Himonides 2019). Furthermore, when considering specific instruments such as the flute, harp and violin, they found that these sections were predominantly played by women. This is interesting to note, as all 3 of those instruments require the player to hold their arms aloft for prolonged periods of time in order to play. In many cases the rate for female PRMDs was recorded at more than twice as high as that for males. Similarly, Rotter *et al.* (2020) concluded that 10 out of 12 studies they examined showed a higher prevalence of MSK issues among women. Females were also reported to have significantly more occasions of pain that interfered with their performances, as well as significantly increased mean scores for PRMD frequency and severity (Kenny and Ackermann 2015). While there are drawbacks to cross-sectional survey studies, such as inability to evaluate behaviour over a period of time, inability to determine cause and effect or the research findings not necessarily being representative of the population, the best literature to date suggests that predominant risk factors associated with MSK development do indeed include gender (Wu 2007). However, chi square tests comparing gender and injury rates were not found to be significant (Guptill, Zaza and Paul 2000).

In conclusion, the general consensus in the literature suggests that women may be more prone to developing PRMDs. They also seem to be prone to developing certain injuries more than men, as well as not healing as well as men. However, more research needs to be done to conclusively show the relationship between PRMDs and gender in musicians.

2.3.3 INSTRUMENT PLAYED

Barton and Feinberg (2008) state that predisposition to injury is an extrinsic factor that is dependent on the instrument played. The different instruments of the orchestra have different characteristics, unique ways of being played and, therefore, different biomechanical demands (Yang, Fufa and Wolff 2021). For example, the size and weight of the instruments, (especially regarding woodwinds and brass instruments), have been found to play a part in the development of chronic pain (Marić *et al.* 2019).

Chan and Ackermann (2014) argue that musicians are like sportsmen in that the area of injury on their body directly correlates to the physical demands of the sport being played. For example, sportsmen who throw balls often would have their upper limb more affected by MSK complaints than other areas of the body. Likewise, the repetitive physical demands related to the playing of a specific instrument will be correlated to the injury that they will incur. For instance, flautists have been found to be affected by musculoskeletal conditions that are specific to them and that are associated with the practice of their instrument, such as rotator cuff impingement and carpal tunnel syndrome (Marić *et al.* 2019). Examples of instrument-specific injury include embouchure and lip problems for brass players and shoulder problems for violinists and violists. Violinists have also been found to suffer from submandibular lesions because of the way they stabilise their instruments, on top of being plagued by bursitis and tendinopathy of the shoulder because of the "constant maximum supination, external shoulder rotation and maximum supination of the left forearm" (Moraes and Antunes 2012). Even specific areas of musicians' bodies that are symptomatic and which are documented by many writers, again reflect characteristics of the played instrument. For example, left arm problems are attributed to violinists, right hand and arm problems are especially seen in pianists, and right-thumbs with oboists and clarinettists as the thumbs bear the weight of their instruments (Lederman 2003). Multiple studies (Chesky, Devroop and Ford 2002; Lederman 2003; Glória *et al.* 2018) have found evidence to suggest that playing brass instruments is directly related to pathologies such as TMJ disorders, malocclusion, raised intraocular pressure and Satchmo's syndrome (rupture of the orbicularis muscles of the mouth).

Another instrument-specific risk factor that has been identified seems to be related to the degree that the artists' arms are raised, as well as whether it is just one arm or both arms (Nyman *et al.* 2007; Moraes and Antunes 2012; Rotter *et al.* 2020; Yang, Fufa and Wolff 2021). As such, Nyman *et al.* (2007) categorised the instrumentalists according to the degree with which their arms are elevated rather than into their "instrument families", (String, woodwind, brass and percussion). They concluded that even if it is for a relatively short workday, working with elevated arms was significantly associated with neck and shoulder pain. Rodríguez-Gude, Taboada-Iglesias and Pino-Juste (2022) found the injury rate to be higher than 50% in those

whose arms were both raised in front of them, (harp and trombone for example), both raised to the left of them, (flute and violin), or when only one arm is raised, such as guitar. Those whose arm position was more neutral, such as the cello, had a prevalence rate in their study of between 40%-50%.

In a study where musicians were asked what they believed caused their pain, Stanhope, Pisaniello and Weinstein (2021) documented that 13% of their respondents felt that the tasks involving the handling of their instruments were the cause of their musculoskeletal symptoms. They specified that tasks like holding the instrument against gravity while playing or features of playing their instrument such as the neck sling that saxophonists use to support their saxophones, were leading to their MSK symptoms. Gasenzer *et al.* (2017), Sousa *et al.* (2017) as well as Yang, Fufa and Wolff (2021), make reference to heavy instruments being a cause of PRMD, especially in the case of brass instruments. Yang, Fufa and Wolff (2021) also suggested that the mid-performance alternation of instruments, particularly in the percussionist section, might lead to increased risk of injury. Further examples of instrument specific techniques include musical techniques such as playing Beethoven tremolo passages on the piano, kick pedalling in drummers, Hanon exercises and playing arpeggios, and overall, having bad embouchure in brass players and having tension in the jaw in all instruments have been associated with pain (Stanhope, Pisaniello and Weinstein 2021).

When looking at instruments that are most prone to MSK injury, the keyboard and string players have been cited to be in that category (Lederman 2003). Baadjou *et al.* (2016) added that even when adjusted for other factors, consistent results indicate that upper string players experience more musculoskeletal disorders than any other instrumentalists, and furthermore that the type of instrument played may be the most important factor in the relationship between gender and PRMD. There is broad consensus that string players, violinists and violist in particular, are most at risk for the development of PRMDs (Barton and Feinberg 2008; Steinmetz *et al.* 2015; Sousa *et al.* 2017; van Selms *et al.* 2020; Yang, Fufa and Wolff 2021). Various hypotheses have been put forward to try and understand why this population may be at highest risk. Firstly, Holst, Paarup and Baelum (2011) stress the importance of

studies distinguishing between 1st and 2nd violins. The factors that make 1st violinists most susceptible in the strings include a higher workload than the other strings, increased technical demands, increased visibility during performances and a higher number of solo performances when compared to other sections. First violinists also experienced significantly more emotional stress than the rest of the orchestra, probably due to those factors. Sousa *et al.* (2017) showed that instruments that enforced an asymmetric posture, which included violin and viola, were also more at risk. Violinists start playing their instruments at an earlier age than others and may have more time to develop MSK injuries than other sections as a result (Steinmetz *et al.* 2015). In the orchestra, they often play most of the repertoire, (Holst, Paarup and Baelum 2011; Steinmetz *et al.* 2015), and therefore, cumulatively, play more hours than the other sections, all while maintaining their awkward postures, (Yang, Fufa and Wolff 2021). In contrast to previous studies, Paarup *et al.* (2011), Ackermann *et al.* (2014) & Guptill, Zaza and Paul (2000) found the prevalence rates of injury and the symptoms between the orchestral family groups are not significantly different between each other. A possible reason for this may be explained by Kaselouris *et al.* (2022) who found that violins, and by extension the string section, are the most studied section of the orchestra (Kaselouris *et al.* 2022). This suggests that violinists may be seen as more affected by PRMDs because they are the most researched section of the orchestra.

2.3.4 PSYCHOSOCIAL

Mátó *et al.* (2021) conducted a study in Hungary on psychosocial risk factors for injury in the general population. Some of the identified psychosocial risk factors for MSK injury included a lack of development possibilities in a job, role conflicts, leadership issues, a lack of social support and no sense of community, an experience of physical violence that exists in the workplace, as well as bullying, and discrimination, the draining nature of shift work, and the challenge of getting a job advancement. Current musical literature suggests that musicians suffer from a higher incidence of mental health problems than the general population, with symptoms of depression and anxiety being twice as high than the general workforce (Detari *et al.* 2020; Vaag, Bjerkeset and Sivertsen 2021). Both the musicians' perceived cause for

their injuries, according to Stanhope, Pisaniello and Weinstein (2021), as well as the evidence based findings show music performance anxiety and high stress levels as being a causative factor for musicians musculoskeletal ailments (Stanhope, Pisaniello and Weinstein 2021). Additionally, Gasenzer *et al.* (2017) opined that the amount of time that musicians spend playing under psychological stress may possibly be the most important risk factor for musician's musculoskeletal symptoms.

The habits that embody being a musician may foster the psychosocial climate that surrounds musicians. Examples of these tendencies include working long hours and late nights, extreme and prolonged concentration, travelling often, insufficient equipment, poor stress management, low levels of health responsibility, inadequate eating habits, highly perfectionist traits, high workloads and the pressure of tight deadlines (Jabusch, Müller and Altenmüller 2004; Rickert, Barrett and Ackermann 2013; Cruder *et al.* 2020; Detari *et al.* 2020; Rodríguez-Gude, Taboada-Iglesias and Pino-Juste 2022). Additionally, Sousa *et al.* (2017) found that, when injured, musicians try to manage their injuries without asking for help from other fellow musicians.

Although literature exists that compares musicians to other professions, particularly comparing them to athletes due to their rigorous practice habits, evidence highlights that the job expectations and nuances that comprise their particular jobs show them to not be adequately comparable (Cruder *et al.* 2018). For instance, most other professions are not necessarily expected to prepare for hours in advance, often the day before in order to be able to perform their job the next day, sacrifice time on weekends and evenings for rehearsals or concerts and, to top it off, do all of this as after-work labour and not be compensated (Detari *et al.* 2020). Another factor to consider is that different positions in the orchestra also experience different psychosocial pressures. For example, concert masters, principals of sections, members of the tutti, conductors and soloists all face varying stressors (Johansson and Theorell 2003). Soloists in particular, when surveyed, voiced that they felt like they are the least supported players in the orchestra (Detari *et al.* 2020).

The increased muscle tension that is a consequence of stress, combined with musicians' tendencies to work beyond their physical limits and not take regular breaks have also been linked to their high rates of injury, (Rickert, Barrett and Ackermann 2013) and depression and anxiety (Kenny and Ackermann 2015). Jacukowicz (2016) noted that, unlike most professions, the effects of stress on musicians can be immediately evident and visible. It can result in phenomena like trembling lips and shortness of breath, which would affect the embouchure of brass musicians and the playing quality of winds in general, as well as symptoms such as unsteady arms and legs which directly impact the playing of string instruments and subsequently lead to the affectionately termed "shaky bow" in string player circles, or even impaired concentration and memory which would affect all instrumentalists.

2.3.5 HEALTH

Musicians, unlike athletes, appear to be either ambivalent to or ignorant of their health related issues and risk of injury (Rodríguez-Gude, Taboada-Iglesias and Pino-Juste 2022). Heming (2004) for example, reported that only 7% of respondents were aware of musician-related injuries. The most commonly recognised condition by the musicians was muscle tension, followed by wrist problems, and dystonia awareness being least recognised. When asked to describe their health in a study by Gasenzer *et al.* (2017), the musicians with pain described their state of health as being excellent, good or just very good in general. However, the response rate of 8.6% for this study suggested that musicians do not like to address MSK issues that plague them. Indeed, Kaufman-Cohen and Ratzon (2011) observed that musicians may become so engrossed in their music, physically and emotionally, that they ignore any discomfort they may feel until playing is over. As a group, they do not have the best health tendencies and are also known for delaying healthcare when symptomatic (Yang, Fufa and Wolff 2021).

When considering the health responsibility of musicians, it is useful to look at tried and trusted mitigating factors for MSK risk. While Cruder *et al.* (2018) and Rodríguez-Gude, Taboada-Iglesias and Pino-Juste (2022) directly correlate the relative sedentary behaviour of musicians and their low levels of physical conditioning to their ongoing pain and disability, Van Hees (1997) and Baadjou *et al.* (2016) showed that

exercise has no effect on the nature of musician musculoskeletal complaints. Chesky, Devroop and Ford (2002) noted that the average time spent exercising for musicians was 3.5 hours a week, which is above the minimum 150 minutes of exercise per week average recommended by the CDC (Centers for Disease Control and Prevention 2022).

Resting from the offending activity has been shown to be one of the most reliable ways to alleviate the symptomatology of MSK injuries, as well as being one of the most common aspects of the treatment protocol after being diagnosed (Heming 2004; Abréu-Ramos and Micheo 2007). Available literature recommends a break be taken of five minutes for every hour of playing, or 10-15 minutes for every 45-60 minutes of playing (Chan and Ackermann 2014). If resting doesn't happen, muscle energy stores risk depletion, leading to damage to the tissues that might outpace the rate of healing and eventually cause an overuse injury. Unfortunately, van Selms *et al.* (2020), found that only 4% of their respondents believed in taking breaks. While rest may help alleviate the symptomatology of PRMDs, the underlying bad habits, unless remedied, will cause the PRMDs to arise again. In addition, the term rest may not be immediately clear to musicians, and warrants an explanation in terms of what is meant by rest and what is expected from the musicians during that period (Lederman 2003). Also, it needs to be specified whether there should be a decrease in playing time or whether they need to temporarily stop playing for a while (Heming 2004). It is important to detail what is meant by rest, however, because it is pertinent to consider that it can be a double-edged sword that may bring on new problems such as muscle atrophy and demineralisation of bone (Heming 2004). Despite the information referenced here, Baadjou *et al.* (2016) have noted that there is currently too little information available on which to base conclusive information on the clinical prevention of PRMDs.

Pre- and post-playing habits are another factor that the musical athlete has in common with the sports athlete. In particular, warming-up before playing is considered routine for sportsmen but may not be done as regularly by musicians. For instance, increasing blood circulation to the arms by warming up prior to rehearsing/ has been noted to be an integral part of musician counselling, with lack

thereof being recognised as a risk factor for injury (Yang, Fufa and Wolff 2021). Abréu-Ramos and Micheo (2007) detailed how, while 90.7% of their population had a warm-up routine before they played, only 20% of them had a cool-down routine. Additionally, Kaufman-Cohen and Ratzon (2011) found that only half of their musicians dedicated time to warming up before they played and spent an average of only 10 minutes warming up. Lederman (2003) advised musicians to consider the length of their rehearsals and take factors such as the intensity of the music played into consideration when considering warm-up length and encouraged them to ensure that their warm-up length is sufficient to cover the manner of practice they'll be having.

2.3.6 EDUCATION AND AWARENESS

Sports' medicine, which is tailored to the needs of sportsmen in various disciplines, is a well-established and understood branch of medicine. Musicians' medicine is, however, a newer, and much needed branch of medicine (Lederman 2003). The "musical athlete" is a term that has been coined by authors due to the shared common traits with athletes (Paarup *et al.* 2011; Cruder *et al.* 2018). Some of these traits include endurance, gruelling practices and injuries that correspond to what the person is doing, namely the instrument they play. This is akin to how athletes have injuries that correspond to their chosen sport. One area where athletes differ from musicians, however, is when it comes to supervision, correction and the instruction received from experts after becoming a professional, or the lack thereof (Chan and Ackermann 2014). Where athletes are supervised by coaches to monitor and correct their technique, coupled with access to medical professionals who understand their injuries and risk factors, musicians are not nearly as closely observed or well supported by professionals in their field to correct faulty technique that may predispose them to injury, or help them understand their injuries (Ackermann, Driscoll and Kenny 2012). Furthermore, musicians are faced with the reality of inadequate education regarding their injuries and bodies, as well as encountering a medicine field that is still developing and trying to gain a better understanding of their unique injuries (Rodríguez-Gude, Taboada-Iglesias and Pino-Juste 2022). Baadjou *et al.* (2016) and Steinmetz *et al.* (2014) opined that currently, too little information exists

surrounding clinical prevention of PRMDs. Studies make a strong case for the development of specialised and tailor-made healthcare for musicians, as well as for specific exercise programs (Rickert, Barrett and Ackermann 2013; Steinmetz *et al.* 2014; Kenny and Ackermann 2015; Kok *et al.* 2016; Yang, Fufa and Wolff 2021). This would achieve better outcomes, result in improved and more specific preventative measures, lead to an increase in the level of knowledge surrounding musicians' ailments, and accelerate musician-specific treatment protocols.

Another factor to consider is that musicians are also subject to stressors such as those caused by sudden changes to practise schedules, required pieces, auditions and performances as well as to career changes (Yang, Fufa and Wolff 2021). Furthermore, as a musician is nearing a performance, they may adopt detrimental playing habits such as neglecting to take breaks and playing with increased intensity (Heming 2004) on top of adopting faulty instrumental techniques (Gasenzer *et al.* 2017), and finally undergoing more strenuous and longer practices (Barton and Feinberg 2008). Emotional stress, a known risk factor for acquiring PRMDs, warrants a program focussed on prevention of musicians' injuries and an increase in the endurance of musicians to prevent injury would be of great benefit to musicians, (Abréu-Ramos and Micheo 2007), which is a goal that is yet to be achieved in musicians 'medicine (Rickert, Barrett and Ackermann 2013; Rodríguez-Gude, Taboada-Iglesias and Pino-Juste 2022).

An Australian study of professional orchestral musicians noted informal feedback from the musicians who had participated in the study which incorporated healthcare education given by researchers (Chan and Ackermann 2014). The surveyed musicians found the information to be valuable and expressed a desire to have gained injury prevention knowledge sooner. This highlights the importance of South Africa musician injury education. Currently, literature shows that the emphasis that is placed on such programs is not yet known. Hohls (2010) examined the topic and found that the South African institutions did not offer formal education surrounding PRMDs, or their prevention. The researcher has not found any current research undertaken in South Africa that contradicts these findings. As education surrounding PRMDs has been shown to be integral to ensuring the good health of musicians, a

push to educate South African musicians about preventative measures and musician health is clearly indicated.

2.3.7 ERGONOMICS

Ergonomics is an evolving science that means “the natural laws of work” (Zunjic 2017). It is defined as “a multidisciplinary science whose goal is to examine the impact of means of work, conditions of work, processes of work, and products as results of work on humans from the psychological, physiological, anatomical, biomechanical, sociological, organisational and physics aspect by applying the quantitative and qualitative research methods, as well as to adapt the design of the aforementioned elements to humans, with the aim of improving comfort, safety, efficiency and satisfaction, which are considered during their interaction with humans” (Zunjic 2017). With this background, it is important to consider ergonomics when looking at risk factors surrounding musicians and their playing (Heming 2004). The literature shows that the most cited ergonomic factors that affect musicians include poor posture, prolonged unnatural positions while playing, repetitive movements, holding the performance posture for long periods leading to muscle fatigue, unphysiological movements and incorrect ergonomics between the player and the instrument (Heming 2004; Abréu-Ramos and Micheo 2007; Barton and Feinberg 2008; Gasenzer *et al.* 2017; Yang, Fufa and Wolff 2021; Rodríguez-Gude, Taboada-Iglesias and Pino-Juste 2022).

When considering posture, it is important to consider the typical spinal posture assumed by musicians, as it can lead to constant spinal pressures of up to five times that of an average person (Jacukowicz 2016). This directly impacts breathing, which in turn affects the music quality of wind instrumentalists (Heming 2004; Chan and Ackermann 2014). Extended periods of poor posture can lead to overuse injuries, tightness and weakness in muscles and muscle fatigue (Yang, Fufa and Wolff 2021). Long movements and pieces, or frequent rehearsals, lead to stressed stamina and muscle fatigue, causing posture to progressively worsen over time (Heming 2004; Gasenzer *et al.* 2017). The weight of the instrument played has also been shown to have an effect on the players. String players have to hold instruments that weigh up

to 4 kg aloft for prolonged periods (Leaver, Harris and Palmer 2011). Musicians themselves point to instrument weight being a risk factor, with over 300 respondents linking their pain to the weight of their instrument (Gasenzer *et al.* 2017).

Despite correct posture being an important part of a musicians' experience, Heming (2004) found that there was an inconsistency in how teachers monitored posture, with one of the surveyed teachers not monitoring the posture of their students at all. Even though different instruments require different playing postures, general tips can be extrapolated and applied to the general population of musicians. For example, Abréu-Ramos and Micheo (2007) suggested that core-strengthening exercises, instrument-specific conditioning and improving endurance could be beneficial to instrumentalists. Also, chairs or stools with proper lumbar support and the reviewing of other work tools used by musicians could also be beneficial (Heming 2004; Abréu-Ramos and Micheo 2007). Another method put forward to reduce stresses on the neck, which is a common area of pain in all musicians, was detailed by Yang, Fufa and Wolff (2021) who recommended the adjustment of music stands to ensure the viewing angle for their music sheets was 10-20 degrees below their eye-level. Cumulatively these changes could significantly decrease the risk for PRMDs, especially in the light of the prolonged performances and practices.

Although devices have been designed to aid musicians ergonomically, uptake has been limited. This may be due to the highly traditional nature of music-making (Paarup *et al.* 2011). For instance, training good posture and using chin and shoulder rests were suggested to help with treatment of abnormalities (Moraes and Antunes 2012). Irritated digital nerves can be protected from further harm by the employ of aids such as gel caps, sleeves, slings around the neck and playing orthoses to help more evenly distribute instrument weight or transfer weight of the instrument to another muscle group (Leaver, Harris and Palmer 2011; Yang, Fufa and Wolff 2021). These studies show that ergonomic aids exist currently in the musical sphere.

2.3.8 ENVIRONMENT

The adjective “competitive” appears frequently when considering the environment and atmosphere that surrounds musicians (Barton and Feinberg 2008; Rickert, Barrett and Ackermann 2013; Yang, Fufa and Wolff 2021). This competitive environment can be present from the collegiate level, with players spending above-average amounts of time practising in order to hone their skills (Barton and Feinberg 2008). It is also present at the professional level and in the interim period from college to professional stages (Yang, Fufa and Wolff 2021). This competitive nature may manifest in different ways. One such manner is the duration of play and practice. The hyper-focused mindset while playing may result in a decreased awareness of pain which may only become evident after playing is complete (Abréu-Ramos and Micheo 2007). This habit may be attributed to their inherent determination and desire to perform at the best level they possibly can (Lederman 2003). Researchers have documented different average daily playing times, ranging from roughly 2.5 hours a day Steinmetz *et al.* (2014), to 4.6-5 hours daily Abréu-Ramos and Micheo (2007), and up to 27.6 hours weekly (Kaufman-Cohen and Ratzon 2011). The yearly average spent playing is 1300 hours, which is also the amount of time that musicians spend a year in ergonomically incorrect positions (Kok *et al.* 2013a).

The conductor of the orchestra has been identified as a potential stressor for members of the orchestra as they decide how long, how loud and how fast the musicians will play for a given piece.

The repertoire that musicians tackle also plays a significant role when considering their risk factors (Abréu-Ramos and Micheo 2007; Kok *et al.* 2013b; Rickert, Barrett and Ackermann 2013; Yang, Fufa and Wolff 2021). Musicians themselves have related their repertoire to risk of injury (Stanhope, Pisaniello and Weinstein 2021). A participant in Rickert’s study suggested that the technicality of the piece is not necessarily the problem, but rather the stamina that is required to play certain pieces (Rickert, Barrett and Ackermann 2013). Giving the example of the Turangalila Symphony, the participant detailed difficulty experienced when playing a certain movement of the piece as a result of playing very slow, long notes on their violin for

ten minutes. While ten minutes may not seem long, the repetition of the passage during rehearsals may directly lead to pain.

A more candid work environment that encouraged helpful habits and practices would be beneficial to musicians and would possibly have many positive knock-on effects. First, it may lead to more reporting of injuries in the musician population, as the current stigma that surrounds injuries leads to feelings of shame and inferiority amongst their colleagues as opposed to empathy (Rickert, Barrett and Ackermann 2013; Chan and Ackermann 2014). Second, the work environment is directly linked to injury as well, as voiced by a musician in Rickert's study who stated honestly that being stressed and having a tense neck and tense shoulders while playing 6-8 hours a day, will greatly impact your chances of getting injured (Rickert, Barrett and Ackermann 2013). Thirdly, lack of control is a phenomenon that is intrinsic to the musician experience and is a notable stressor (Rickert, Barrett and Ackermann 2013). Musicians have little control of their schedule, the music they play or the conductor choice and rehearsal technique (Rickert, Barrett and Ackermann 2013). This is significant as lack of control can be linked to a loss of interest in a job as well as a decrease in job satisfaction (van Selms *et al.* 2020). Lack of job satisfaction is a risk factor that plagues orchestral musicians, and has been measured to be lower than that of US state prison guards (Rickert, Barrett and Ackermann 2013).

2.4 CONCLUSION

The current literature available on PRMDs show that the prevalence rates are high amongst musicians. Certain risk factors put musicians more at risk for these injuries. These include being of the female gender, age and instrument played as well as average number of hours playing per week and the psychosocial aspects of their situation. The factors affecting musicians differ from area to area, and some areas have been researched more than others. The specific focus on Kwa Zulu-Natal musicians will give more insight into the similarities and differences between musicians in South Africa and those abroad.

3 CHAPTER 3: MATERIALS AND METHODS

This chapter will detail the research material and the methods that were used to meet the objectives outlined in Chapter 1. It will also address the statistical analyses used to interpret the data.

3.1 STUDY DESIGN

This study was a quantitative, cross-sectional descriptive study based on a self-administered questionnaire (Appendix J). The main goal of quantitative research is to gather numerical data to describe a specific occurrence (Sukamolson 2007). After the numerical data has been carefully assessed, it can be used to anticipate the future outcomes of that population and make changes accordingly (Questionpro Survey Software 2022).

For population-based surveys, and in order to determine the prevalence of diseases, cross-sectional designs are employed. In a cross-sectional study, the researcher can assess a population, as well as variables affecting that population, at a point in time (Setia 2016).

A questionnaire was chosen for the study for a few reasons. First, anonymity was needed to ensure the responses were as honest as possible. Second, it helped to minimise collection bias when compared to other methods such as interviews, etc. Thirdly, the questions could be standardised and the results could be collated, and interpreted to reveal patterns and relationships in variables. The average time taken to complete the questionnaire was seven minutes.

3.2 STUDY LOCATION

The research was undertaken at the locations where the selected orchestras practised. The Pietermaritzburg City Orchestra was approached at Pietermaritzburg

Girls' High School. The Durban City Orchestra was approached at St Peter's Lutheran Church in Westville where they practised.

3.3 SAMPLING

3.3.1 STUDY POPULATION AND SAMPLE SIZE

All musicians that met the inclusion criteria were included in the sample. This included all musicians in all four sections of the orchestra: Brass, Percussion, Strings and Woodwind. The size of the orchestras was calculated based on the number of musicians listed on their websites and was estimated to be at around 90 players between the two orchestras. However, upon speaking to the concertmasters of the orchestra, the actual size of the orchestras were determined to be much smaller, largely due to COVID-19 and its after-effects which included members not returning after the pandemic.

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The South African lockdown levels during COVID-19 determined the activities that were lawful during the pandemic. Due to orchestral activities not being regarded as a necessity, orchestras could not practise during that time. Additionally, as the orchestras were not convening, the researcher was unable to commence data collection until the lockdown regulations allowed for it. Furthermore, the Kwa Zulu-Natal Philharmonic orchestra was originally intended to be included in the study population; however, due to various attempts at contacting the orchestra and not receiving any correspondence back, they were removed from the study sample. An application to amend the original proposal document was sent to the Institutional Research Ethics Committee, (IREC), and was subsequently approved after consideration (Appendix L).

3.3.2 SAMPLING METHOD

The purposive sampling method of total population sampling was used, where every eligible member of both orchestras was invited to participate. Potential participants were informed that participation was voluntary and that they could withdraw their

participation up to the point of the submission of the questionnaire. The orchestras were contacted by email before the researcher visited them to ask for permission and agree on a data collection date. To be considered eligible to participate, participants had to meet the following criteria:

3.3.2.1 Inclusion criteria

a) Participants had to be 18 years or older
b) All members of the two selected orchestras who were actively playing in the year of data collection were eligible.
c) Participants who completed the informed consent form.

3.3.2.2 Exclusion criteria

Only those participants that participated in the pilot study were excluded from the main study. Pilot study participants were contacted via email and completed the pilot electronically. Pilot study participants were informed that they could not participate in the main study.

3.4 ETHICAL CONSIDERATIONS

This study was approved by the Institutional Research Ethics Committee (IREC) of the Durban University of Technology (Ethical Clearance number IREC 054/21) (Appendix M). Gatekeeper permissions were then sought and obtained via email from both the Durban and Pietermaritzburg City Orchestras (Appendices F and G).

All voluntary participants of the study were asked to read the letter of information and then, once informed, requested to sign the informed consent forms to be able to participate. All participants were made aware that participation was to be of their free will and were told they could withdraw at any point.

There were no personal identifying details that were needed or asked for, in order to participate in the study. This was done to ensure anonymity was maintained among the participants. The data was coded and stored in the DUT Chiropractic Department and only the researcher and supervisors had access to the raw data. After 5 years, the hard copies will be shredded and disposed of, along with the electronic data.

Participants were not offered any form of remuneration to participate in the research and participants were informed, through the letter of information, that no harm would come to them for participating in the research. Participants' autonomy was maintained by the fact that participants were not recruited under duress and they were reassured by the knowledge that they could withdraw their consent at any time without there being any negative consequences. The expected knowledge surrounding Kwa Zulu-Natal musicians was the beneficence of this study. It was also anticipated that the chiropractic and medical community at large would benefit by having a more thorough understanding of the population. Non-maleficence was preserved as no harm befell any of the research participants.

Justice was maintained as every participant had an equal opportunity to give their views and detail their perceptions in the research study without being discriminated against. Furthermore, the research exclusion criteria did not exclude anybody by race, sex, religious or political beliefs or any other criteria.

3.5 RESEARCH TOOL

3.5.1 QUESTIONNAIRE DEVELOPMENT

The questionnaire was developed using a pre-validated questionnaire developed by Hohls (2010), for which permission was sought. The questionnaire was further enhanced with the research tools known as the Musculoskeletal Pain Intensity and Interference Questionnaire for Musicians, MPQIIM, Lamontagne and Belanger (2012) as well as the Nordic Musculoskeletal Questionnaire, (NMQ) (De Barros and Alexandre 2003; Crawford 2007). These research tools were chosen due to their high reliability and validity, and subsequently adapted for the study questionnaire. On the analysis of the reliability and validity of the MPQIIM, Berque, Gray and McFadyen (2014) found that the tool was valid due to the strong test-retest reliability for the pain intensity items (range 0.78-0.82), as well as the test-retest reliability for the pain interference items (range 0.56-0.76). The NMQ was found to be valid for Chronic

Musculoskeletal Pain and Chronic Widespread Musculoskeletal Pain with kappa values ranging between 0.63 and 0.68 (Dahl, Havang and Hagen 2022).

The questionnaire was formulated in order to assess the prevalence of MSK pain, associated risk factors and the nature of care-seeking that musicians choose and are aware of. It was also formulated to assess education on the prevention and treatment of occupational injuries and maladies, physical and psychological, and attitudes and feelings towards those injuries, as well as areas most affected by injuries. Considering that a focus was already conducted by Hohls, no additional focus group was conducted for this study. The researcher refined the questionnaire by means of a pilot study.

3.5.2 PILOT STUDY

A pilot study is defined as a small study for helping to design a further confirmatory study (Arain *et al.* 2010). The researcher conducted this pilot study to test the questionnaire in terms of ambiguity, clarity, quality and of validity of questions. A questionnaire based on Hohls (2010), the MPQIIM and the Nordic musculoskeletal questionnaire was put together. The pilot questionnaire was electronically distributed to 1 player from both orchestras in KwaZulu-Natal. The researcher also distributed hard copies of the pilot questionnaire to other musicians that were not members of the main orchestras.

Prior to participation, pilot study participants were required to read the letter of information and sign the Informed Consent. Questionnaires were then completed and returned electronically. Any feedback given by the participants was noted and changes were implemented to produce the final questionnaire.
Following the pilot study, the following changes were made to the questionnaire:

- Removal of Section A question 11,
- Removal of Section B Q 11,
- Section C table removal of 3 questions,

- Section D question 15 removal of the homunculus, removal of 2 questions from question 16 table, re-wording of question 16.1 for clarity, removal of last table in section D entirely.

There were questions that were modified and removed in order to shorten the questionnaire in light of the main comment from the Pilot study participants being that the questionnaire was too long, with repetitive questions which were not always clear.

Pilot study inclusion criteria: The participants had to be a musician over the age of 18.

Pilot study exclusion criteria: Any member of the orchestras who were not actively playing in said orchestra in the year of data collection. All participants of the pilot study were excluded from participating in the main study.

3.5.3 FINAL QUESTIONNAIRE

The final questionnaire (Appendix J) comprised of 4 sections, which included both open and closed ended questions. The questionnaire was in English due to the fact that players in both orchestras needed to be fluent in English to be a member. The sections in the questionnaire were as follows:

Section A was a **Demographics** section. This section was concerned with details about the participant as an individual such as age, gender, race, height and weight, highest level of education and other details were collected.

Section B was on **Musical background**. This delved into what age they started playing their instruments, whether they had any information on musician health-related problems and other such questions.

Section C was a section on **Occupational information**. This included how many hours a week they played to other jobs they worked as well as other related questions.

Section D was exclusively on **Playing-related health issues**. This included information on their signs, symptoms and consequences.

Section E was about the **Personal opinions and views** of the musicians on pertinent issues that involve musicians, ending in open-ended questions. These questions were graded from Strongly agree to Strongly disagree.

3.6 Research procedure

Prior to data collection, permission was obtained from each orchestra involved (Appendices H and I). The researcher attended 2-3 rehearsals of the orchestras to try and make sure that as many members of the orchestra had a chance to participate as possible. The orchestras were notified before the researcher arrived so as to determine days that were most suitable for data collection. These days were determined by days when the whole orchestra was practising, or when certain sections were practising half-day etc. The different orchestras have different breaks in length, ranging from 15 minutes to 1 hour in length. The longest break was targeted for data collection, as well as after-practice time.

On the initial arrival date at each orchestra, the researcher addressed the orchestra to explain the nature of the research and the procedure. The Letter of Information was administered, and Informed Consent was then sought. Following that, the questionnaire was handed out. Participants were able to complete the form and the questionnaire in roughly 15 minutes. Once the willing participants had filled in the questionnaire, it was placed in a sealed box. The participants had already been instructed that the questionnaire was anonymous and that no identifying information was to be on any part of the questionnaire. The completed questionnaires were only handled by the researcher. Furthermore, the completed informed consent forms were placed in a separately marked box to ensure anonymity.

3.7 STATISTICAL ANALYSES

The statistical package IBM SPSS version 28 was used to analyse the data.
Proportions and categorical data were summarised using frequency tabulations. Descriptive statistics such as mean and standard deviation were used to summarise continuous variables. Association between specific risk factors and 12-month prevalence of MSK was assessed using Fisher's exact 2-sided tests for categorical

risk factors and t-tests for continuous risk factors. Sample size did not permit multivariate analysis. A p-value <0.05 was taken as statistical significance.

4 CHAPTER 4: RESULTS

This chapter presents the results of the study. The demographical data will be discussed first, followed by the research objectives.

4.1 STATISTICAL METHODS

The data was analysed using IBM SPSS version 28. Descriptive statistics such as mean and standard deviation were used to summarise continuous variables. Association between specific risk factors and 12-month prevalence of MSK was assessed using Fisher's exact 2-sided tests for categorical risk factors and t-tests for continuous risk factors. Sample size did not permit multivariate analysis. A p-value <0.05 was taken as statistical significance.

4.2 PARTICIPANTS

All members of the Durban City Orchestra (DCO) and Pietermaritzburg City Orchestra (PCO) were the intended target population (25 PCO + 30 DCO = 55). The final sample size was 30 participants which included 16 participants from the PCO, who all completed hardcopy questionnaires, and 14 participants from the DCO, 1 of whom completed the questionnaire online. This totalled to a response rate of roughly 54,5%. Data collection for the Pietermaritzburg City Orchestra was on the dates of the 25th of May 2022 and June 1st. The Durban City Orchestra was visited between the dates of 22nd of June to the 14th of July.

4.3 DEMOGRAPHICS

4.3.1 AGE

Participant age ranged from 18 to 92. The number of participants in each age distribution was fairly even, with the exception of the age group 35-44 which was notably smaller. Figure 4.1 shows the age distribution of the participants.

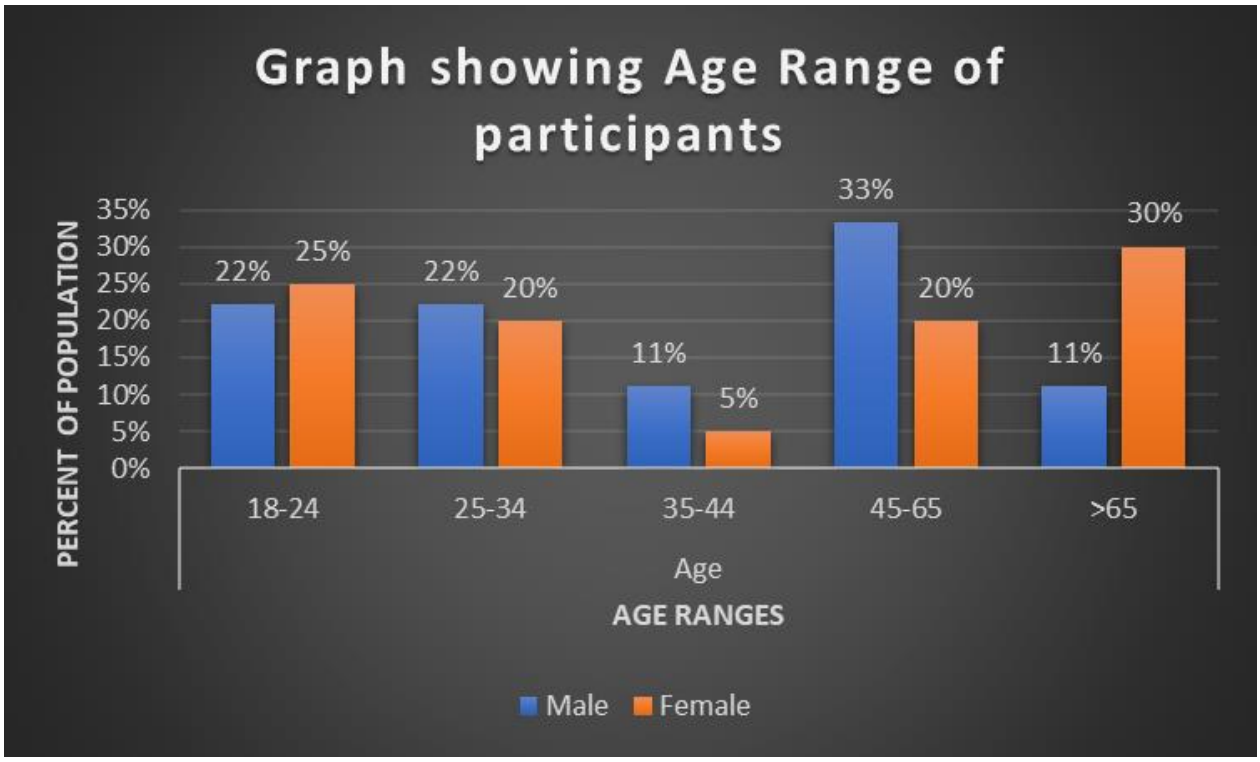


Figure 4.1 Bar graph showing age of the participants in males and females

4.3.2 GENDER

Two thirds of the participants were female (n=20), nine were male and a single participant identified as non-binary.

4.3.3 RACE

Far majority (97%; n=29) of the participants were White. The one remaining participant was Black.

4.3.4 HAND DOMINANCE

Most of the participants (93,3%; n=28) were right-hand dominant. Of the participants, one of the respondents was left-handed, and one was ambidextrous. Figure 4.2 documents the hand dominance by gender of the participants.

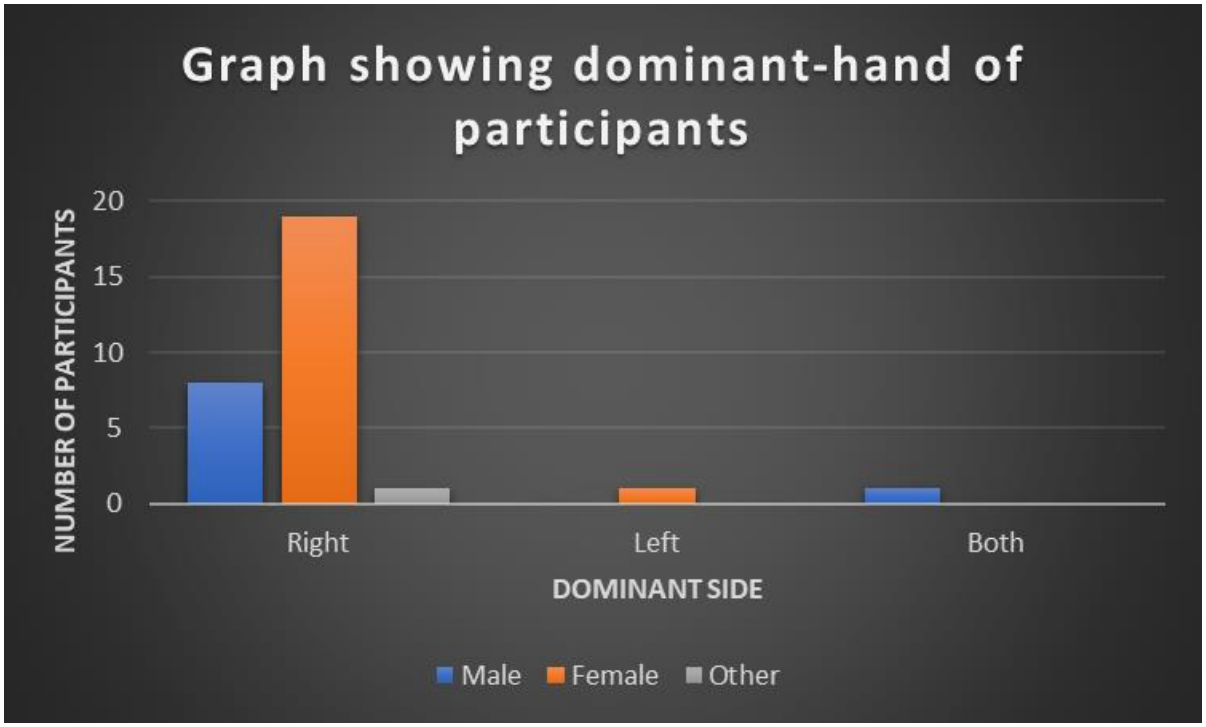


Figure 4.2 Bar graph showing hand-dominance of the participants

4.3.5 SMOKING

The majority of the population (93%; n=28) were non-smokers. When considering the gender of the non-smokers, 8 of them were male and 19 of them were female. Only two participants (7%) were smokers, one male and one female.

4.3.6 COUNTRIES WHERE MUSIC QUALIFICATIONS WERE OBTAINED

More than two thirds of the participants had attained their music degree from South African institutions (70%; n=21). The other countries represented in the study had one respondent each who had attained their music qualification in the Netherlands, England, Zimbabwe and Kenya.

4.3.7 HEIGHT, WEIGHT AND BMI

The height and weight of the participants was asked in the questionnaire in order to determine their BMI. The BMIs of the injured respondents spanned from the Underweight category to the Obese category. The majority of the injured respondents fell into the Normal BMI category. The category with the most injuries overall was the

overweight category with (75%; n=6) of the players being injured. These findings were not statistically significant. Figure 4.3 categorises the respondents into BMI categories and shows how many of them were injured in each category.

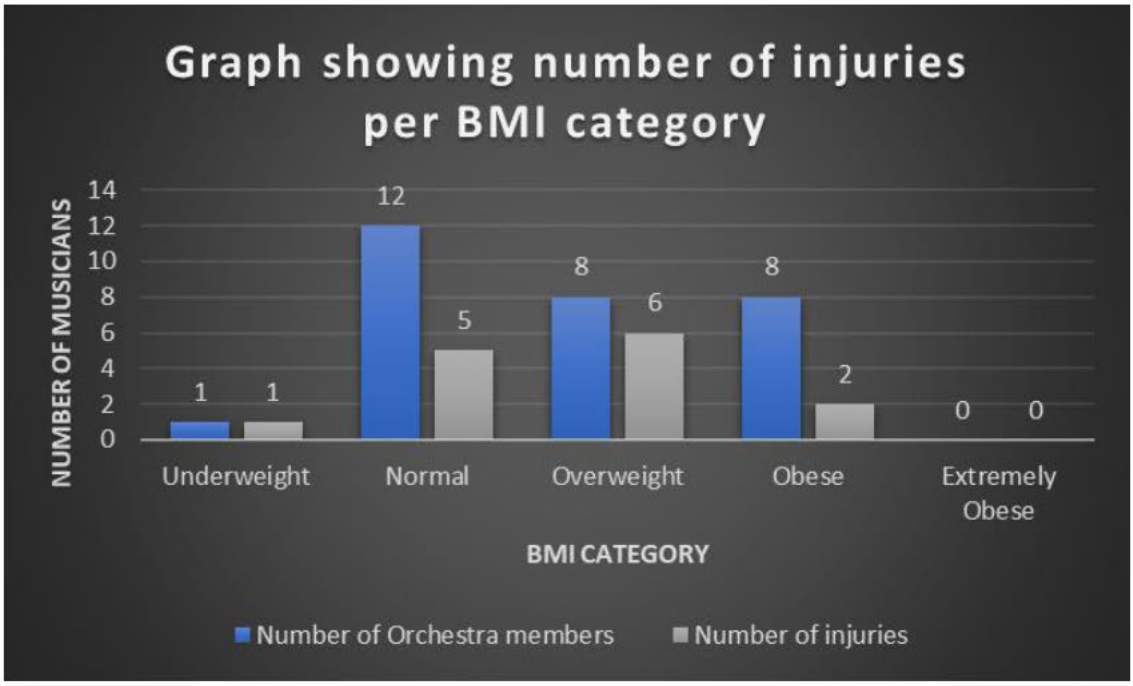


Figure 4.3 Bar graph showing BMI categories and number of injuries

4.4 THE PREVALENCE OF MSK INJURIES AMONG PROFESSIONAL ORCHESTRAL MUSICIANS IN KWA-ZULU NATAL AND BY THE ORCHESTRA'S VARIOUS SECTIONS

The research data showed that the prevalence of MSK injury amongst musicians from the study sample was 46.7% over the last year. It was noted that 40% of the participants had experienced MSK injuries in the last 4 weeks, as well as at the time of data collection. Table 4.1 details the number of respondents who reported PRMDs at various times in the past year.

	No		Yes	
	Count	%	Count	%
Have you experienced a playing-related musculoskeletal problem: last 12 months	16	53.3%	14	46.7%
During the last month? (4 weeks)	18	60.0%	12	40.0%
Currently? (In the last 7 days)	18	60.0%	12	40.0%

Table 4.1 Showing percentage of participants that have experienced PRMDs at various time frames

4.4.1 PRMD PREVALENCE BY SECTION OF THE ORCHESTRA

Figure 4.4 shows the prevalence of injury at 12 months, 4 weeks and currently, experienced by the different sections of the orchestra. The section with the most injuries at both 12 months, and on the current timeline, was the string section (53,3%; n=16), followed closely by the woodwinds (37%; n=11). The brass section only had 2 players, (6,7%) as part of the respondents, both of whom reported having PRMDs. The mixed section of the graph includes any percussion respondents as well as any other instrumentalist that don't fit into the other sections.

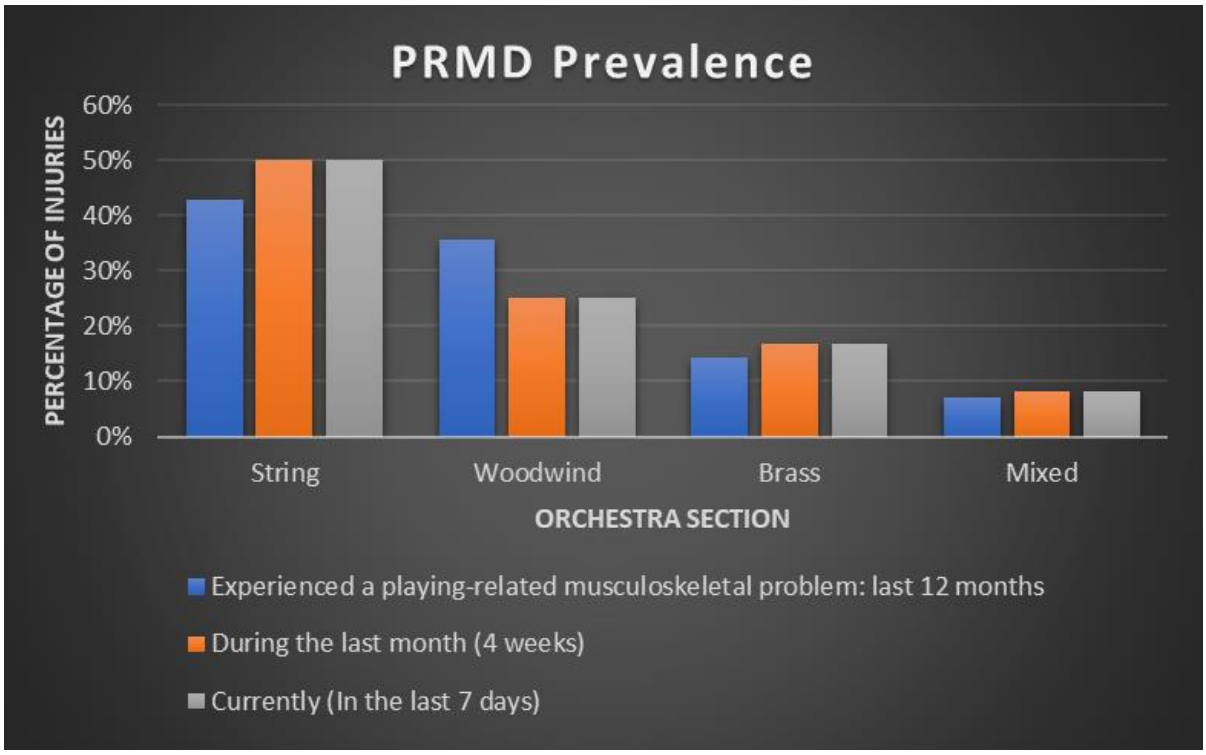


Figure 4.4 Bar graph showing prevalence of injury in the orchestral sections

4.4.2 PRMD PREVALENCE BY AREA OF THE BODY

When the musicians were asked to report which areas of the body had musculoskeletal issues, the data showed that the most affected areas reported amongst the participants were the left and right shoulders (13%; n=4). Those injured only in the right wrist were 10% (n=3), while those injured in the left wrist only (n=2; 6.7%) and both wrists (6.7%; n=2) were also mentioned frequently. Figure 4.5 shows a bar graph plotting the percentage of PRMDs by area on the bodies of the participants. Upper back and Lower back injuries are designated by the letters U and L respectively.

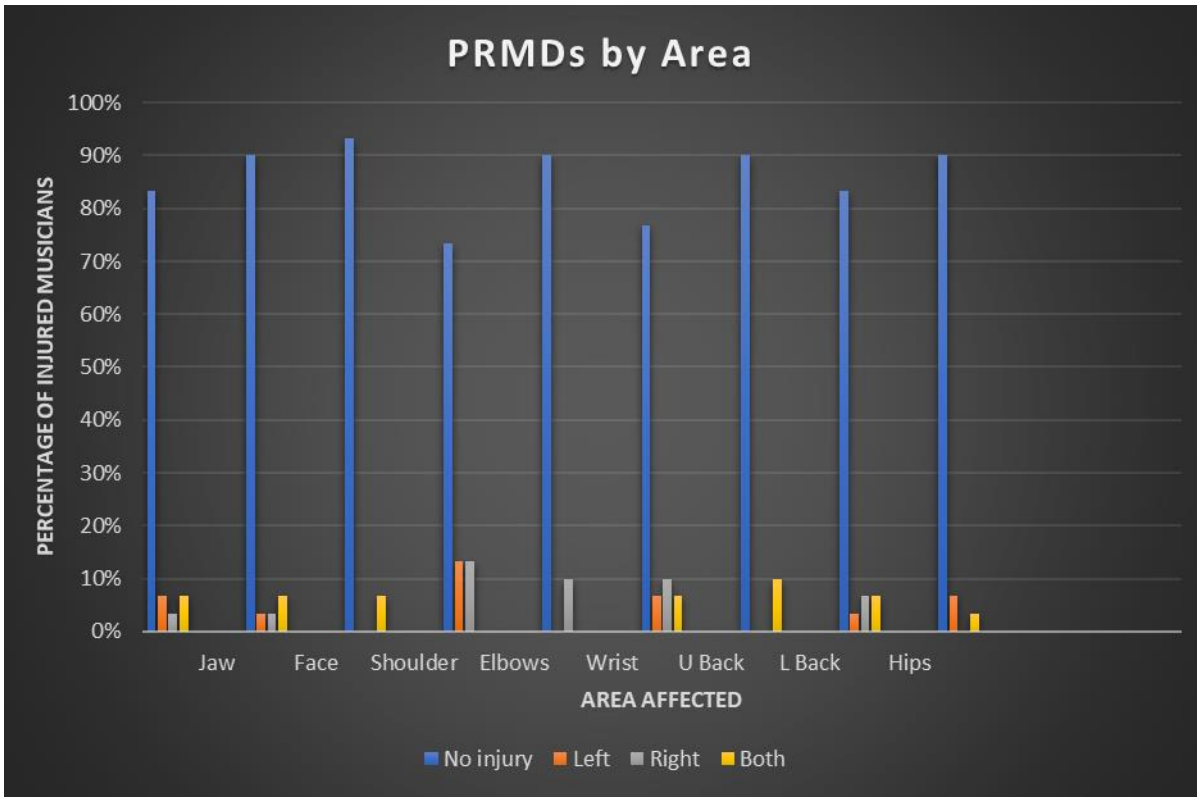


Figure 4.5 Bar graph showing areas of experienced PRMDs

4.4.3 RISK FACTORS ASSOCIATED WITH MSK INJURIES

The most cited risk factors associated with PRMDs were explored in this research. These included:

- Age of the participant
- Age at which they initially started playing their instrument
- Gender
- Race
- Dominant hand
- Smoking habits
- Whether they engaged in physical activities or not
- How they carried their instrument
- Awareness of PRMDs
- Orchestral section
- Hours a week spent playing their instrument.
- Whether they did any non-music related work

Fisher's exact tests were conducted to assess whether any association existed between the chosen risk factors and prevalence of MSK injuries. No significant associations between any of the aforementioned risk factors and MSK problems were found.

4.4.4 AGE AND PREVALENCE OF INJURY

The age range with the highest prevalence of injury was the 25–34-year-old range at 66.7%. The second most affected age category were the 65+ musicians (p= 0.650). Figure 4.6 shows the prevalence of injury per age range.

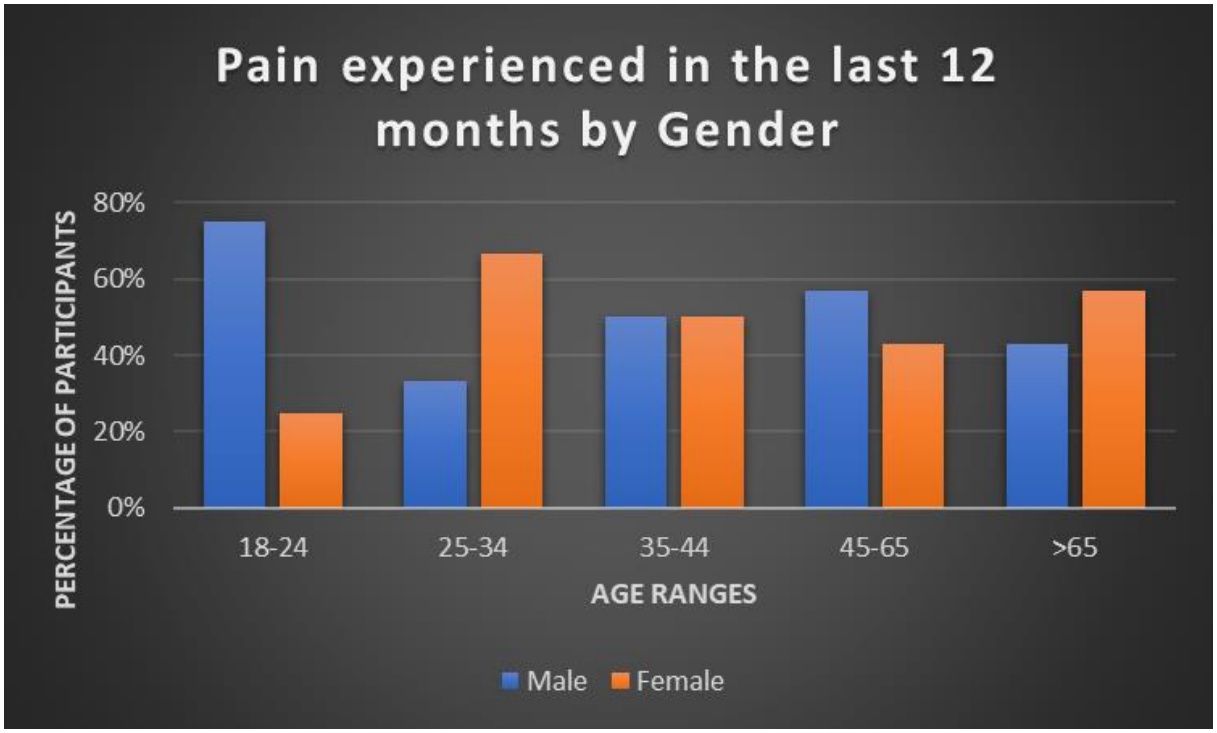


Figure 4.6 Bar graph showing age groups and percentage of pain experienced in the last 12 months

4.4.5 GENDER AND PREVALENCE OF INJURY

Female participants reported injury more than their male counterparts overall. Of the participants who reported an injury in the last 12 months, 33%; n=3 were male and 55%; n=11 were female (p= 0.427).

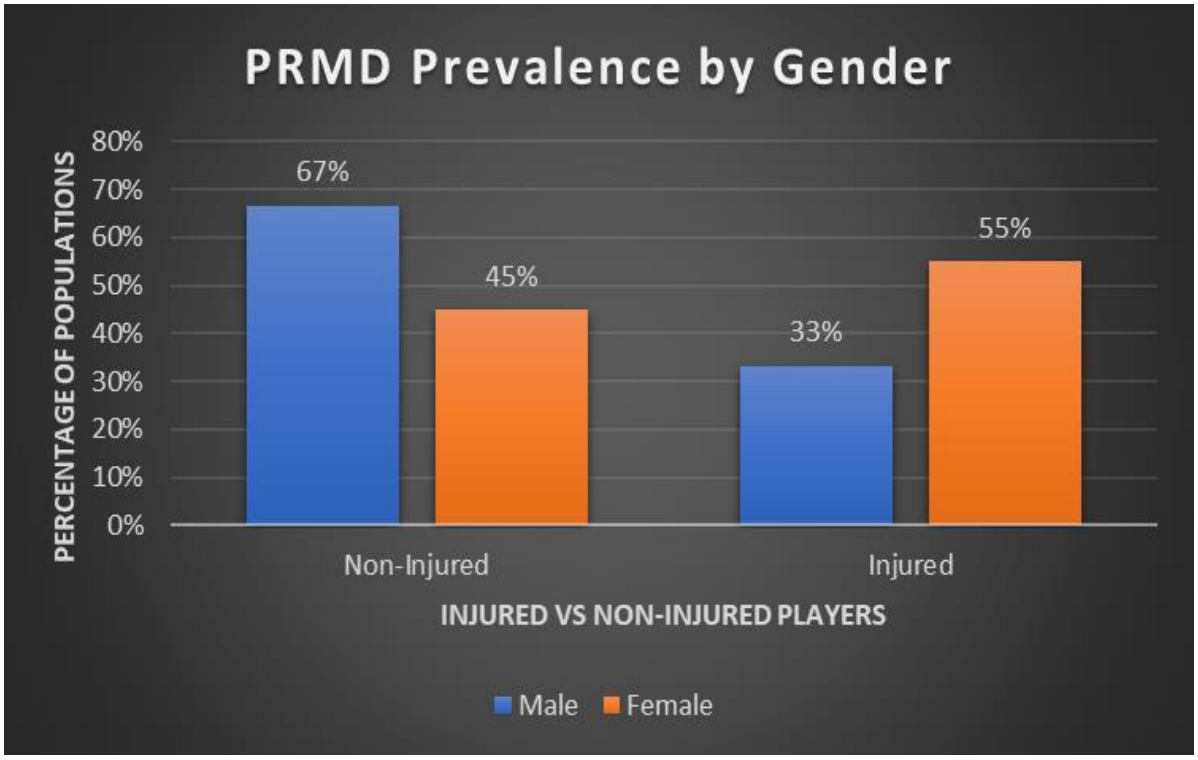


Figure 4.7 Bar graph showing gender and prevalence of injury

4.4.6 HAND-DOMINANCE AND PRMD

The data showed that the majority of the musicians were right-handed (90%; n=27) and 46% of the right-handed players reported injuries (p= 0.724). The only left-handed player also mentioned having PRMDs.

4.4.7 SMOKING AND PRMD

The results showed that both of the smokers in the sample reported PRMD presence. However, no significant association was found between their smoking and risk of acquiring PRMD (P= 0.209).

4.4.8 PHYSICAL ACTIVITY AND PRMD

The results showed that the majority of the musicians engaged in regular physical activity (63,3%; n=19). Of those who engaged in regular physical activity, approximately half (47.4%; n=8) experienced MSK symptoms. No significant association was found between exercise and PRMD prevalence (p= 1.000).

4.4.9 AWARENESS OF PRMDS

Two thirds (73,3%; n= 22) of the orchestra indicated that they had knowledge of PRMDs prior to the study. Amongst those who were aware of PRMDs, there was a prevalence of injury of (54.5%; n=12), while those who were not aware had a prevalence of (25%; n=2). Most of the PRMD information was gained via lecture format. It was determined that there was no significant association between those who were aware of PRMDs and those who had received preventative information on the prevalence of PRMD (p= 0.226).

4.4.10 CARRYING OF THE INSTRUMENT

One of the questions asked of the respondents required them to detail the way they carried their instrument. The options were by strap (on either shoulder), on their backs, by handle (in either hand) or pulling it on wheels. The results showed that the musicians carried their instruments most often by handle, and in their right hands, (n=19). Secondly, they carried their instruments by strap on the left and right shoulders equally (n=10). Of the musicians that reported PRMDs, those that carried their instruments by handle in their right hands reported pain most often (n=11). Another finding was that those who carried their instruments on either shoulder were also more prone to PRMDs (n=5 for left and right shoulders). No significant association was found between the method of carrying the instruments and the risk for contracting a PRMD. Right shoulder (p= 1.0), Left shoulder (p= 1.0), Back (p= 0.209), Right hand (p= 0.260), Left hand (p= 0.175), wheels (p= 0.485). Figure 4.8 graphically shows how the respondents carried their instruments by gender.

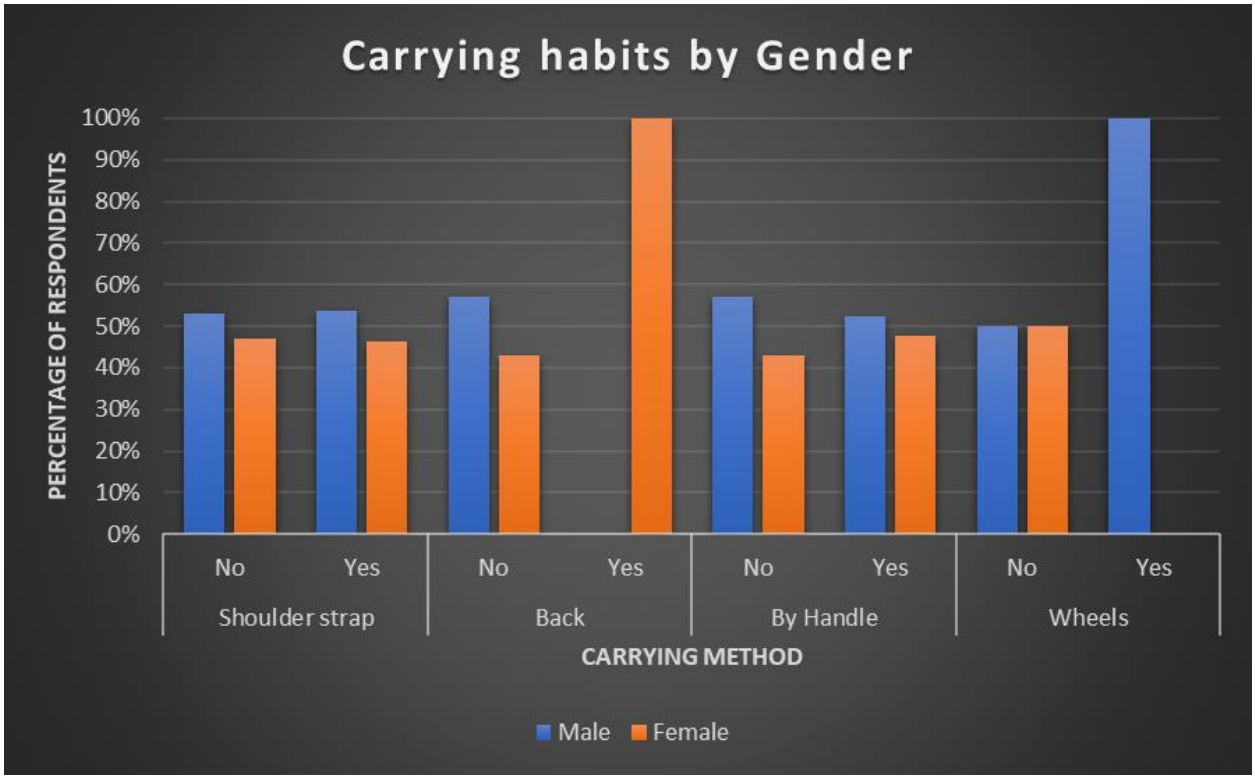


Figure 4.8 Bar graph showing carrying habits by gender

4.4.11 PRACTISING HABITS

Participants were asked to detail their habits before playing their instruments. Questions asked included:

1) Do you practise technical exercises specifically for your instrument?

2) Do you physically warm up without your instrument before a practice session?

3) Do you warm up on your instrument before a practice session?

Slightly less than half of the musicians practiced technical exercises on their instruments (n=43%). Almost all, (n=93%), of the orchestra admitted to not physically warming up prior to practicing their instruments. However, more than half of the orchestra stated that they warm up on their instruments before playing (n=57%). No statistical association was found between any practice habits and PRMDs (p= 0.209).

4.4.12 BREAK TIME

A question regarding whether the musicians felt that they had adequate break time was posed. The respondents who said they did not receive enough break time were all male (n=3). To those who responded yes, the distribution was 48.1% to 51.9%

male to female respectively. No association was found between duration of breaks and prevalence of injury (p-value= 0.228).

4.5 IMPACT OF MSK INJURIES

The 14 participants who had experienced MSK injuries due to playing in the last 12 months were selected for most of this subgroup analysis.

4.5.1 Main occupation

Of the subgroup that was analysed, nine of the respondents were involved with music on a professional basis (30%). Majority of the orchestral participants had main occupations that were non-music related (70%; n=21). Seven participants were music teachers by profession, one participant was a full-time performer, and one of the respondents was a music student at university level.

4.5.2 HOURS SPENT PER WEEK PLAYING IN THE ORCHESTRA

Participants were asked to give an estimate of the number of hours they spent playing an instrument per week. Majority of participants, (77%; n=23), spent between 1-5 hours a week playing. Only two participants (6,7%) spent in excess of 16 hours a week playing.

Figure 4.9 Bar graph showing average hours spent playing per week and gender

4.5.3 WEIGHT, BMI AND PRMD

Of the respondents who stated they had experienced PRMDs within the last 12 months, their average weight was 75.14 kgs with a BMI of 26.89, while those who did not report PRMDs had an average weight and BMI of 76.3 kgs and 26.27. No significant association between the prevalence of injury and the participants weight (p=0.812) or BMI (p=0.678) was found.

4.5.4 FINANCIAL LOSS DUE TO MSK INJURY

Participants were asked their income from playing or being in the orchestra, and from other combined non-music related work. They were also asked how many days of their career they had lost due to injury, and how much money they had lost to injury over their lifetime.

None of the respondents had lost any income due to their injuries. The average music-related amount earned among participants was in the R15 000- R19 000 range.

4.5.5 ANXIETY RELATED TO MSK INJURIES

The question “How often do you worry about getting a MSK injury?” was posed to assess whether the musicians felt anxiety towards acquiring PRMDs. Six participants reported either an absence of worry or that they only worried about it seldomly. High level of worry was experienced in a similar number (n=5) of respondents. Three of the participants did not respond to this section.

4.5.6 FREQUENCY AND NATURE OF THE MSK PROBLEM

Participants were asked how often their pain was present as well as when the pain was at its worst. The frequency of pain presentation ranged from occasionally, usually to always, while the times when it was at its worst ranged from during playing, to after playing, or during and after playing. Figure 4.10 shows the frequency with which the injuries occurred. Figure 4.11 shows when the musicians felt their pain was at its worst.

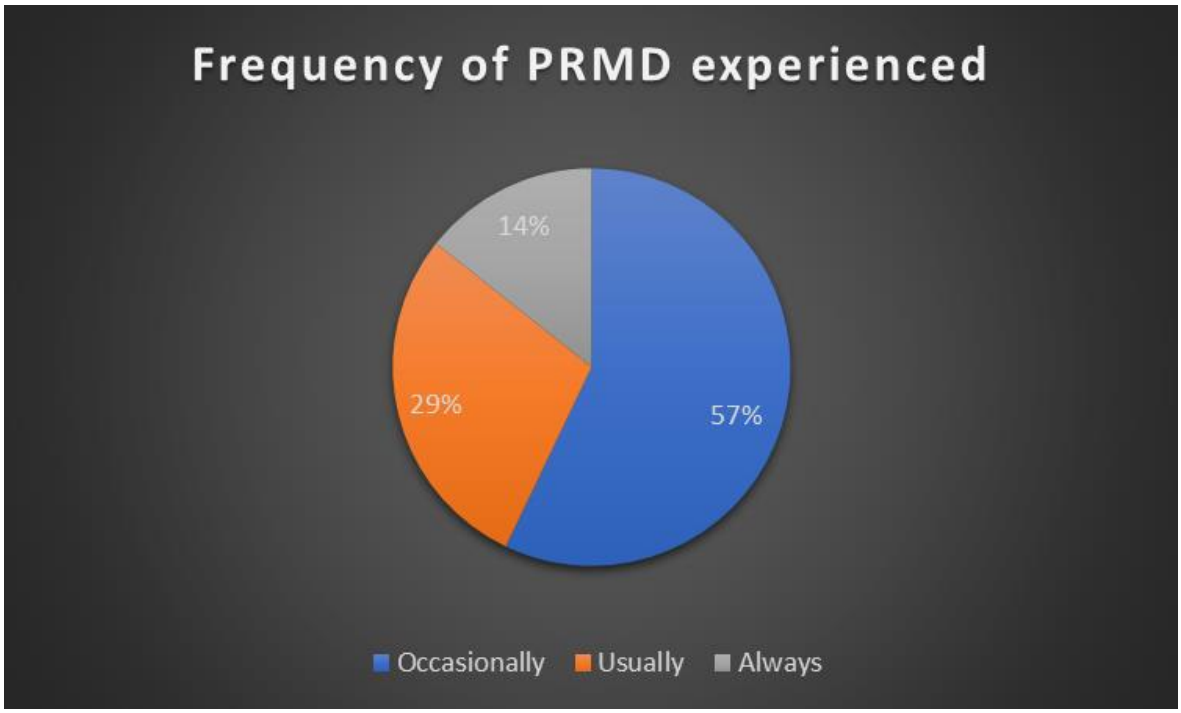
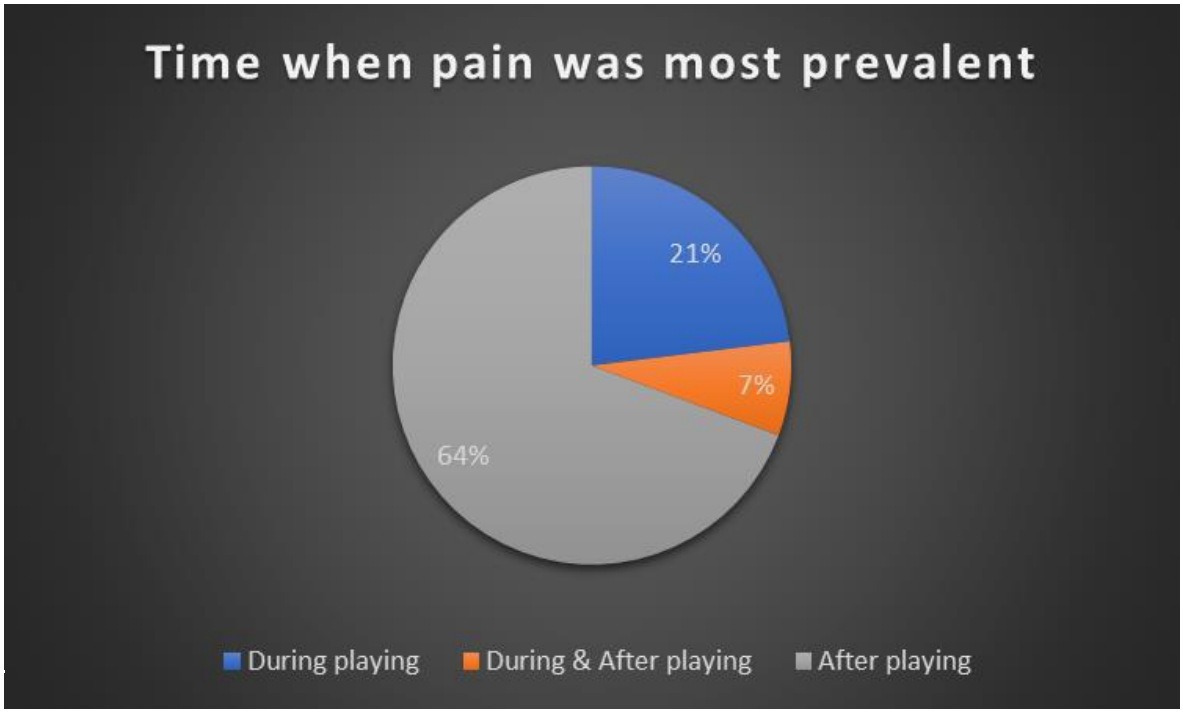


Figure 4.10 Pie chart of PRMD frequency
Figure 4.11 Pie chart demonstrating when pain was most prevalent



4.5.7 MSK INJURY IMPACT AND PAIN LEVELS

The injured musicians were asked to detail the impact of their injuries on their daily lives with the question, “does your problem affect your activities of daily living?”. This question was answered with a majority of the injured musicians (n=11; 78.6%) not

having been affected in any way. Pain in the study was measured using a pain scale that ranged from one to ten. A one on the scale represented the lowest level of pain, while a ten represented the presence of severe pain. When asked to quantify how painful their injuries were on the pain scale, the average pain rating reported was between 3.18 during playing and 4.85 after playing/ doing activities of daily living. The maximum rating recorded was 7 during playing, and 8 afterward. Approximately one third (36%, n=5;) of the participants with MSK complaints stated that they were not playing their instrument as much as they would like to be able to due to the presence of injury or intensity of pain.

4.5.8 CHANGES IN MUSICIANS' HABITS DUE TO PLAYING

Possible ways in which musicians changed their playing habits due to pain were explored. The questions asked included:

1) Have you decreased playing time because of this problem?
2) Have you stopped playing your instrument/s for any time period because of your problem and if so, for how long?
3) Have you changed your playing technique because of this problem, if so how?
4) Have you changed your playing position because of this problem and if so, how?

Of the 14 injured participants, five neglected to say whether they had decreased their playing time. Of the nine participants that answered, seven stated that their injuries had not led them to decreasing their playing time while two stated that it had.
Only two participants stopped playing their instruments altogether for any length of time. One participant had stopped playing for a period of three days due to "hands being too painful to play", while another had not practised for an entire year due to pain.

Of the 14 injured musicians, three had changed their playing technique in one way or another. These changes included changing positions of their fingers or body position to ease pain (Participants 6, 19 and 27), to changing technique of playing such as bowing technique (Participant 27). Participant 19 noted that "trying to relax & not have tension in hands/ wrists or shoulders" was their method employed to try and ensure they did not develop an injury.

4.6 PLAYER PERCEPTIONS

The participants were asked whether they considered PRMDs a serious problem or not. Almost half (47%; n=14) of the population answered in the affirmative. They were given the chance to elaborate on their answer if they answered yes.

The main reason given was that pain in any area of the body would result in difficulty playing the instrument. Some expressed that the pain would be serious for professional players as it could lead to unemployment, loss of income or being ostracised in their career, especially if the injury was chronic. For example, Participant 6 commented on how PRMD's affect their career and ability to make a livelihood "I can't have a career as an orchestral player because of the pain I get after 30 minutes of playing. I also struggle with playing gigs, which would contribute to financial gain. I need regular visits to the chiro to just be able to function through the chronic back pain". Participant 20 commented on how the presence of PRMD's can be scary when they commented, "Pain can stop you from functioning, ie, you can be too sore to play. Very scary when it is your livelihood! Also, when you are older, you are stiffer and you don't recover as quickly as you do when you're young – so it is important not to overdo practice and build up playing slowly to avoid injury as much as possible". Participant 10 observed that PRMD's can also cause stress and said that "any shoulder issue or hand issue can cause extreme pain or stress and make one not want to play".

The musicians had a variety of views on the matter. Another observation that the musicians had was that it impacted their ability to participate in a beloved activity. Participant 30 in particular mentioned that "Pain prevents people doing what they enjoy most. Players should be able to express themselves musically without having to suffer through some sort of pain".

4.6.1 COVID-19

The participants were asked an open-ended question pertaining to COVID-19 and whether it had changed any aspect of their playing or affected them in any way. The answers that were received were varied. Most players felt that COVID took away valuable practice and playing time as an orchestra. The lockdowns also had the

knock-on effect of taking away opportunities for them to practise for and play at concerts together as well. A few noted that they weren't able to teach their instruments, nor play at retirement facilities to entertain older people. The lack of concert performance led to decreased motivation among the players with a corresponding drop in attendance numbers of musicians. This was also attributed to musicians testing positive for COVID-19 and having to miss practices, being too tired to play music post-COVID or not returning to play in the orchestra at all. The silver lining to lockdown was the increase in ability to have at-home practice and the opportunity to hone their music skills and self-correct any technical problems. As stated by a career professional in the responses, musicians' incomes were also stifled, as any opportunity to make money from performances were hindered by lockdowns.

Instrument specific concerns were also voiced. A respondent mentioned that certain sections could play their instruments and wear masks, while other sections, like the woodwind and brass sections, could not. Those unable to wear masks experienced anxiety as they worried that it may increase their chances of becoming ill. This was worsened by concerns over the nature of saliva during the process of playing. Humorously, a clarinet player mentioned how advantageous face masks were as they allowed them to make a cushion for their chin against their clarinet which prevented chafing experienced while playing their instrument.

Of the 30 respondents, only three felt that COVID-19 had had no effect on them. The vast majority had felt some kind of impact from the incidence of COVID-19. This mostly centred around lost playing time with the orchestra, lost rehearsal time and on the other hand, increased time to play from home.

4.6.2 OPINION QUESTIONS

This section was to determine player's perceptions on common attitudes, mannerisms and habits that are prevalent in musicians. As this was opinion based, it was emphasised that there were no correct or incorrect answers. Participants had to rate the degree of their opinion on a Likert scale.

The statements that the players agreed with on average were:

- I would stop or decrease my playing time if I have pain.
- If I had a playing related problem, I would tell my colleagues because they would understand, and might be able to help
- Playing music and experiencing some form of stress, (stage fright, shaky bow etc.) go hand-in-hand.
- Stress affects me and my playing.

The statements that the musicians were mostly neutral on were:

- Musicians should play through pain.
- Musicians who have playing-related pain, must be doing something wrong in their playing
- The stressful environment that comes with making music is a problem in the music community.

Lastly, the statements that the musicians mostly disagreed on were:

- Pain is a normal part of playing and should be expected
- You have to experience some pain when you practise if you are going to improve

Figure 4.12 depicts the median score for each question asked.

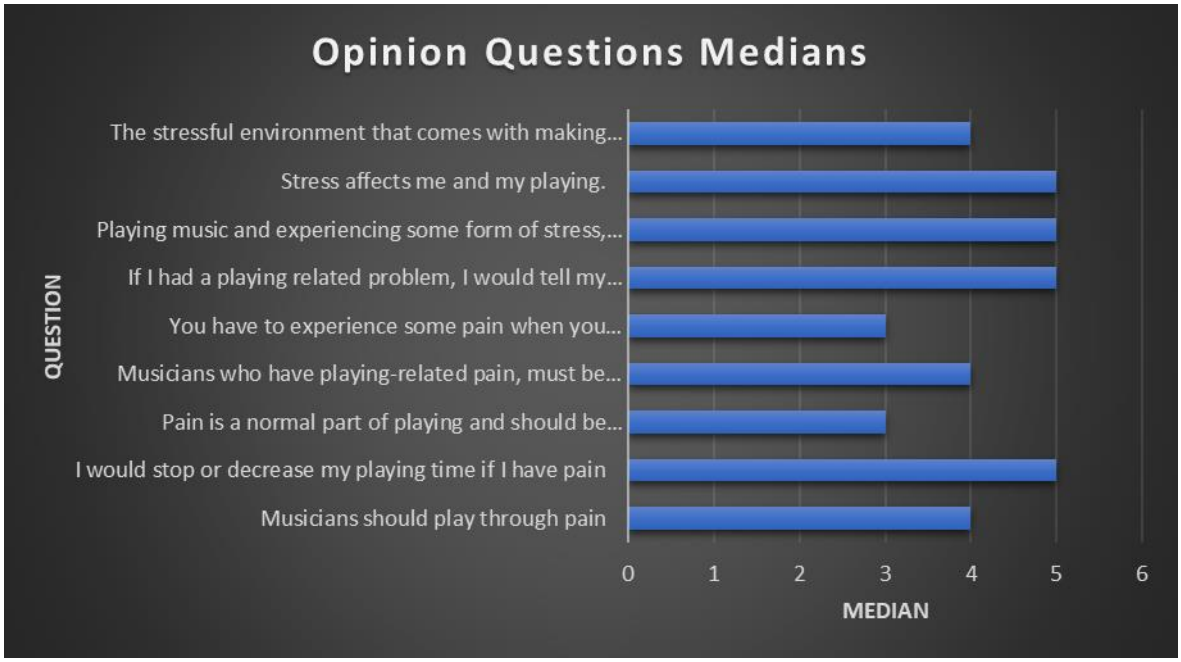


Figure 4.12 Bar graph showing medians of various opinion questions

4.7 CONCLUSION

The prevalence of playing-related MSK injuries was 46.7% for the past year and 40% currently. No associations between any risk factors and MSK injuries were detected in the study. Due to the relatively small sample size, it is suggested that this study be used to determine trends present in this population of musicians. Until a larger study is performed, it cannot be seen as representative of most musicians in KZN, or in South Africa.

5 CHAPTER 5- DISCUSSION

This chapter will discuss the results detailed in Chapter 4. The results will be analysed and compared with results from similar studies locally and abroad.

5.1 DEMOGRAPHICS

Response rate

Due to the small population of orchestral performers in the selected orchestras, the researcher endeavoured to target all performers and have a response rate of 100% of the sample size while gathering data. The researcher was present physically on the day of data collection to distribute questionnaires, answer questions and clarify any misunderstandings regarding the questionnaire. The sample size was originally set at 90 players, based on the number of players listed on the website of the orchestras. However, upon starting data collection, the size of the orchestras was significantly less than estimated due to the complexities that COVID-19 introduced such as illness, fear of contracting the disease and possible deaths in the orchestras. As such, the combined size of both orchestras was numbered at 55 (25 from Pietermaritzburg City Orchestra and 30 from Durban City Orchestra). 16 of the respondents were from the former and 14 from the latter. The revised total response rate of the study was therefore 54,5%. This sample size and response rate fall within the response range of 26-99% established in a systematic review by (Kok *et al.* 2016). Additionally, the response rates of similar studies conducted in South Africa were 34% in a study by Hohls', 41.67% in a study conducted by Ajidahun, in 2013 and 40.9% in a 2017 study (Hohls 2010; Ajidahun and Phillips 2013; Ajidahun *et al.* 2017). These studies were all conducted amongst orchestral musicians in South Africa. Hohls (2010) and Ajidahun *et al.* (2017) both focused on string players in South African orchestras while Ajidahun and Phillips (2013) included all instrumentalists.

Age

Most of the respondents that reported musculoskeletal injury fell within the 18-24 age range, as depicted in Figure 4.8. This finding was analogous to findings by Cruder *et al.* (2019), van Selms *et al.* (2020) and Rodríguez-Gude, Taboada-Iglesias and Pino-

Juste (2022), who all found younger age to significantly be associated with injury. This may be due to less experience with instrumental techniques, leading to an increased frequency of injury (Brandfonbrener 2009). This age group is also more likely to take exams and assessments, leading to temporary increases in playing time and intensity (Abréu-Ramos and Micheo 2007). The younger group are also more likely to have played instruments for a shorter period of time and may be yet to adopt correct postures or become accustomed to playing their instrument (Abréu-Ramos and Micheo 2007). Contrary to this study's findings were the results in the studies of Baadjou *et al.* (2016) and Marić *et al.* (2019) who found that PRMDs were most prevalent in participants 40 years of age and older.

It is worth noting that the 45-65 years and over 65 years age range were found to have a low injury rate, despite a combined percentage of 44% of male respondents and 50% of the female participants. This is distinctive because other studies (Abréu-Ramos and Micheo 2007; Kok *et al.* 2016) have reported that the age ranges most prone to injury were 22-29 and 50-61. This high rate of injury found in the aforementioned studies in the 50-61 years category could be due to the older participants in the population who were most likely to be section leaders in the orchestras and have employment outside the orchestra that could predispose them to other risk factors for injury. Moreover, older people are more likely to heal slower or in a more incomplete manner (Rodríguez-Gude, Taboada-Iglesias and Pino-Juste 2022). In the study, only eight participants were employed in a musical capacity full-time. The rest of the participants had non-musical jobs primarily. This would greatly reduce the amount of time that the respondents would be playing overall and would be protective for injuries.

5.1.1 GENDER

In the study, two thirds of the respondents were female. This is comparable to Cruder *et al.* (2020) where the female population made up 61.4% of their respondents in a study of European music students, and Kok *et al.* (2013b) who had a higher female response rate at 73.8% amongst a study comparing music students to non-music students. This was however in contrast to Holst, Paarup and Baelum (2011) as well

as Sousa *et al.* (2017), where males represented a higher percentage of the population in the orchestras they researched. It is possible that females had a higher turnout in this study than males due to the fact that it has been hypothesised that women are more willing to participate in research, and also more likely to engage in community services (Otufowora *et al.* 2021). It is interesting that in general, the literature shows that males display increased participation in orchestral activities when compared to females. In a study by Sergeant and Himonides (2019), 40 orchestras were surveyed and majority of the Principal and co-Principal seats were held by men. Likewise, an article published on the Quartz website found that of the more than 2000 musicians included in their research, 69% of them were men (Quartz 2018). Additionally, the instruments played were divided along gender lines with only the harp being 94%, or almost exclusively, female-played. In this study, 50% of the string section were female but 82% of the woodwinds were female, showing an overwhelming majority of the woodwind respondents. Furthermore, it shows that the respondents in this study were also divided among gender lines and influenced the injury rate being higher in females. This also shows the link to how some instruments are more prone to causing injury than others such as the flute and violin (Baadjou *et al.* 2016). This is due to the asymmetric way that they're played (Nyman *et al.* 2007; Sousa *et al.* 2017; Yang, Fufa and Wolff 2021). Of the ten female string players in the study, eight were violin players and of nine woodwind players, five of them were flautists.

In this study, 55% of the injured musicians were female, 33% of injured respondents were male with the remaining 11% non-binary. Rotter *et al.* (2020) found that 10 out of 12 of the studies included in their systematic review showed a higher prevalence of MSK complaints among women. This is in line with the findings of Ajidahun *et al.* (2017), who found that female gender is significantly associated with the presence of MSK problems. This study however found no statistical significance between gender and the prevalence of MSK problems. Findings by Kaufman-Cohen and Ratzon (2011) and Guptill, Zaza and Paul (2000) detected: no difference in injury rates between the two genders, and where there were differences noted, these were not statistically significant. A possible reason for most of the injured musicians in the study being female may be due to more females having responded than males.

Furthermore, sample bias cannot be ruled out. Sample bias, or selection bias, results from any mistakes made when choosing study participants, as well as from variables influencing study participation (Tripepi *et al.* 2010). Other than personality traits, interest in the research topic can be a decisive factor when considering participant involvement. For example, a study by Nuzzo (2021) found that females were more likely to participate in research on social psychology and pre-school training. When considering the number of females that participated in this research, it may be worth considering the factors that make females more likely to participate in research.

In current literature, another one of the hypotheses that have been put forward to explain females suffering from PRMDs more than men was reported by (Marić *et al.* 2019). They opined that anatomical and hormonal differences may also be an important factor behind the different prevalence rates between the genders.

5.2 THE POINT AND PERIOD PREVALENCE OF MSK INJURIES AMONG ORCHESTRAL MUSICIANS IN KWA-ZULU NATAL

The data showed that the annual prevalence of PRMDs in the two orchestras was 46.7%. The point and one month prevalence were both 40%. These findings indicate that, at the time of data collection, the injury rate in the musician group was relatively low. The results of the study are comparable to historical lifetime PRMD prevalence rates in older studies which were found to be between 32-87%, as well as the findings of more recent research which found the rates to be between 44.7-93% (Zaza 1998; Bragge, Bialocerkowski and McMeeken 2006; Jacukowicz 2016; Kochem and Silva 2018). The relatively low injury rate could be explained by the COVID-19 pandemic and the resultant effects on practising. The respiratory and highly contagious nature of the virus, as well as regulations imposed by the government, meant that musicians could not practise as often as they wanted to. Because rehearsal time is correlated with musicians' PRMDs, COVID-19 average playing time reduction probably resulted in lower injury rates, or the decrease in severity or resolution of repetitive strain injuries. (Yang, Fufa and Wolff 2021).

All the prevalence rates found in this study were markedly lower than those from other similar African studies. For example, a study of Nigerian string players found a

prevalence of injury of 82.4%, and a South African study of string players recorded a prevalence of 77% (Victor *et al.* 2016; Ajidahun *et al.* 2017). These studies were conducted pre COVID-19 and, as such, were more likely to consist of orchestras that were practising the usual amount and with the full complement of players.

While musicians have been compared to athletes in literature, they have also been identified as being a special population deserving investigation into their specific difficulties (Cruder *et al.* 2018). In light of this observation, a larger data set would be favourable in order to more accurately observe any trends and correlations. Professions with comparable job conditions and activities to musicians, such as those with repetitive actions required to do the job, awkward postures, long working hours or incorrect ergonomics show an increased prevalence of injury, which is unlike the findings of this study. A study conducted in Ethiopia on informal hairdressers found that the prevalence of musculoskeletal disorders in the last 12 months was 70.2%. The physicality of the job, education level of the hairdressers and amount of time spent standing per day doing hair were the factors with the strongest association with injury (Mekonnen *et al.* 2020). Dentists in Saudi Arabia were likewise found to have a work-related musculoskeletal disorder rate of 70%, with primary risk factors being female gender, duration of the dental appointment and years practicing. Furthermore, a similar prevalence rate of 70.2% was found in Nigerian School teachers where unfavourable chair ergonomics, lifting of children improperly and repetitive mechanical loads were the main causative factors (Meisha *et al.* 2019; Ojukwu *et al.* 2021). Highest of all was the injury prevalence of physiotherapists in Iran (94%) who had musculoskeletal disorders and were particularly prone to injury if they performed repetitive movements and had long treatment sessions (Rahimi *et al.* 2018).

South African populations have also been shown to have high injury rates. Most of the workplace injuries acquired by rehabilitation unit nurses are musculoskeletal in nature as. their characteristic duties leave them vulnerable to injury. These include helping patients of all sizes change position or lifting heavier patients, combined with maintaining an unnatural bent forward posture to execute their duties. These actions resulted in more than half of the population experiencing musculoskeletal complaints

(Brien *et al.* 2018). Moreover, almost all (99.1%),of dentists surveyed in Kwa Zulu-Natal reported musculoskeletal disorders at one or more sites on their body (Moodley and Naidoo 2015). The ergonomics characteristic of dentists, biomechanical and work environment factors inherent to dentistry (including psychosocial factors), were the contributing factors. Additionally, a 2019 study of Chiropractors in eThekwini found that the practitioners had a lifetime prevalence for injury of 69% (Lamprecht and Padayachy 2019)). The risk factors highlighted in the study were routine duties such as positioning the patient for treatment (which caused awkward postures), performing adjustments on patients and maintaining prolonged, unnatural positions. All of these professions with similar injury rates show that the shared risk factors are the common factor.

Areas most affected by PRMD

The findings of this study revealed that left and right-side shoulder injuries were the most injured areas on the respondents' bodies. Wrists, particularly the right wrist, were the second most injured. Bilateral neck and bilateral lower back injuries were also injured more than the other listed areas. These findings are in concurrence with studies conducted by Jacukowicz (2016), Leaver, Harris and Palmer (2011), Paarup *et al.* (2011), Steinmetz *et al.* (2014) and (Marić *et al.* 2019); all of whom had found these areas to be the most injured in musicians, regardless of the instrument played. A feasible reason for the consistent injury to these areas is that they are the areas that are most involved in music making. For example, trombone players rest their trombone on their left shoulder, and operate their slide with their right arm. If the trombonists arms aren't long enough, there may be a little involvement of the right shoulder in order to play the instrument. Flautists play with their flute held aloft for long periods of time, keeping their arms and shoulders abducted. Violinists and violists also all rest their instruments on their left shoulder and operate the bow with their right arm, which is also a position that causes their instrument to be held in the air for extended periods of time. Elevated arm postures was the focus of research by (Nyman *et al.* 2007) and Gasenzer *et al.* (2017), who concluded that instrumentalists that play in that position are twice as likely to suffer from shoulder pain than instruments that are played in more symmetrical or neutral positions. Also, 90% of

the respondents were right-handed. It is probably another reason that Right-side upper body injuries were so prevalent.

Mobile, pain free wrists are also necessary in music making. This is especially true when playing fast or repetitive passages in music (Kaur and Singh 2016). Accordingly, this research found that wrist pain was the second most injured area. This aligns with (Steinmetz *et al.* 2015) who found that left wrist pain was particularly prevalent in string players. Pianists playing or practising long passages that have loads of tremolo, for example, may experience wrist pain at the end of the practice. Smaller note divisions such as semiquavers, demisemiquavers and hemidemisemiquavers require rapid changing of playing positions to achieve. Many instrumentalists, including guitarists, the string section in general, trombonists, clarinettists and harpists are among those that have more wrist involvement and would be impacted by injured wrists.

Upper and Lower back pain were also noteworthy areas reported by the respondents in the study. Jacukowicz (2016) found that upper back pain was one of the notable injury areas, while Steinmetz *et al.* (2014), Marić *et al.* (2019) and Rodríguez-Gude, Taboada-Iglesias and Pino-Juste (2022) found either lower back or upper and lower back to be the problem areas. Back pain was also the most frequently painful area of the body in South African rehabilitation nurses, followed closely by their shoulders (Brien *et al.* 2018). Like nurses, musicians who stand for prolonged periods and play in unnatural postures experience this particular pain pattern. Lamprecht and Padayachy (2019) also noted that lower back pain was one of the areas of complaint reported by Chiropractors in the eThekwini region. For musicians, prolonged postures of sitting or standing are a normal part of the orchestral experience. However, postural factors such as these are known risk factors for musician's injuries and are a likely factor in this study (Yang, Fufa and Wolff 2021).

Ergonomics

There were disparities in the frequency of injuries between the various ways in which musicians carried their instruments. Work ergonomics are an important factor to consider when it comes to frequency of work injuries. As such, the respondents were

asked whether they carried their instruments by strap on either shoulder, in a bag on their back, by handle in one hand or pushed/pulled their instrument on wheels. This study found that those who carried their instrument by the handle in one hand or the other reported the most PRMDs. This is likely due to the asymmetrical strain on the musculoskeletal system, with associated compensatory mechanisms (REF). The asymmetrical strain theory reinforces similar findings by Lamb and Cook (2002) and Hohls (2010), who support the notion that work ergonomics should be considered in musician's lives. Factors such as the carrying of their instrument would be part of their occupational ergonomics. Those who carried their instruments by shoulder strap were also at increased risk of injury, although the injuries were evenly distributed between both shoulders. A possible reason for this is the impingement of the rotator cuff, which could cause shoulder pain. The carrying of instruments by wheels or on the back was least associated with PRMDs, with two reports of MSK injury by each method. When an instrument is carried on a musician's back the weight of the instrument is carried by larger muscle groups and even distributed which could account for the low rate of injury. By contrast, transporting instruments via wheels puts little strain on the musculoskeletal system and rather transfers the weight of the instrument to the case.

Frequency of injury

The respondents in the study were asked to describe how frequently they experienced PRMDs and to state if the pain was experienced occasionally, usually or always. Of the 14 injured respondents, eight experienced pain occasionally, four usually experienced pain while just two said that the pain was always experienced. This differs from the findings of Yang, Fufa and Wolff (2021) who found that musicians' injuries tended to be chronic. Chan, Driscoll and Ackermann (2013) also found that 46% of the PRMDs reported in their study were chronic injuries with acute injuries being least experienced at 26%. A possible reason for the occasional pain experienced in this study could be the time the data was collected. Kaufman-Cohen and Ratzon (2011) established that the amount of time spent playing may be linked to how frequently musicians experience pain. In addition, prolonged practice times are a known risk factor for musician injury and have been demonstrated by multiple studies (Abréu-Ramos and Micheo 2007; Barton and Feinberg 2008; Rickert, Barrett

and Ackermann 2013; Gasenzer *et al.* 2017).The data collection in this study took place at the commencement of concert season, where practice is less frequent than during concert periods. This was also exacerbated by the COVID-19 pandemic which resulted in less practice time overall for the orchestras. Another consideration is that the musicians in this study potentially underreported their injuries. Musicians have been known to avoid reporting the presence of injuries to colleagues and only start seeking treatment for injuries when the condition is severe. Studies by Rickert, Barrett and Ackermann (2013) and Chan and Ackermann (2014) show that musicians fear shame and contempt should they inform their colleagues about their injuries, as it might suggest that their technique is inferior to others. Kaufman-Cohen and Ratzon (2011) and Yang, Fufa and Wolff (2021) both commented on the tendency of musicians to only seek medical help when the problem was severe, while Abréu-Ramos and Micheo (2007) found that 12% of musicians end their careers early due to being in debilitating pain. The knowledge that musicians are reluctant to be honest about their injuries could therefore also be behind this finding.

Majority of the respondents stated that their pain was at its worst after playing, a quarter during playing, while only a single participant mentioned that the pain was experienced both during and after playing. This finding makes sense as PRMDs are injuries caused by playing instruments and would be exacerbated by repeating the offending movements, leading to overuse syndromes and inflammatory syndromes over time. Fourteen participants indicated that the PRMDs did not affect their activities of daily living. The relatively low response rate could, however, have influenced this finding.

5.3 SELECTED RISK FACTORS FOR THOSE WITH MSK INJURIES PRESENT AMONG ORCHESTRAL MUSICIANS IN KWA-ZULU NATAL

5.3.1 EDUCATION

No correlation between education level of the respondents and injury was found in this study, however the participants with Bachelors of Music were observed to have more injuries than the respondents with other types of musical qualification. These

findings were not however statistically significant. A similar observation was noted by Gasenzer et al. (2017) in that less experienced musicians might not have learned the appropriate playing techniques that would protect them from injury. In this study, of those participants from higher-education musical backgrounds, none had been educated at university about the prevention of PRMDs, but had rather gained information about musician injuries from different informal places. Sources of information varied from YouTube videos to the Internet. Informed respondents reported PRMDs at a slightly lower, albeit not statistically significant, rate than those who had no knowledge of PRMDs prior to the research. Information directed specifically towards musicians would be able to alert the profession about potential injuries, and when to seek medical help, as well as potential treatment options. This supports the need for formal, musician specific injury education for musicians. It should also be noted that persons with higher educational levels are more likely to earn higher salaries, enabling them to access better healthcare.

5.3.2 SMOKING

Only two of the respondents are smokers, representing less than 7% of the participants. This is lower than the current estimation of the percentage of smokers in South Africa of 20% (University of Bath 2021). Both smokers in the study reported PRMDs. Smoking has been shown to potentially increase the likelihood of acquiring chronic pain since nicotine causes the immune system to become activated (Kirsch Micheletti *et al.* 2019). The nicotine itself causes vascular damage that makes people more susceptible to problems like back pain as it speeds up the breakdown of collagen and reduces blood and oxygen delivery. The reduction in blood flow would also delay healing time. Hohls (2010) suggested that smoking was an underrated potential risk factor for the development of PRMDs.

5.3.3 EXERCISE AND FITNESS

A high body Mass Index (BMI), obesity and lack of exercise are known risk factors for musculoskeletal injury. While BMI alone is not a good indicator of health risk, when used with other anthropometric measures it can give useful information about the general health of a person within the BMI categories (Chernenko, Meeks and Smith 2019). In the research, the majority of the orchestra fell within the normal category,

with an equal number being in the overweight and obese categories (Calorie Control Council 2022). The BMI category that had the most injuries were the overweight players, followed by normal and then obese. The research also revealed that 63.3% of the population exercised for more than one hour a week on a weekly basis, which explains the average BMI of the players falling within the normal range. While this study found no correlation between the weight of the participants, their BMI and PRMD risk, other literature links obesity as a risk factor for musculoskeletal injury, while exercise, especially musician-specific programs, are factors that are protective of musculoskeletal injuries (Nawrocka *et al.* 2014; Kenny and Ackermann 2015; Cruder *et al.* 2018; Rodríguez-Gude, Taboada-Iglesias and Pino-Juste 2022). Baadjou *et al.* (2016) conducted a systematic review that looked at risk factors for musicians' musculoskeletal complaints. They concluded that the amount that musicians exercised did not have a bearing on their rate of injury. Their findings mirror the lack of statistical significance found in the study.

A study conducted on 16 000 Radiation Therapists found significant association between MSK injury, obesity and a BMI of 30 or higher, as well as an association of decreased risk in those who exercised regularly (Hanania *et al.* 2020). Considering the fact that obesity is frequently linked to injury, it is interesting to note that the obese players did not report more injuries. Looking at the injuries that were experienced by the overweight and obese players, it was revealed that the obese players played string and woodwind instruments, namely the violin and the clarinet, while the overweight players played string instruments and woodwind as well. The difference being that the overweight players played more asymmetrical instruments (violin, flute) than the obese players (violin, clarinet). Additionally, a host of musical researchers have made cases for musician-specific exercise programs in order to reduce their risk of acquiring PRMDs (Rickert, Barrett and Ackermann 2013; Steinmetz *et al.* 2014; Kenny and Ackermann 2015; Kok *et al.* 2016; Yang, Fufa and Wolff 2021). The researcher suggests that facts about the link between exercise and reduction of PRMD rates be made available to musicians as part of their musical lessons or in higher-education curriculums.

5.3.4 WARM-UPS AND BREAKS

It has been suggested that, like athletes, musicians should perform a variety of warm-ups, such as playing scales or passages from the music, and practise technical exercises before beginning practice in order to prevent injury. In fact, musicians' literature has found warming-up before practice to be protective of injury for musicians, although the duration of normal practice time should be considered when determining the length of the warm-up (Lederman 2003; Baadjou *et al.* 2016; Kochem and Silva 2018; Matei *et al.* 2018; Stanhope, Pisaniello and Weinstein 2021).

In the results, it was revealed that 56% of the respondents practised technical exercises on their instruments. Roughly 6.7% warmed up for playing using methods that didn't include their instruments and 56% of them warmed up on their instruments before playing. This research showed that those who had practised technical exercises prior to practising reported injuries more than those who didn't. This seemingly contradictory finding could be explained by exploring the manner of the musicians' warm-ups. Firstly, Kaufman-Cohen and Ratzon (2011) reported that, on average, musicians spend ten minutes warming-up before playing. However, if that is all they dedicate to warming up, it may be an insufficient amount of warm-up time based on the duration of their rehearsal or even depending on the repertoire the musicians may be practising/performing (Lederman 2003). Second, PRMD's in general are caused by repetitive motions. Performing the offending movements for a short time before the practice starts, often in a quick or rapid manner, would be more likely to flare-up existing issues rather than warm-up muscles needed for playing and maintaining proper posture. A positive correlation for warming–up causing musicians harm was made by Yoshimura *et al.* (2008) who found a high correlation between warm-up exercises and increasing pain levels.

A possible way forward may include exercises that are tailor-made to musicians, or even ones that are specific to the instrument being played. A technique that exemplifies this is the Alexander technique. Founded by Fredrick Matthias Alexander in 1869, it aims to not only to enhance the quality of the physical actions involved in singing or playing an instrument, but also the music's overall quality by making

musical performances more fluid (Rickover 2023). The Alexander Technique aids in habit evaluation so that people who practise it may determine how their habits impact the overall use of their bodies, and, if necessary, develop new habits that will improve how they use their body. There are several ways in which the Alexander Technique relates to musicians specifically (New York Jazz Workshop 2023). It has been designed to improve one's awareness of their body. This can aid in preventing overuse injuries in addition to aiding in the development of proper posture and playing technique. Additionally, students of the Technique report being able to breathe more effectively. That is especially beneficial for wind players, but more open and free breathing can also aid all musicians in remaining open and free while playing any instrument (New York Jazz Workshop 2023). The fact that it has been specialised to cater to musicians is probably the reason behind the technique's effectiveness in helping musicians.

Taking breaks from practice have also been shown to be protective for many ailments, as well as being part of the treatment protocol for PRMDs (Heming 2004). However, musicians have been known to be a group that are reluctant to take sufficient breaks, whether it's due to injury or just intense practising (Heming 2004; Rickert, Barrett and Ackermann 2013). A 2020 study found that only 4% of the musicians surveyed believed in taking breaks (van Selms *et al.* 2020). Ninety percent of the respondents felt that their breaks were sufficient and most of the participants agreed that they would stop playing their instrument completely or decrease the amount that they played if they were injured. This is at odds with the findings of researchers like Rickert, Barrett and Ackermann (2013) and Chan and Ackermann (2014) who have observed that musicians tend to not prioritise their physical wellbeing.

5.3.5 MUSIC TEACHER/ PERFORMER AND INJURY RATE/ OUTSIDE OCCUPATION INJURY

One of the established risk factors for PRMDs is an increase in playing time or intensity (Greer and Panush 1994; Yang, Fufa and Wolff 2021). Professional performers, university students and music teachers are all alike in that they play more than other musicians who may only play for recreational purposes and may have

greater reason to play for more prolonged and intense periods of time. Teachers will especially be at risk of injury, as not only are they spending more time playing, but some even teach other instruments that aren't their main instrument. This will result in more time spent in non-ergonomic postures and asymmetric limb demands which can lead to injury (Yang, Fufa and Wolff 2021).

The results revealed that the only career music performer and most of the music teachers in the research sample reported suffering from PRMDs. On average, they reported spending more than 16+ hours per week teaching music which was time spent playing, exclusive of their orchestral practices and performances. The nature of their occupation, as well as the demands implicit in their job description in the music field, predispose them to injury more than most other musicians as there may only be one or two teachers in a school who are required to teach multiple instruments to multiple students. When exploring measures that helped musicians recover from PRMDs, Heming (2004) noted that decreases in playing time was an important factor while Yang, Fufa and Wolff (2021) said that professional musicians spend more time practising their instrument and are surrounded by that environment. Almost half of study participants played in other capacities such as in different ensembles or other orchestras, for an average of 1-5 hours per week. Though statistical significance was not noted, those who played in other capacities did report more musculoskeletal complaints than those who did not. This correlation is likely due to longer playing times resulting in injury.

5.3.6 SECTION OF THE ORCHESTRA AND PRMD

There are conflicting opinions when it comes to the section of the orchestra that is most prone to acquiring PRMDs. There does seem to be a general opinion that the string section, especially the upper strings consisting of the violins and violists, are the most prone to injury in the whole orchestra. Kaufman-Cohen and Ratzon (2011) found that 68% of those who complained of upper-limb pain were from the string section. Sousa *et al.* (2017) remarked that the strings had the highest number of complaints per player and Baadjou *et al.* (2016) even commented that the instrument played may be the single most important factor when considering PRMDs. Other studies (Guptill, Zaza and Paul 2000; Paarup *et al.* 2011; Ackermann *et al.* 2014)

have concluded that although the injury rate of the musicians was high, there was no correlation between the sections and the injury rate. In contrast to the more conventional classification of instrument families, Nyman *et al.* (2007) considered it more appropriate to classify the musicians according to posture in their study which examined neck and shoulder pain within the orchestra. Their results revealed that working with elevated arms was linked to neck/shoulder pain, even when the amount of active playing time per workday was brief.

In terms of the findings of this research, it was revealed that the string section had the most reports of PRMD presence, as demonstrated in figure 4.6. Majority of the complainants were violinists (n=6), followed by woodwinds (n=5). The strings also reported the greatest number of areas on the body in contrast to the other sections, with the average number of affected areas being 4 and with one of them even reporting 7 affected areas, reported by a violinist. No statistical significance was found between the section played in and the susceptibility to PRMDs. A possible reason for the higher number of string complaints, when compared to any other section, was that this section comprised slightly more than half of all respondents. This is however representative of the average orchestra where the strings are 50-60% of musicians (Usarov and Ismoilova 2022). Additionally, when asked about how COVID-19 affected musicians, one of the respondents stated that they felt hesitant to return to playing in the orchestra because some instruments (for example the strings) could play while masked, while other sections, (for example the brass and woodwinds) were unable to do so. This reflection may point to a possible reason why ratios in the researched orchestras may not have been as they were pre-COVID-19 and also why they may have encouraged more string players to return to practice than the other sections, possibly explaining why their injury rate was higher than the other sections as well. It is also useful to note violinists are able to practise for longer lengths of time than players of other instruments, such as brass musicians, because they don't experience embouchure fatigue. This, combined with the small and compact form of upper strings, may have enabled them to be more comfortable with playing for longer periods of time.

The section with the second most reported injuries was the woodwinds with an overall prevalence rate of 46% of this section reporting injuries. There were an equal number of flutes and clarinets in the sample (5 players of each). As the woodwinds were the second most injured section, it might suggest that even the clarinettists, who play in a more symmetrical style were contributing to the number of injured players. This would support previous findings that state that no musicians are immune to the development of PRMDs (Brusky 2009).

5.3.7 INCOME LEVEL AND INJURY

The income of musicians has historically been considered as a risk factor that contributes to the development of PRMDs. A respondent in a study done by Rickert, Barrett and Ackermann (2013) mentioned how she would have opted to stop playing in the orchestra if she could afford to do so, due to her health challenges from orchestral participation. The study conducted by Hohls (2010) concurred. He found that the average professional string player was not able to make ends meet on their orchestral salary alone, and therefore suffered from significant financial stress. Similarly, a study conducted by Wolff (2020) found that waitrons with better income had access to better healthcare than musicians.

This study produced similar results. One participant stated that although her playing for the orchestra equated to her husband's job in terms of both skill and working hours, he earned four times the amount she did. The average salary earned outside of the orchestra that was disclosed by the orchestral players in the study was within the range of R15 000-R20 000 per month. However, there were a few whose salary was in the R1 000-R5 000 per month range. These ranges fall slightly below the national average of salaries, which is currently around R24 000 per month, and subsequently may have implications on the ability to access comprehensive medical aid which can be an expensive addition to a family budget (Briefly 2022; Independent Financial Consultants 2022).

A study of German musicians revealed that musicians who work for public symphony orchestras, theatre orchestras, and opera orchestras are employed as public

servants which is rare in the musical space (Gasenzer *et al.* 2017). As state employment is likely to include health benefits, these musicians would have access to free healthcare. This is not true for the South African music population who are responsible for their own private health costs due to the overburdened public health system. As previously noted, musicians have been documented as being a group that is reluctant to seek timeous help for their injuries, financial constraints could exacerbate that behaviour.

5.3.8 WORRY OVER MSK INJURIES

One of the more researched risk factors for MSK injuries in general, including PRMDs, are psychosocial factors. Specific to musicians these can include stage fright, adverse work environments and stress. Stress has been identified as a difficult to define term as it can be described in many ways and mean different things to different people. For this study, stress will be identified based on the responses to the question of whether the participants worried about contracting MSK injuries. Also, the general adjectives used in the answers to the opinion questions will be used to surmise whether they experienced any stress or anxiety.

Almost half of the respondents considered PRMDs to be a serious problem. A response like this is encouraging and differs from findings by authors like Kaufman-Cohen and Ratzon (2011) and Yang, Fufa and Wolff (2021), who had stressed that musicians don't timeously seek out medical help for their ailments. Indeed, in the current study, 18% of the population worried about acquiring PRMDs frequently, showing that their health was of concern to them. Despite this finding, only two participants had decreased their playing time or stopped playing entirely due to their injury.

More than a third (36%) of the population expressed that they were not able to play as much as they would like to due to injury and one of the reasons given was the stress that the pain caused. This mirrors findings by Kenny and Ackermann (2015) who detailed how anxiety and psychosocial stress, among other factors, can contribute to the development of work-related upper arm disorders and that static postures are an exacerbating factor. Most of the players agreed that stress and

playing music go hand in hand and that stress affected their playing. This indicates that problematic beliefs surrounding the environment of the musicians that are perceived as normal still exist.

5.3.9 COVID-19 ANXIETY

The COVID-19 pandemic was a novel experience with emotions that potentially affected the respondents. A study looking at the reactions of musicians and non-musicians to different tempos of music was conducted (Liu *et al.* 2018). The results showed that, while there were no differences between the groups when considering the integrated emotional ratings of the music, the emotional experience of the musicians was stronger than the non-musicians. Musicians are naturally expressive people and are taught how to incorporate expressive devices such as articulation, dynamics and ornamentation to enhance their music (Meissner and Timmers 2020). With research showing that from playing expressively to feeling stronger emotions than non-musicians when exposed to music, it is reasonable to assume that circumstances that would lead to musicians not being able to play music would negatively affect them. Literature that is available on the experiences of people during the pandemic show that most of the experiences were varied to negative. Xiong *et al.* (2020) related that there was a higher prevalence of mostly adverse psychological symptoms that were being exhibited, but that there were variations in prevalence of the symptoms. Interestingly, a 2022 study found that there had been little to no psychological impact on the public during the beginning times of COVID-19 (Hansen *et al.* 2022). The current study posed questions that asked whether COVID-19 had affected their playing experience in any way or affected any aspect of their music playing. The responses varied greatly. Some commented on how their music-making ability was hindered due to lack of opportunities to practise as an orchestra as well as perform. Many responses lamented the ability to do what they loved so much. Upon return to practice, a general lack of enthusiasm was noted by some. The lack of performance opportunities resulted in loss of income for not only the musicians and performers, but the orchestras as well as they are paid to perform at venues. Others had thoughts on the implications of the disease itself and the feelings they experienced regarding the complications for music making. A few participants mentioned that infected players were not allowed to attend rehearsals and that, even

after they had recovered, some players were too tired to participate fully, leading to empty seats in rehearsal and a decrease in the quality of music made. The complexities that surrounded mask-wearing was also detailed by a participant who mentioned that while some musicians can wear masks, others like woodwind players cannot, which worried them. Furthermore, the proximity of the respondent to the saliva of wind instruments, the players of which were seated close by, was a worry for them in the earlier stages of the COVID-19 pandemic.

Not all views about the COVID-19 pandemic were negative, with some respondents finding a ‘silver-lining’ in their situation in that there was more time to practise technical exercises as well as practice in general, thus empowering an improvement in their subsequent playing. A clarinettist noted in jest that the mask that was resting on their chin protected them from the chafing they usually experienced from their mouthpiece. The responses showed how varied the experiences of the respondents were. The effects on the musicians as individuals as well as within the orchestral setting may have been varied as well but tended to be negative in general.

5.4 CONCLUSION

In summary, prevalence of PRMDs in the Kwa Zulu-Natal orchestral population in South Africa is high. No statistical relevance was found for any of the risk factors, but known risk factors such as gender, instrument played, exercise and fitness, length of time sitting, age and warm-ups and duration of breaks taken tended to align with the findings of current literature and were associated with presentation of PRMDs in the orchestras.

6 CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

This study was an investigation into the epidemiology of musculoskeletal pain in Kwa Zulu-Natal orchestral musicians. The point, one month and annual prevalence of injuries were found to be 40%, 40% and 46,7% respectively. The most injured section of the orchestra was the string section with an average of 4 complaints per player. Shoulder and wrist injuries were the most common sites of injury, with the average pain rating being between 3.18 to 4.85 on the pain scale. The musculoskeletal pain was linked to changes and decreases in playing time. COVID-19 led to general loss of practice time, lack of performances and anxiety surrounding the virus and the inability to meet with fellow musicians and practise the activity that they love.

Limitations:

1. Due to data collection being done during the COVID-19 pandemic, the sample size was small. This could lead the results to not be as accurate as a survey that involved more musicians would be. As an example, Figure 4.6 includes a section of the orchestra that has been titled “mixed” due to the fact that there were not enough players in the sample size that could make a full section. Furthermore, only one participant was black in the sample. As South Africa has a large population of black, Indian and coloured people, it would have been beneficial to have a larger variety of the population represented. Furthermore, the literature shows that most orchestras are comprised of a majority of male players, which wasn’t the case in this research. This is probably also due to the size of the sample.
2. Specific definitions for terms such as “injury” might have been interpreted differently by the respondents. This could have led to some respondents not reporting their ailments as they might not have considered their symptoms to constitute an injury.
3. The results might have been impacted by recall bias, as the respondents might not have remembered their injuries when asked about the 12-month incidence of injury. This could have led to a lower prevalence than the true prevalence.

4. Only two of the 3 orchestras participated in the study. The orchestra that declined to participate was different to the other 2 as they are comprised of majority career musicians. The inclusion of this orchestra would have provided a more holistic view of different musicians in Kwa Zulu-Natal. Further, orchestras in the other provinces were not included which could have enabled a comparison with results within the country. Inclusion of the other provinces might result in the results being more representative of the true picture of musicians in the country.
5. Data collection was done only once during the year. As musicians have concert seasons, it would have been advantageous to collect data at least twice to be able to compare the injury rates during different times in the musicians' calendar.
6. Only musicians who were present on the days of data collection were able to participate in the study. This could have led to a slightly decreased respondent rate.

6.2 RECOMMENDATIONS

It is recommended that music programmes and degrees in South Africa implement specific training regarding the risk factors for the development of PRMDs as well as preventative measures. This includes basic information on the player's anatomy, the biomechanics of their instrument and correct ergonomics for their instrument, such as recommending healthier ways to carry their instruments, coupled with musician techniques like the Alexander technique. More research should be done regarding optimal times that should be spent on warm-ups and minimum recommended break times. Further studies on the musicians should be undertaken during both on-peak and off-peak performance periods to be able to get a better holistic picture surrounding musicians' injuries. This research was collected during the COVID-19 pandemic. As such, the musicians may not have been practising as often as they usually do; leading to potentially inaccurate results.

Furthermore, larger sample sizes are recommended as well to be able to draw statistically significant conclusions on risk factors. Further studies on risk factors unique to the South African environment would be advantageous as well. Other

musical populations should also be explored such as student and school orchestras and bands, as well as the specifics of South African music students and their risk factors.

Appendix A

LETTER OF INFORMATION

Title of the Research Study : An Epidemiological study of Musculoskeletal pain in Kwa Zulu-Natal orchestral musicians

Principal Investigator/s/researcher: Linley Muhondo (M. Tech. Chiro student)

Co-Investigator/s/supervisor/s: (Yasmeen Thandar, B. Pharm MMedSc (Clin Pharm) PhD (Pharmacology)) Supervisor, (Colette Kell, M. Tech Hom) Co-Supervisor

Brief Introduction and Purpose of the Study:

There is a high incidence of player-related musculoskeletal injuries amongst orchestral musicians. Studies that have been done previously have found that no specific sections of the orchestra are immune to the chances of developing a playing-related injury. Studies also show that these musculoskeletal injuries can have a significant impact on musicians' lives and livelihoods, as an injured player cannot practice or perform and therefore cannot earn money. There is also a scarcity of literature representing South African Orchestras, with only 3 studies having been done in the last decade.

Good day and thank you for taking the time to read this document of information. I am a 6th year student at DUT doing this research to complete my Master's degree in Chiropractic. I would like to invite you, as a potential participant, to participate in my research and grow the body of research available on musicians internationally, and more importantly, locally in South Africa. My research consists of one questionnaire, which you will answer anonymously, and then put into the box labelled Questionnaire. Take your time reading the questions and

please attempt to answer every question in the questionnaire to make the data as valid as possible. If there are any questions you don't understand or know how to answer, please feel free to ask me right away and I will clarify things for you. This letter of information is for you so feel free to take it with you.

Outline of the Procedures: If you agree to participate in this study, you will be required to sign an informed consent form, after reading this letter of information, and answer the questionnaire about your instrument/s, musical experience and any related pain or injuries you have sustained. Your name will NOT be required; as all the questionnaires are to be kept anonymous. Once you have completed the questionnaire, place the questionnaire in the marked box (Box B) and the completed and **signed** informed consent form in the other box, (Box A). This will ensure that the questionnaires are completely confidential and that your answers will not be disclosed to any third parties. Please answer all the questions, if you are able to, as this will enable accurate statistical results.

Risks or Discomforts to the Participant: There will be no risk to you, if you participate in this study as all information given will be treated as confidential.

Explain to the participant the reasons he/she may be withdraw from the Study: If you do not sign the informed consent form or do not meet the inclusion criteria. Also, if you have participated in the pilot study you cannot participate in this. You may withdraw from the study at any time.

Benefits: Your full co-operation will assist in expanding knowledge of problems and ailments suffered by professional musicians. This is especially important in South Africa where there is a lack of such information and will thus serve to help make future treatment of patients with similar profiles and problems more effective.

Remuneration: There will be no remuneration given upon completion of the study.

Costs of the Study: There will be no costs required to participate in this study.

Confidentiality: All completed questionnaires are kept in complete confidence. The questionnaire will be administered and collected by the researcher (Collection Box Method) to maintain confidentiality at all times. The researcher will thereafter document the information for statistical analysis. All the information is confidential, and the overall results of the study will be made available in the Durban University of Technology library in the form of a dissertation.

Identities of the respondents will not be known by the researcher or the university. The researcher will only use the answers for data analysis meaning that your individual particulars won't be identifiable.

Results: Upon completion of my study, a hard-copy will be available in the DUT Library. Soft copies of the research can be accessed on the DUT repository at openscholar.dut.ac.za.

Research-related Injury: There will be no research-related injuries or risks associated with participation in this study.

Storage of all electronic and hard copies including tape recordings: The soft-copies of the data will be kept on a protected database for a period of 5 years. After 5 years have elapsed, they will be deleted. The hard-copy questionnaires will be kept by the researcher during data collection. Following this, they will be kept at the Durban University of Technology, in the Chiropractic Department, for 5 years. After 5 years, the hard-copies will be shredded by the department.

Persons to contact in the Event of Any Problems or Queries Please contact the researcher, Miss Muhondo at 0744535190, my supervisor, Dr Yasmeen Thandar at 0834594381, Yasmeent@dut.ac.za. or the Institutional Research Ethics Administrator on 031 373 2375. Complaints can be reported to the Director: Research and Postgraduate Support Dr L Linganiso on 031 373 2577 or researchdirector@dut.ac.za.

Appendix B

CONSENT

Full Title of the Study: An Epidemiological study of Musculoskeletal pain in Kwa Zulu-Natal orchestral musicians

Names of Researcher/s: Linley Muhondo (student), Dr Y Thandar, (supervisor), Dr C Kell, (co-supervisor)

Statement of Agreement to Participate in the Research Study:

- I hereby confirm that I have been informed by the researcher, _____ (name of researcher), about the nature, conduct, benefits and risks of this study - Research Ethics Clearance Number: IREC 054/21,
- I have also received, read and understood the above written information (Participant Letter of Information) regarding the study.
- I am aware that the results of the study, including personal details regarding my sex, age, date of birth, initials and diagnosis will be anonymously processed into a study report.
- In view of the requirements of research, I agree that the data collected during this study can be processed in a computerised system by the researcher.
- I may, at any stage, without prejudice, withdraw my consent and participation in the study.
- I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.
- I understand that significant new findings developed during the course of this research which may relate to my participation will be made available to me.

_____	_____	_____	_____
Full Name of Participant	**Date**	**Time**	**Signature / Right Thumbprint**

I, _____ (name of researcher) herewith confirm that the above participant has been fully

informed about the nature, conduct and risks of the above study.

Full Name of Researcher	**Date**	**Signature**
Full Name of Witness (If applicable)	**Date**	**Signature**

Appendix C

QUESTIONNAIRE: AN EPIDEMIOLOGICAL INVESTIGATION OF MUSCULOSKELETAL PAIN IN KWAZULU-NATAL ORCHESTRAL MUSICIANS

Participant number: _____ **Orchestra Name:** _____

SECTION A

DEMOGRAPHICS

1. Age:
   - € 18 – 24[1]
   - € 25 – 34[2]
   - € 35 – 44[3]
   - € 45 – 65[4]
   - € 65 and above[5]
2. Sex:
   - € Male[1]
   - € Female[2]
   - € Other[3]
3. Race (for statistical purposes)
   - € White[1]
   - € African[2]
   - € Indian[3]
   - € Coloured[4]
   - € Asian[5]
   - € Other[6] (please specify): _____
4. Height: _____m
5. Weight: _____Kg
6. Are you:
   - € Right Handed[1]
   - € Left Handed[2]
   - € Both[3]
7. Do you smoke?
   - € Yes[1]
   - € No[0]
8. What is your country of origin? _____
9. What is your highest level of musical qualification?
   - € Bachelor of Music[1]
   - € Masters in Music[2]
   - € PhD[3]
   - € Other[4] (please specify): _____
10. What year did you obtain this qualification? _____
11. Did you obtain your qualification from a South African University?

€ Yes[1]
€ No[0]

a) If yes, please specify from which University you obtained your qualification _____

b) If No, in which country and University did you obtain your qualification?

Country: _____ University: _____

12. Do you engage in any regular physical activities or hobbies (e.g. gym, jogging etc.?)

€ Yes[1]
€ No[0]

If Yes, please list them and how many hours per week you engage in these activities

Sport or hobby	Hours per week
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

SECTION B

a) MUSICAL BACKGROUND

1. At what age did you first begin having music lessons? _____ years
2. At what age did you first begin playing in a professional orchestra? _____ years
3. Are you aware of musicians' playing related health problems, e.g. Tendonitis?

€ Yes[1]

€ No[0]

4. Have you ever received information to help prevent musicians' playing-related health problems such as tendonitis etc.?

€ Yes[1]
€ No[0]

4.1 If yes, where did you receive this information/how was this information provided to you? (Please mark)

€ Health Care Professional[1]

€ Music teacher[2]

€ Colleague[3]

€ Part of your university curriculum[4]

€ Online Course/ Article/ Youtube[5]

€ Word of mouth[6]

€ Other[7] (please specify) _____

4.2 If you have received any information on musician health-related problems, please select the type of instruction? (Mark all that apply)

€ Lecture[1] (1 hour) _____

€ Workshop[2] (2-3 hours) _____

€ Course[3] (several weeks) _____

€ Other[4] (please specify) _____

4.3 Were the instructions given a specific technique name (E.g. Alexander Technique)?

€ Yes[1]
€ No[0]
If yes, please specify the name of the technique _____

4.4 Did the instructions lead you to change any of your playing habits?

€ Yes[1]
€ No[0]
4.4.1 If yes, please describe how _____

_____

_____

4.4.2 If no, why not? _____

_____

_____

5. How do you carry your instrument when it is in it's case? (Please mark all that apply)

€ I don't carry my instrument[1]
€ I use a shoulder strap on my: Right shoulder[2] ___ Left Shoulder[3]___ Back[4] ____
€ I carry it by handle in my: Right hand[5] _____ Left Hand[6] _____
€ I have wheels attached to my case[7] _____
€ Other (please specify)[8] _____

b) PLAYING TECHNIQUES

Please mark Yes or No in the box below, or if applicable, mark over one of the selections

No.	Question	Yes	No	
6.	Have you significantly changed your playing technique in the last 12 months?	1	0	
7.	Do you practice technical exercises specifically for your instrument? E.g.: finger independence, embouchure, etc.?	1	0	
8.	Do you feel that you have enough breaks during rehearsal?	1	0	
9.	Do you physically warm up without your instrument before a practice session? (e.g. stretching, movement exercises etc.)	1	0	
10.	Do you warm up on your instrument before a practice session? (e.g.: slow scales, blowing long notes drumming cadences)	1	0	
	If yes, do you do this:	Occasionally[1]	Usually[2]	Always[3]

11.	Do you perform a physical cool down after practicing on or playing your instrument? (eg: stretches, body movement etc.)	[1]	[2]	[3]
	If yes, is this:	Occasionally[1]	Usually[2]	Always[3]

12. When playing, are you:

Seated[1]_____ Standing[2]_____ Alternate between standing and seated[3]_____

12.1 On average, how long are you standing or seated for per day in a rehearsal? _____ mins/hours

SECTION C

OCCUPATIONAL INFORMATION

1. What is your main occupation? (Mark all that apply)

€ Performer[1]
€ Teacher[2]
€ Other (please specify)[3]: _____

2. What instrument do you play in the orchestra? _____
3. Do you play any other instruments in the orchestra?

€ Yes[1]
€ No[0]

If yes, what other instrument/s and how many hours per week:

_____ _____
_____ _____
_____ _____

No.	Questions	Responses				
4.	How many years have you been playing your instrument?	0-5 years[1]	5-10 years[2]	10–15 years[3]	15–20 years[4]	20+ years[5]
5.	How many years have you been playing in a professional orchestra?	0-5 years[1]	5-10 years[2]	10–15 years[3]	15–20 years[4]	20+ years[5]
6.	On average, how many hours a week do you spend playing your instrument in the orchestra (Including performances, recordings and rehearsals)?	0-1 hours[1]	1-5 hours[2]	6-10 hours[3]	11-15 hours[4]	16+ hours[5]
7.	Do you provide music lessons with the instrument that you are playing in the Orchestra or any other instrument	Yes[1]	No[0]			
	If yes, how many hours per week do you teach during an academic term?	0-1 hours[1]	1-5 hours[2]	6-10 hours[3]	11-15 hours[4]	16+ hours[5]
8.	Do you play in any other orchestras, ensembles, bands or any freelance playing?	Yes[1]	No[0]			
	If yes, how many hours per week do you play in the additional capacities?	0-1 hours[1]	1-5 hours[2]	6-10 hours[3]	11-15 hours[4]	16+ hours[5]
9.	Do you engage in any non-music related work (i.e. work that doesn't require you to play your instrument)?	Yes[1]	No[0]			
	If yes, please specify					

10.	How many hours per week do you perform this work?	0-1 hours[1]	1-5 hours[2]	6-10 hours[3]	11-15 hours[4]	16+ hours[5]

11. What is your salary range from this orchestra?

R0 – R4,999[1]_____

R5000 – R9,999[2]_____

R10 000 – R14 999[3]_____

R15 000 – R19 999[4]_____

R20 000 – R24 999[5]_____

R25 000+[6] _____

12. What is your salary range from any other combined additional income (teaching, playing in other orchestras, freelancing etc.?)

R0 – R4,999[1]_____

R5000 – R9,999[2]_____

R10 000 – R14 999[3]_____

R15 000 – R19 999[4]_____

R20 000 – R24 999[5]_____

R25 000+[6] _____

13. How many estimated days have you lost due to injury? _____

13.1 Please estimate any loss of income in your lifetime arising from being unable to play due to injury

R0 – R4,999[1]_____

R5000 – R9,999[2]_____

R10 000 – R14 999[3]_____

R15 000 – R19 999[4]_____

R20 000 – R24 999[5]_____

R25 000+[6] _____

SECTION D

PLAYING-RELATED MUSCULOSKELETAL PROBLEMS

For the purposes of this study, a playing-related musculoskeletal problem is defined as: "Pain, weakness, numbness, tingling, or other symptoms that arise from playing, and that interfere with your ability to play your instrument at the level you are accustomed to. This definition DOES NOT include mild transient aches and pains. (Pain or any other symptoms that are caused by an

accident or other non-playing-related event are NOT considered to be a playing-related problem)"

1. Have you experienced a playing-related musculoskeletal problem:

   During the last 12 months

   € Yes[1]
   € No[0]

   During the last month? (4 weeks)

   € Yes[3]
   € No[0]

   Currently? (In the last 7 days)

   € Yes[1]
   € No[0]

   If Yes to the last two, please give details in the questions below and specify if it was Right, Left or both where applicable.

No	Region	Responses			
		Left Side	**Right Side**	**Both Sides**	
2.	Neck	1	2	3	
3.	Face (Jaw)	1	2	3	
4.	Face (Embouchure)	1	2	3	
5.	Shoulder/Upper Arm	1	2	3	
6.	Elbows/Forearms	1	2	3	
7.	Wrist/Hands/Fingers	1	2	3	
8.	Upper Back	1	2	3	
9.	Lower Back (Small of back)	1	2	3	
10.	Hips/Thighs/Buttocks	1	2	3	
11.	One or Both Knees	1	2	3	
12.	Ankles or Feet	1	2	3	
13.	Do you worry about getting a playing related Musculoskeletal problem?	Never[1]	Seldom[2]	Often[3]	Very Often[4]

14. Have you ever been officially diagnosed with a playing-related musculoskeletal problem by a medical practitioner, as defined above?

    (If no, please proceed to section E, Question number 1)

    € Yes[1]
    € No[0]

    If "Yes"

    14.1.1 What was the diagnosis? _____

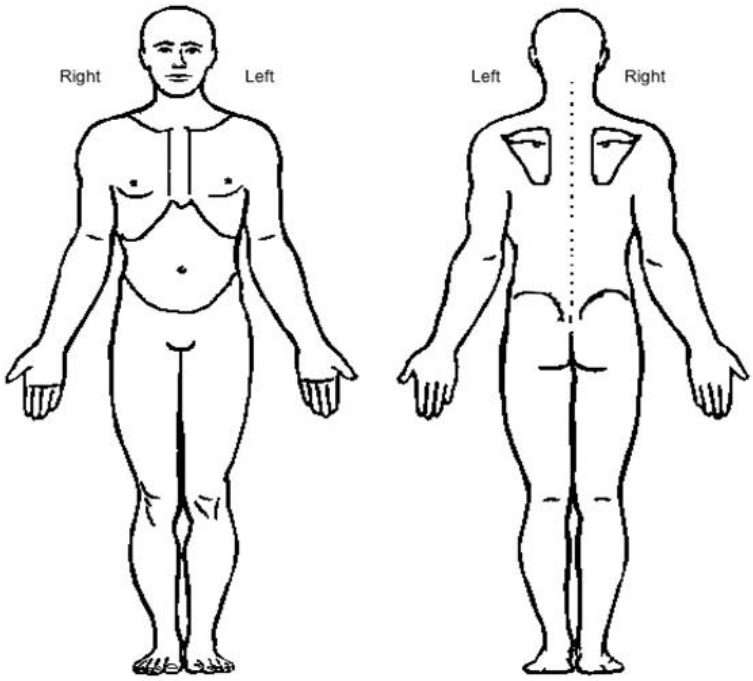
    14.1.2 What year/month did the pain begin? _____

    14.1.3 What year/month did the pain subside? (If it hasn't, please mention)

    _____

15. Using the diagram below, please indicate where you feel symptoms related to your playing-related
Musculoskeletal problem(s):

Please **shade** the area where you feel pain, discomfort or other symptoms
Please **circle** any areas of tingling or loss of feeling:



16. Thinking of the most severe current problem you are experiencing, please circle the number on these scales that best describes your experience with playing-related musculoskeletal problems.

Frequency Scale	Severity Scale
0 = no problem ever[1]	0 = no negative symptoms[9]
1 = had a problem once, but now it is gone[2]	1 = mild noticeable symptoms[10]
2 = problem occurs occasionally, during or after playing[3]	2 = discomforting symptoms[11]
3 = problem occurs usually, during or after playing[4]	3 = troublesome symptoms[12]
4 = problem always occurs, during or after playing[5]	4 = distressing symptoms[13]
5 = problem affects many activities of daily living as well as playing[6]	5 = severe symptoms[14]
6 = problem affects all activities of daily living as well as playing[7]	6 = debilitating symptoms[15]
7 = problem affects all activities of daily living and I cannot play at all because of the problem[8]	7 = unbearable symptoms[16]

16.1 Which healthcare professionals have you seen for your diagnoses?

- € Family medical doctor[1]
- € Chiropractor[2]
- € Homoeopath[3]
- € Medical Specialist[4]
- € Physiotherapist[5]
- € Occupational Therapist[6]
- € Biokineticist[7]
- € Other (please specify)[8] _____

16.2 What impact did the diagnosis you were given have on your playing?

Question	Yes	No
Have you decreased your playing time because of this problem?	1	0
Have you stopped playing your instrument/s for any time period because of your problem? If yes, for how long?	1	0
Are you playing as much as you would like to play?	1	0
Have you changed your playing technique because of this problem? If yes, what have you changed about your technique?	1	0
Have you changed your playing position because of this problem? If yes, how?	1	0

17. Has this problem impacted negatively in the following aspects of your life? (Please mark all options applicable to you)

- € Socially[1]
- € Mentally[2]
- € Financially[3]

These next few questions refer to your playing activities right **BEFORE** you experienced a problem.

That is, a few days or a week before you noticed symptoms.

Question			

BEFORE you began experiencing symptoms of a problem, did you take breaks during practice sessions?	Yes[1]		No[0]	Cannot Remember[2]
BEFORE you began experiencing symptoms of a problem, did you physically warm up without your instrument before a practice session? (e.g. stretching, movement exercises etc.) If "Yes", was this done:	Yes[1] Occasionally[1]		No[0] Usually[2]	 Always[3]
BEFORE you began experiencing symptoms of a problem, did you warm up on your instrument before a practice session? (e.g. slow scales, long tones etc.) If "Yes", was this done:	Yes[1] Occasionally[1]		No[0] Usually[2]	 Always[3]
BEFORE you began experiencing symptoms of a problem, how stressful was your work? (Please mark the appropriate number)	**NOT AT ALL STRESSFUL**		**STRESSFUL**	**VERY STRESSFUL**
	1[1]	**2[2]**	**3[3]**	**4[4]** **5[4]**
BEFORE you began experiencing symptom of a problem, were you playing more than usual?	Yes[1]		No[0]	
BEFORE you began experiencing symptoms of a problem, were you playing less than usual?	Yes[1]		No[0]	
BEFORE you began experiencing symptoms of a problem, did you just return from a break away from playing? (e.g. Christmas break, leave, other work, long illness)	Yes[1]		No[0]	

SECTION E

PERSONAL OPINIONS

Listed below are some statements about pain and playing. Read each statement and decide whether you agree or disagree and to what extent. If you Strongly agree, mark 7; if you strongly disagree, mark 1; if you feel somewhere in between, mark any of the numbers between 1 and 7. If you feel neutral or undecided, the midpoint is 4. Do not spend too much time on any one statement but give the answer which seems to describe how you generally feel.

There are no right or wrong answers.

No	Statement	Disagree			No Opinion	Agree		
		1	2	3	4	5	6	7
1.	Musicians should play through pain	1	2	3	4	5	6	7
2.	I would stop or decrease my playing time if I have pain	1	2	3	4	5	6	7
3.	Pain is a normal part of playing and should be expected	1	2	3	4	5	6	7
4.	Musicians who have playing-related pain, must be doing something wrong in their playing	1	2	3	4	5	6	7
5.	If I had a playing related problem I wouldn't tell my colleagues for fear of loosing work	1	2	3	4	5	6	7
6.	You have to experience some pain when you practice if you are going to improve	1	2	3	4	5	6	7
7.	If I had a playing related problem, I would tell my colleagues because they would understand, and might be able to help	1	2	3	4	5	6	7
8	Playing in pain might hurt me, but it's not going to harm me, so I may as well put up with the pain and play.	1	2	3	4	5	6	7

Open Ended Questions:

9. Do you consider playing related musculoskeletal problems a serious problem?
   - € Yes[1]
   - € No[0]

10. If "Yes", what makes (or would make) playing related musculoskeletal problems a serious problem?

_____

_____

_____

_____

_____

This is the End! Thank you for your time taken to answer this questionnaire!!!!!!

6 August 2020

Appendix D

LETTER OF INFORMATION

Title of the Research Study : An Epidemiological study of Musculoskeletal pain in Kwa Zulu-Natal orchestral musicians

Principal Investigator/s/researcher: Linley Muhondo (M. Tech. Chiro student)

Co-Investigator/s/supervisor/s: (Yasmeen Thandar, B. Pharm MMedSc (Clin Pharm) PhD (Pharmacology)) Supervisor, (Colette Kell, M. Tech Hom) Co-Supervisor

Brief Introduction and Purpose of the Study:

There is a high incidence of player-related musculoskeletal injuries amongst orchestral musicians. Studies that have been done previously have found that no specific sections of the orchestra are immune to the chances of developing a playing-related injury. Studies also show that these musculoskeletal injuries can have a significant impact on musicians' lives and livelihoods, as an injured player cannot practice or perform and therefore cannot earn money. There is also a scarcity of literature representing South African Orchestras, with only 3 studies having been done in the last decade.

Good day and thank you for taking the time to read this document of information. I am a 6th year student at DUT doing this research to complete my Master's degree in Chiropractic. I would like to invite you, as a potential participant, to participate in my research and grow the body of research available on musicians internationally, and more importantly, locally in South Africa. My research consists of one questionnaire, which you will answer anonymously, and then put into the box labelled Questionnaire. Take your time reading the questions and please attempt to answer every question in the questionnaire to make the

data as valid as possible. If there are any questions you don't understand or know how to answer, please feel free to ask me right away and I will clarify things for you. This letter of information is for you so feel free to take it with you.

Outline of the Procedures: If you agree to participate in this study, you will be required to sign an informed consent form, after reading this letter of information, and answer the questionnaire about your instrument/s, musical experience and any related pain or injuries you have sustained. Your name will NOT be required; as all the questionnaires are to be kept anonymous. Once you have completed the questionnaire, place the questionnaire in the marked box (Box B) and the completed and **signed** informed consent form in the other box, (Box A). This will ensure that the questionnaires are completely confidential and that your answers will not be disclosed to any third parties. Please answer all the questions, if you are able to, as this will enable accurate statistical results.

Risks or Discomforts to the Participant: There will be no risk to you, if you participate in this study as all information given will be treated as confidential.

Explain to the participant the reasons he/she may be withdraw from the Study: If you do not sign the informed consent form or do not meet the inclusion criteria. Also, if you have participated in the pilot study you cannot participate in this. You may withdraw from the study at any time.

Benefits: Your full co-operation will assist in expanding knowledge of problems and ailments suffered by professional musicians. This is especially important in South Africa where there is a lack of such information and will thus serve to help make future treatment of patients with similar profiles and problems more effective.

Remuneration: There will be no remuneration given upon completion of the study.

Costs of the Study: There will be no costs required to participate in this study.

Confidentiality: All completed questionnaires are kept in complete confidence. The questionnaire will be administered and collected by the researcher (Collection Box Method) to maintain confidentiality at all times. The researcher will thereafter document the information for statistical analysis. All the information is confidential, and the overall results of the study will be made available in the Durban University of Technology library in the form of a dissertation.

Identities of the respondents will not be known by the researcher or the university. The researcher will only use the answers for data analysis meaning that your individual particulars won't be identifiable.

Results: Upon completion of my study, a hard-copy will be available in the DUT Library. Soft copies of the research can be accessed on the DUT repository at openscholar.dut.ac.za.

Research-related Injury: There will be no research-related injuries or risks associated with participation in this study.

Storage of all electronic and hard copies including tape recordings: The soft-copies of the data will be kept on a protected database for a period of 5 years. After 5 years have elapsed, they will be deleted. The hard-copy questionnaires will be kept by the researcher during data collection. Following this, they will be kept at the Durban University of Technology, in the Chiropractic Department, for 5 years. After 5 years, the hard-copies will be shredded by the department.

Persons to contact in the Event of Any Problems or Queries Please contact the researcher, Miss Muhondo at 0744535190, my supervisor, Dr Yasmeen Thandar at 0834594381, Yasmeent@dut.ac.za. or the Institutional Research Ethics Administrator on 031 373 2375. Complaints can be reported to the Director: Research and Postgraduate Support Dr L Linganiso on 031 373 2577 or researchdirector@dut.ac.za.

Appendix E

CONSENT

Full Title of the Study: An Epidemiological study of Musculoskeletal pain in Kwa Zulu-Natal orchestral musicians

Names of Researcher/s: Linley Muhondo (student), Dr Y Thandar, (supervisor), Dr C Kell, (co-supervisor)

Statement of Agreement to Participate in the Research Study:

- I hereby confirm that I have been informed by the researcher, _____ (name of researcher), about the nature, conduct, benefits and risks of this study - Research Ethics Clearance Number: _____,
- I have also received, read and understood the above written information (Participant Letter of Information) regarding the study.
- I am aware that the results of the study, including personal details regarding my sex, age, date of birth, initials and diagnosis will be anonymously processed into a study report.
- In view of the requirements of research, I agree that the data collected during this study can be processed in a computerised system by the researcher.
- I may, at any stage, without prejudice, withdraw my consent and participation in the study.
- I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.
- I understand that significant new findings developed during the course of this research which may relate to my participation will be made available to me.

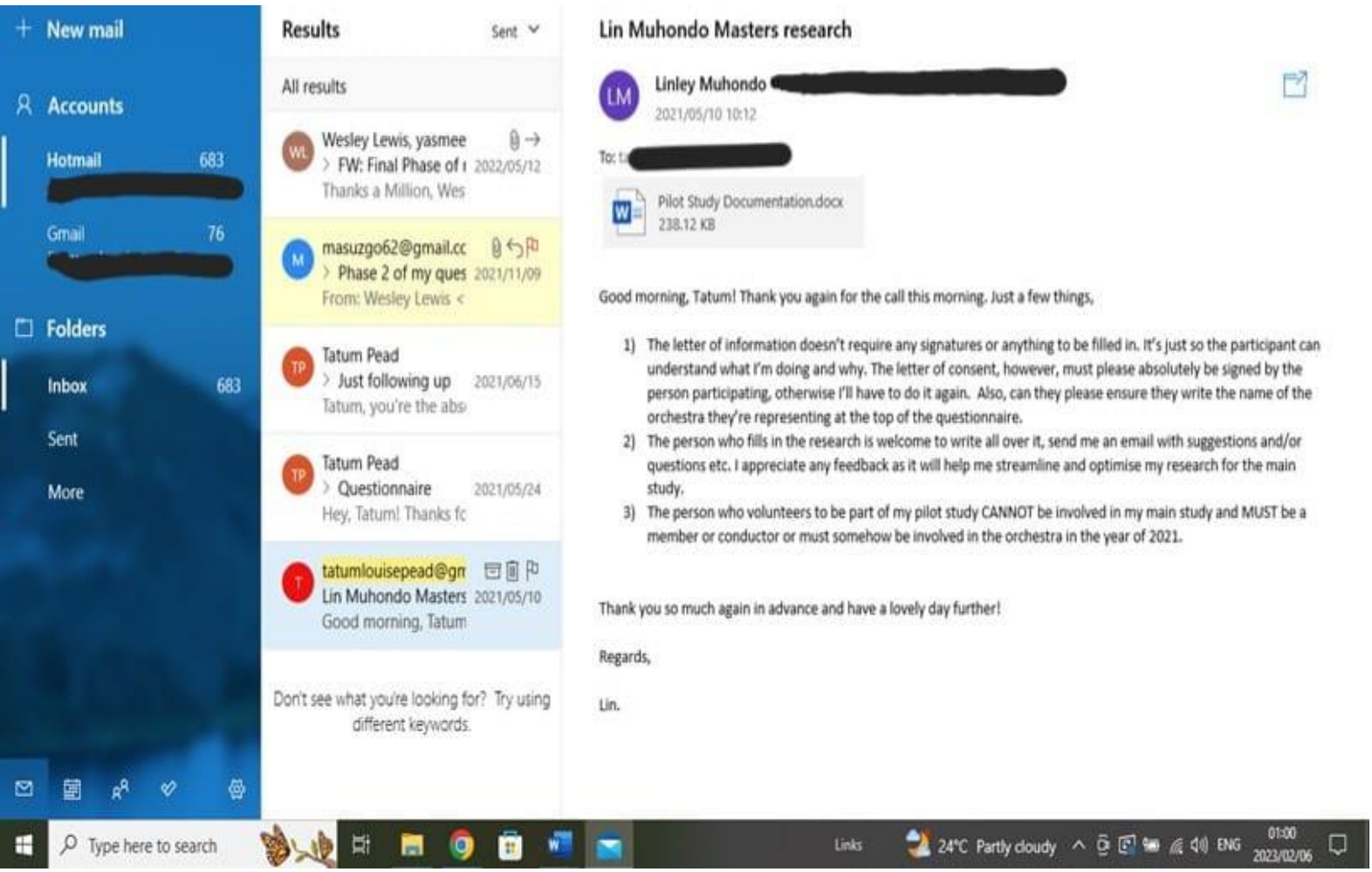
_____	_____	_____	_____
Full Name of Participant	**Date**	**Time**	**Signature / Right Thumbprint**

I, _____

(name of researcher) herewith confirm that the above participant has been fully informed about the nature, conduct and risks of the above study.

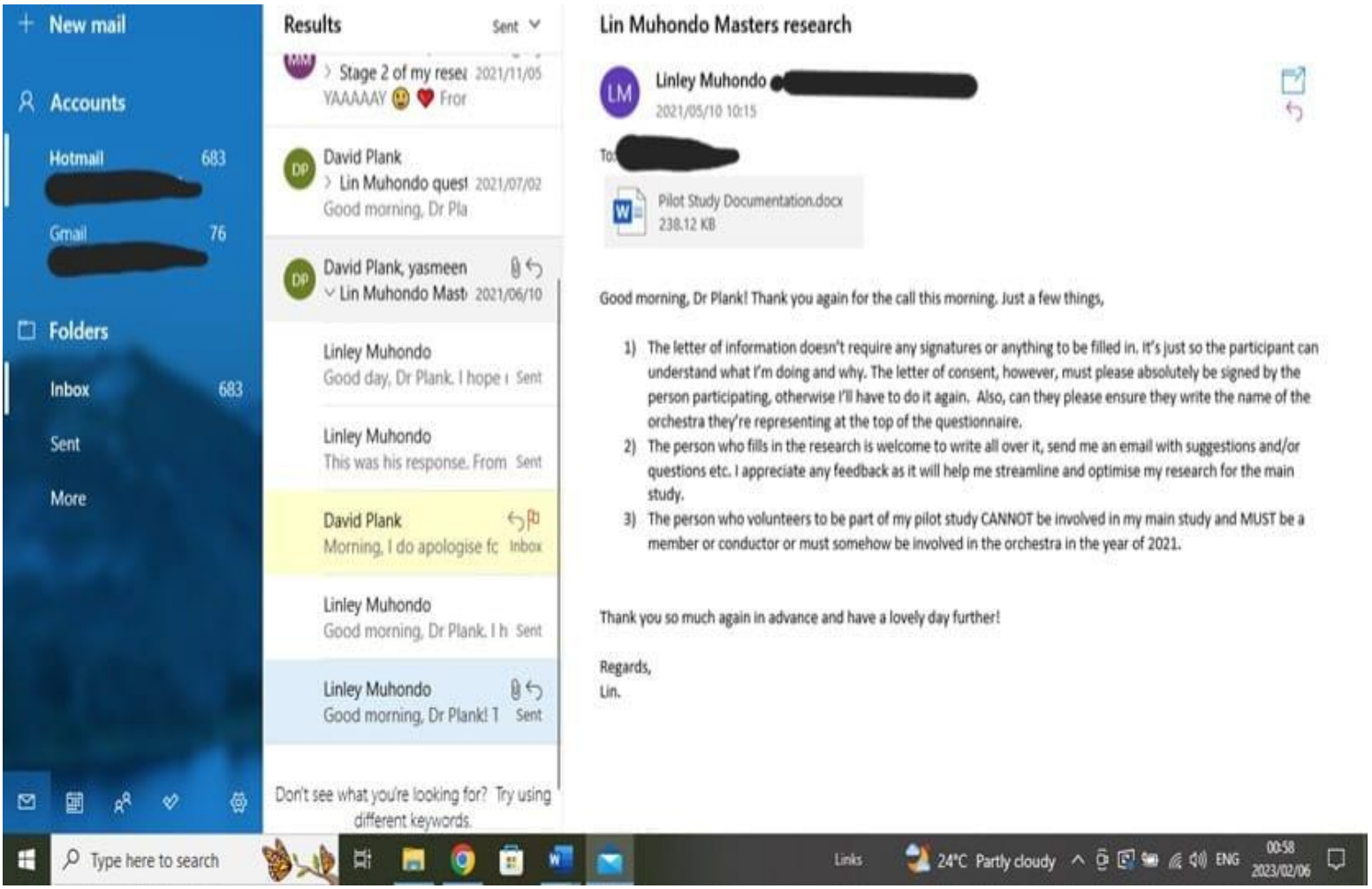
Full Name of Researcher	**Date**	**Signature**
Full Name of Witness (If applicable)	**Date**	**Signature**

Appendix F



6 August 2020

Appendix G



6 August 2020

Appendix H

30/10/2021

To whom it may concern at Durban University of Technology

On behalf of the Durban City Orchestra, I, Wesley Lewis, hereby give Linley Muhondo (21205680) permission to undertake research on the Durban City Orchestra for her Masters degree.

For any queries or concerns, don't hesitate to contact me.

Kind Regards

_____

Wesley Lewis
+27 72 996 9994
Concert & Logistics Manager

Appendix I

Pietermaritzburg City Orchestra

04 November 2021

To Whom It May Concern,

This is to certify that Linley Muhondo has been granted permission to conduct research, by way of voluntary questionnaires, from the members of the Pietermaritzburg City Orchestra.

If you would like any further information, please feel free to contact me on 033-395-4212 during office hours. On behalf of the Pietermaritzburg City Orchestra, I would like to wish Linley all the best in the advancement of her research.

Yours faithfully,

Dr David Plank
Conductor: Pietermaritzburg City Orchestra

Appendix J

QUESTIONNAIRE: AN EPIDEMIOLOGICAL INVESTIGATION OF MUSCULOSKELETAL PAIN IN KWAZULU-NATAL ORCHESTRAL MUSICIANS

Participant number: _____ **Orchestra Name:** _____

SECTION A

DEMOGRAPHICS

1. Age:
   - € 18 – 24[1]
   - € 25 – 34[2]
   - € 35 – 44[3]
   - € 45 – 65[4]
   - € 65 and above[5]
2. Sex:
   - € Male[1]
   - € Female[2]
   - € Other[3]
3. Race (for statistical purposes)
   - € White[1]
   - € African[2]
   - € Indian[3]
   - € Coloured[4]
   - € Asian[5]
   - € Other[6] (please specify): _____
4. Height: _____m
5. Weight: _____Kg
6. Are you:
   - € Right Handed[1]
   - € Left Handed[2]
   - € Both[3]
7. Do you smoke?
   - € Yes[1]
   - € No[0]
8. What is your country of origin? _____
9. What is your highest level of musical qualification?
   - € Bachelor of Music[1]
   - € Masters in Music[2]
   - € PhD[3]
   - € Other[4] (please specify): _____
10. What year, and in which country, did you obtain this qualification?

    _____

11. Do you engage in any regular physical activities or hobbies (e.g. gym, jogging etc.?)

€ Yes[1]
€ No[0]
If Yes, please list them and how many hours per week you engage in these activities

Sport or hobby	Hours per week
_____	_____
_____	_____
_____	_____

SECTION B

a) MUSICAL BACKGROUND

1. At what age did you first begin having music lessons? _____ years
2. At what age did you first begin playing in a professional orchestra? _____ years
3. Are you aware of musicians' playing related health problems, e.g. Tendonitis?

   € Yes[1]

   € No[0]
4. Have you ever received information to help prevent musicians' playing-related health problems such as tendonitis etc.?

   € Yes[1]
   € No[0]

   4.1 If yes, where did you receive this information/how was this information provided to you? (Please mark)

   € Health Care Professional[1]

   € Music teacher[2]

   € Colleague[3]

   € Part of your university curriculum[4]

   € Online Course/ Article/ Youtube[5]

   € Word of mouth[6]

   € Other[7] (please specify) _____

   4.2 If you have received any information on musician health-related problems, please select the type of instruction? (Mark all that apply)

   € Lecture[1] (1 hour) _____

   € Workshop[2] (2-3 hours) _____

   € Course[3] (several weeks) _____

   € Other[4] (please specify) _____

   4.3 Were the instructions given a specific technique name (E.g. Alexander Technique)?

€ Yes[1]
€ No[0]
If yes, please specify the name of the technique _____

4.4 Did the instructions lead you to change any of your playing habits?

€ Yes[1]
€ No[0]
4.4.1 If yes, please describe how _____

_____

_____

4.4.2 If no, why not? _____

_____

_____

5. How do you carry your instrument when it is in it's case? (Please mark all that apply)

€ I don't carry my instrument[1]
€ I use a shoulder strap on my: Right shoulder[2] ___ Left Shoulder[3]___ Back[4] ____
€ I carry it by handle in my: Right hand[5] _____ Left Hand[6] _____
€ I have wheels attached to my case[7] _____
€ Other (please specify)[8] _____

6. PLAYING TECHNIQUES

Please mark Yes or No in the box below, or if applicable, mark over one of the selections

No.	Question	Yes	No	
1.	Have you significantly changed your playing technique in the last 12 months?	1	0	
2.	Do you practice technical exercises specifically for your instrument? E.g.: finger independence, embouchure, etc.?	1	0	
3.	Do you feel that you have enough breaks during rehearsal?	1	0	
4.	Do you physically warm up without your instrument before a practice session? (e.g. stretching, movement exercises etc.)	1	0	
5.	Do you warm up on your instrument before a practice session? (e.g.: slow scales, blowing long notes drumming cadences)	1	0	
	If yes, do you do this:	Seldom[1]	Usually[2]	Always[3]

7. When playing, are you:

Seated[1]_____ Standing[2]_____ Alternate between standing and seated[3]_____

7.1 On average, how long are you standing or seated for per day in a rehearsal? _____ mins/hours

SECTION C

OCCUPATIONAL INFORMATION

1. What is your main occupation? (Mark all that apply)

€ Performer[1]
€ Music Teacher[2]
€ Other (please specify)[3]: _____

3. What instrument do you play in the orchestra? _____
3. Do you play any other instruments in the orchestra?

€ Yes[1]
€ No[0]

If yes, what other instrument/s and how many hours per week:

_____ _____

_____ _____ _____

No.	Questions	Responses				
1.	On average, how many hours a week do you spend playing your instrument in the orchestra (Including performances, recordings and rehearsals)?	0-1 hours[1]	1-5 hours[2]	6-10 hours[3]	11-15 hours[4]	16+ hours[5]
2.	Do you provide music lessons with the instrument that you are playing in the Orchestra or any other instrument	Yes[1]	No[0]			
	If yes, how many hours per week do you teach during an academic term?	0-1 hours[1]	1-5 hours[2]	6-10 hours[3]	11-15 hours[4]	16+ hours[5]
3.	Do you play in any other orchestras, ensembles, bands or any freelance playing?	Yes[1]	No[0]			
	If yes, how many hours per week do you play in the additional capacities?	0-1 hours[1]	1-5 hours[2]	6-10 hours[3]	11-15 hours[4]	16+ hours[5]
4.	Do you engage in any non-music related work (i.e. work that doesn't require you to play your instrument)?	Yes[1]	No[0]			
	If yes, please specify					
5.	How many hours per week do you perform non orchestra-related work?	0-1 hours[1]	1-5 hours[2]	6-10 hours[3]	11-15 hours[4]	16+ hours[5]

4. What is your salary range from this orchestra?

R1000 – R4,999[1]_____

R5000 – R9,999[2]_____

R10 000 – R14 999[3]_____

R15 000 – R19 999[4]_____

R20 000 – R24 999[5]_____

R25 000+[6] _____

I don't earn money playing in this orchestra[7]_____

5. What is your salary range from any other combined additional music-related income (teaching, playing in other orchestras, freelancing etc.?)

R1000 – R4,999[1]_____

R5000 – R9,999[2]_____

R10 000 – R14 999[3]_____

R15 000 – R19 999[4]_____

R20 000 – R24 999[5]_____

R25 000+[6] _____

N/A _____

6. How many estimated days have you lost due to injury in your career? _____

6.1 Please estimate any loss of income in your lifetime arising from being unable to play due to injury

R1000 – R4,999[1]_____

R5000 – R9,999[2]_____

R10 000 – R14 999[3]_____

R15 000 – R19 999[4]_____

R20 000 – R24 999[5]_____

R25 000+[6] _____

I haven't lost any income from my injury/s_____

SECTION D

PLAYING-RELATED MUSCULOSKELETAL PROBLEMS

For the purposes of this study, a playing-related musculoskeletal problem is defined as: "Pain, weakness, numbness, tingling, or other symptoms that arise from playing, and that interfere with your ability to play your instrument at the level you are accustomed to. This definition DOES NOT include mild transient aches and pains. (Pain or any other symptoms that are caused by an accident or other non-playing-related events are NOT considered to be playing-related problems)"

1. Have you experienced a playing-related musculoskeletal problem:

During the last 12 months

€ Yes[1]
€ No[0]

During the last month? (4 weeks)

€ Yes[3]
€ No[0]

Currently? (In the last 7 days)

€ Yes[1]
€ No[0]

If Yes to the last two, please give details in the questions below and specify if it was on the Right, Left or both sides where applicable.

No	Region	Responses			
		Left Side	**Right Side**	**Both Sides**	
2.	Neck	1	2	3	
3.	Face (Jaw)	1	2	3	
4.	Face (Embouchure)	1	2	3	
5.	Shoulder/Upper Arm	1	2	3	
6.	Elbows/Forearms	1	2	3	
7.	Wrist/Hands/Fingers	1	2	3	
8.	Upper Back	1	2	3	
9.	Lower Back (Small of back)	1	2	3	
10.	Hips/Thighs/Buttocks	1	2	3	
11.	One or Both Knees	1	2	3	
12.	Ankles or Feet	1	2	3	
13.	Do you worry about getting a playing related Musculoskeletal problem?	Never[1]	Seldom[2]	Often[3]	Very Often[4]

2. Have you ever been officially diagnosed with a playing-related musculoskeletal problem by a medical practitioner, as defined above?
(If no, please proceed to section E, Question number 1)

€ Yes[1]
€ No[0]

If "Yes"

2.1.1 What was the diagnosis? _____

2.1.2 What year/month did the pain begin? _____

2.1.3 What year/month did the pain subside? (If it hasn't, please mention)

_____

3. Thinking of the most severe current problem you are experiencing, please circle the number on these scales that best describes your experience with playing-related musculoskeletal problems.

3.1.1 Does your problem occur **occasionally**/**usually**/ **always**? (Please circle the correct one)

3.1.2 Does your problem occur **during** or after **playing**? (Please circle the correct one)

3.1.3 Does your problem affect your activities of daily living? For example: bathing, combing your hair or driving? **Yes**/ **No** (Please circle the correct one)

3.1.4 On a scale of **0 to 10** how bad is your pain DURING playing? _____

3.1.5 On a scale of **0 to 10** how bad is your pain AFTER playing/ doing activities of daily living?

_____

4.1 Which healthcare professionals have treated you for your diagnoses?

- € Family medical doctor[1]
- € Chiropractor[2]
- € Homoeopath[3]
- € Medical Specialist[4]
- € Physiotherapist[5]
- € Occupational Therapist[6]
- € Biokineticist[7]

€ Other (please specify)[8] _____

€ None[9]

4.2 What impact did the diagnosis you were given have on your playing?

Question	Yes	No
Have you decreased your playing time because of this problem?	1	0
Have you stopped playing your instrument/s for any time period because of your problem? If yes, for how long?	1	0
Are you playing as much as you would like to play?	1	0
Have you changed your playing technique because of this problem? If yes, what have you changed about your technique?	1	0
Have you changed your playing position because of this problem? If yes, how?	1	0

SECTION E

PERSONAL OPINIONS

Listed below are some statements about pain and playing. Read each statement and decide whether you agree or disagree and to what extent. If you Strongly agree, mark 7; if you strongly disagree, mark 1; if you feel somewhere in between, mark any of the numbers between 1 and 7. If you feel neutral or undecided, the midpoint is 4. Do not spend too much time on any one statement but give the answer which seems to describe how you generally feel.

There are no right or wrong answers.

No	Statement	Disagree	No Opinion	Agree

1.	Musicians should play through pain	1	2	3	4	5	6	7
2.	I would stop or decrease my playing time if I have pain	1	2	3	4	5	6	7
3.	Pain is a normal part of playing and should be expected	1	2	3	4	5	6	7
4.	Musicians who have playing-related pain, must be doing something wrong in their playing	1	2	3	4	5	6	7
5.	You have to experience some pain when you practice if you are going to improve	1	2	3	4	5	6	7
6.	If I had a playing related problem, I would tell my colleagues because they would understand, and might be able to help	1	2	3	4	5	6	7
7.	Playing music and experiencing some form of stress, (stage fright, shaky bow etc.) go hand-in-hand.	1	2	3	4	5	6	7
8.	Stress affects me and my playing.	1	2	3	4	5	6	7
9.	The stressful environment that comes with making music is a problem in the music community.	1	2	3	4	5	6	7

Open Ended Questions:

10. Do you consider playing related musculoskeletal problems a serious problem?

    € Yes[1]
    € No[0]

11. If "Yes", what makes (or would make) playing related musculoskeletal problems a serious problem?

_____
_____
_____
_____
_____

10. Has Covid-19 changed or affected any aspect of your music making? If yes, how so?

_____
_____
_____
_____
_____

This is the End! Thank you for your time taken to answer this questionnaire!!!!!!

Appendix K

Institutional Research Ethics Committee
Research and Postgraduate Support Directorate
2nd Floor, Berwin Court
Gate 1, Steve Biko Campus
Durban University of Technology

P O Box 1334, Durban, South Africa, 4001

Tel: 031 373 2375
Email: lavishad@dut.ac.za
http://www.dut.ac.za/research/institutional_research_ethics

www.dut.ac.za

22 April 2021

Ms L M Muhondo
2 Silver Mist
9 Dalry Road
Scottsville
Pietermaritzburg

Dear Ms Muhondo

An epidemiological investigation into Musculoskeletal pain in KwaZulu- Natal orchestral musicians.

I am pleased to inform you that **PROVISIONAL APPROVAL** has been granted to your proposal subject to:

- Piloting of the data collection tool. *Please note that should there be any changes to the data collection tool, in a letter signed by the researcher and supervisor, list the changes to the documents and submit to IREC with the final data collection tool. Even when there are no changes to the data collection tool, IREC has to be notified.*
- Obtaining and submitting the necessary gatekeeper permission/s to Institutional Research Ethics Committee (IREC).

PLEASE NOTE THAT THIS IS NOT A FINAL APPROVAL LETTER. KINDLY SUBMIT THE ABOVE MENTIONED DOCUMENTS WITHIN THREE MONTHS TO THE IREC OFFICE. DATA COLLECTION CAN ONLY COMMENCE WHEN IREC ISSUES FULL APPROVAL

The Proposal has been allocated the following Ethical Clearance number **IREC 054/21**. Please use this number in all communication with this office.

Approval has been granted for a period of **ONE YEAR**, before the expiry of which you are required to apply for safety monitoring and annual recertification. Please use the Safety Monitoring and Annual Recertification Report form which can be found in the Standard Operating Procedures [SOP's] of the IREC. This form must be submitted to the IREC at least 3 months before the ethics approval for the study expires.

Yours Sincerely

Prof J K Adam
Chairperson: IREC

Appendix L

APPLICATION FOR APPROVAL OF AMENDMENT

To be completed electronically by the principal investigator/researcher in accordance with the Standard Operating Procedures of the IREC.

Title of the study: An Epidemiological study of Musculoskeletal pain in Kwa Zulu-Natal orchestral musicians

Institution: Durban University of Technology	Date: 03/12/2021
Name and qualification of principal investigator/researcher: Linley Muhondo, MTech: Chiropractic	Name and qualification of supervisor(s): Yasmeen Thandar, B. Pharm MMedSc (Clin Pharm) PhD (Pharmacology) (Supervisor) Colette Kell, M. Tech Hom (Co-Supervisor)
Name of qualification: MTech: Chiropractic	Student Number: 21205680
Ethical approval number: IREC 054/21	Research site: Kwa Zulu-Natal

Nature of amendment:
Removal of one Orchestra from the sample as gatekeeper permission could not be obtained.
Inclusion of option of electronic questionnaire

Effect on risk benefit profile of participants: None

Please submit the following documentation:

- Amended proposal (changes to be underlined)
- Changes to letter of information and consent
- Any other relevant documentation

Signature:	**Date: 03/12/2021**
Researcher:	
Supervisor:	
Head of Department:	

TO BE COMPLETED BY THE CHAIRPERSON OF THE IREC.

Date received:	Review required:
	Expedited

TO BE COMPLETED BY THE CHAIRPERSON OF THE IREC

The amendment is:	Yes	No	N/A
Approved – there are no evident grounds for concern or further investigation.			
Approved subject to minor changes			
Needs to be re-submitted after recommendations are met			
Approved however a site inspection is recommended.			
Denied (please see attached)			

	Signature:	**Date:**
Chairperson of FRC		
Chairperson of IREC		

Appendix M

Institutional Research Ethics Committee
Research and Postgraduate Support Directorate
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11 April 2021

Ms L M Muhondo
2 Silver Mist
9 Dalry Road
Scottsville
Pietermaritzburg

Dear Ms Muhondo

Application for Amendment of Approved Research Proposal

An epidemiological investigation into Musculoskeletal pain in KwaZulu- Natal orchestral musicians
Ethical Clearance number IREC 054/21

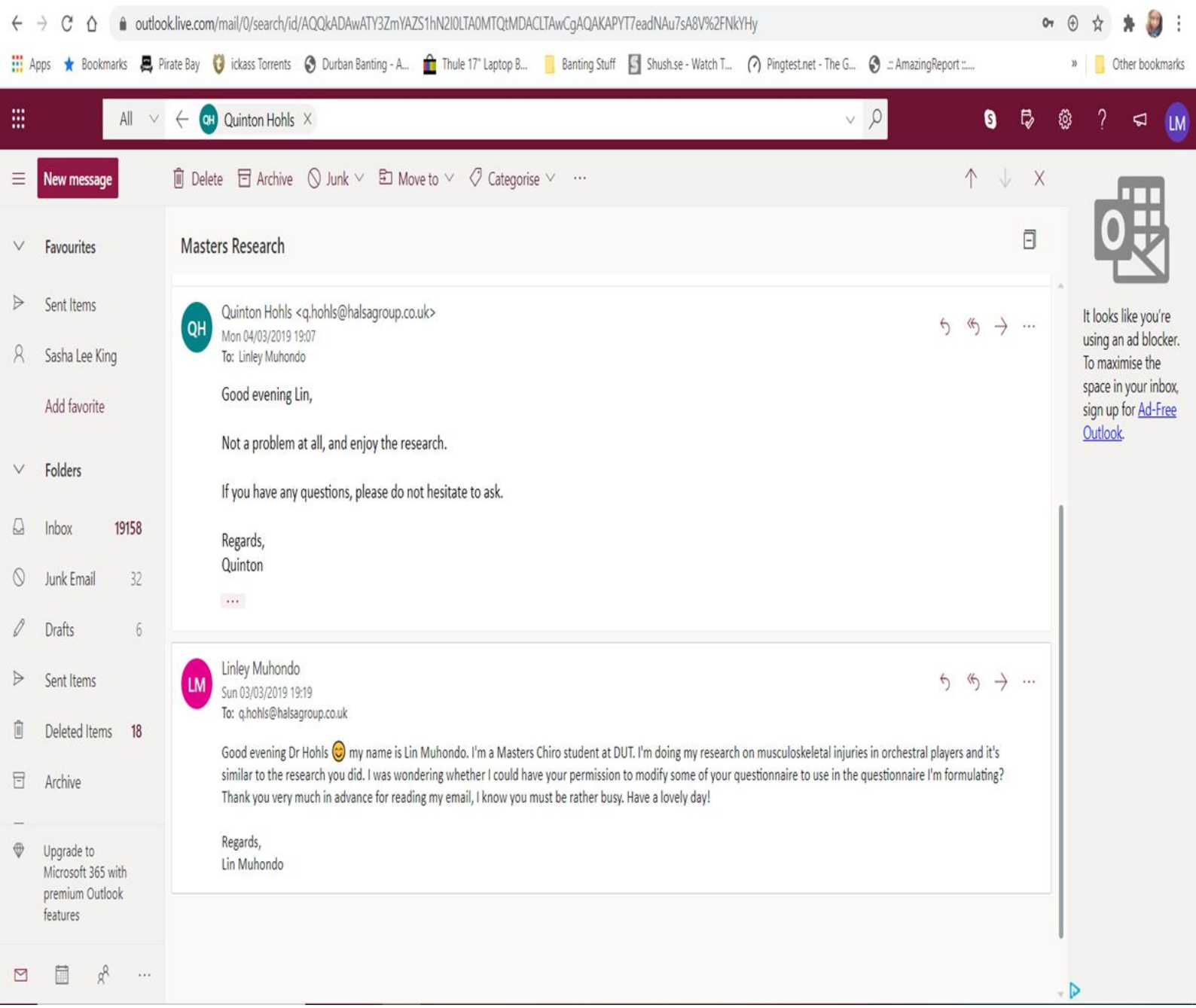
I am pleased to inform you that your application for amendment has been approved.

Yours Sincerely

Prof J K Adam
Chairperson: IREC

6 August 2020

Appendix N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Apps
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Durban Banting - A...
Thule 17" Laptop B...
Banting Stuff
Shush.se - Watch T...
Pingtest.net - The G...
::: AmazingReport :::...
Other bookmarks
All
Quinton Hohls
New message
Delete
Archive
Junk
Move to
Categorise
Favourites
Sent Items
Sasha Lee King
Add favorite
Folders
Inbox 19158
Junk Email 32
Drafts 6
Sent Items
Deleted Items 18
Archive
Upgrade to Microsoft 365 with premium Outlook features
Masters Research
Quinton Hohls <q.hohls@halsagroup.co.uk>
Mon 04/03/2019 19:07
To: Linley Muhondo
Good evening Lin,
Not a problem at all, and enjoy the research.
If you have any questions, please do not hesitate to ask.
Regards,
Quinton
Linley Muhondo
Sun 03/03/2019 19:19
To: q.hohls@halsagroup.co.uk
Good evening Dr Hohls my name is Lin Muhondo. I'm a Masters Chiro student at DUT. I'm doing my research on musculoskeletal injuries in orchestral players and it's similar to the research you did. I was wondering whether I could have your permission to modify some of your questionnaire to use in the questionnaire I'm formulating? Thank you very much in advance for reading my email, I know you must be rather busy. Have a lovely day!
Regards,
Lin Muhondo
It looks like you're using an ad blocker. To maximise the space in your inbox, sign up for Ad-Free Outlook.

BIBLIOGRAPHY

Abréu-Ramos, A. M. and Micheo, W. F. 2007. Lifetime Prevalence of Upper-body Musculoskeletal Problems in a Professional-level Symphony Orchestra: Age, Gender, and Instrument-specific Results. *Medical Problems of Performing Artists*, 22 (3): 97-104.

Ackermann, B. and Driscoll, T. 2010. Development of a New Instrument for Measuring the Musculoskeletal Load and Physical Health of Professional Orchestral Musicians. *Medical Problems of Performing Artists*, 25: 95-101.

Ackermann, B., Driscoll, T. and Kenny, D. T. 2012. Musculoskeletal Pain and Injury in Professional Orchestral Musicians in Australia. *Medical Problems of Performing Artists*, 27 (4): 181-187.

Ackermann, B., Kenny, D., O'Brien, I. and Driscoll, T. 2014. Sound Practice-improving occupational health and safety for professional orchestral musicians in Australia. *Frontiers in Psychology*, 5.

Ackermann, B. J. 2019. Diversity and Training in Performing Arts Medicine. *Medical Problems of Performing Artists*, 34 (2): 122-123.

Ajidahun, A. T., Mudzi, W., Myezwa, H. and Wood, W. 2017. Musculoskeletal problems among string instrumentalists in South Africa. *South African Journal of Physiotherapy*, 73 (1): 1-7.

Ajidahun, A. T. and Phillips, J. 2013. Prevalence of Musculoskeletal Disorders Among Instrumental Musicians at a Center for Performing Arts in South Africa. *Medical Problems of Performing Artists*, 28 (2): 96-99.

Akodu, A. K. and Ashalejo, Z. O. 2019. Work-related musculoskeletal disorders and work ability among hospital nurses. *Journal of Taibah University Medical Sciences*, 14 (3): 252-261.

Almekinders, L. C. and Temple, J. D. 1998. Etiology, diagnosis, and treatment of tendonitis: an analysis of the literature. *Medicine and science in sports and exercise*, 30 (8): 1183-1190.

Arain, M., Campbell, M. J., Cooper, C. L. and Lancaster, G. A. 2010. What is a pilot or feasibility study? A review of current practice and editorial policy. *BMC Research Methodology*, 10 (67): 1-7.

Ascenso, S., Williamon, A. and Perkins, R. 2017. Understanding the wellbeing of professional musicians through the lens of Positive Psychology. *Psychology of Music*, 45 (1): 65-81.

Azar, N. R. 2020. Rates and Patterns of Playing-Related Musculoskeletal Disorders in Drummers. *Medical Problems of Performing Artists*, 35 (3): 153-161.

Baadjou, V., Roussel, N., Verbunt, J., Smeets, R. and Bie, R. 2016. Systematic review: Risk factors for musculoskeletal disorders in musicians. *Occupational Medicine*, 66 (8).

Barton, R. and Feinberg, J. R. 2008. Effectiveness of an educational program in health promotion and injury prevention for freshman music majors. *Medical Problems of Performing Artists*, 23 (2): 47-53.

Berque, P., Gray, H. and McFadyen, A. 2014. Development and psychometric evaluation of the Musculoskeletal Pain Intensity and Interference Questionnaire for professional Orchestral Musicians. *Manual Therapy*, Article ID: 575-588.

Bragge, P., Bialocerkowski, A. and McMeeken, J. 2006. A systematic review of prevalence and risk factors associated with playing-related musculoskeletal disorders in pianists. *Occupational Medicine*, 56 (1): 28-38.

Brandfonbrener, A. G. 2003. Musculoskeletal problems of instrumental musicians. *Hand Clinics*, 19 (2): 231-239, .

Brandfonbrener, A. G. 2009. History of Playing-related Pain in 330 University Freshman Music Students. *Medical Problems of Performing Artists*, 24 (1): 30-36.

Briefly. 2022. *What is the average salary in South Africa in 2023?* Available: https://briefly.co.za/30142-what-average-salary-south-africa.html (Accessed 18 November 2022).

Brien, K., Lukhele, Z., Nhlapo, J. M., Pieterse, A., Swanepoel, A., Wagener, L. and Mashola, M. K. 2018. Work-related musculoskeletal disorders in nurses working in South African spinal cord rehabilitation units. *International Journal of Africa Nursing Sciences*, Article ID.

Briggs, A. M., Cross, M. J., Hoy, D. G., Sanchez-Riera, L., Blyth, F. M., Woolf, A. D. and March, L. 2016. Musculoskeletal Health Conditions Represent a Global Threat to Healthy Aging: A report for the 2015 World Health Organisation World Report on Ageing and Health. *The Gerontologist*, 56 (2): S243-S255.

Brusky, P. 2009. High Prevalence of Performance-related Musculoskeletal Disorders in Bassoon Players. *Medical Problems of Performing Artists*, 24 (2): 81-87.

Çalisgan, E., Ünal, İ. and Burcu, T. 2018. Evaluation of pain and functional disability body parts seen between musicians playing string instruments. *İnönü Üniversitesi Kültür ve Sanat Dergisi*, 4 (1): 1-8.

Calorie Control Council. 2022. *BMI Calculator*. Available: https://caloriecontrol.org/healthy-weight-tool-kit/bmi-calculator/ (Accessed 04 December 2022).

Carpenter, B., Nyirenda, M. and Hanass-Hancock, J. 2021. Disability, a priority area for health research in South Africa: an analysis of the burden of disease study 2017. *Disability and Rehabilitation*, Article ID: 1-9.

Cebriá i Iranzo, M., Pérez-Soriano, P., Camacho, C. I., Belloch, S. L. and Cortell-Tormo, J. M. 2010. Playing-related musculoskeletal disorders in woodwind, brass and percussion players: a review. *Journal of Human Sport and Exercise*, 5 (1): 94-100.

Centers for Disease Control and Prevention. 2022. *Physical activity*. Available: https://www.cdc.gov/physicalactivity/basics/adults/index.htm#:~:text=Each%20week%20adults%20need%20150,Physical%20Activity%20Guidelines%20for%20Americans.&text=We%20know%20150%20minutes%20of,do%20it%20all%20at%20once (Accessed 03 January 2023).

Chan, C. and Ackermann, B. 2014. Evidence-informed physical therapy management of performance-related musculoskeletal disorders in musicians. *Frontiers in Psychology*, 5: 1-14.

Chan, C., Driscoll, T. and Ackermann, B. 2013. The usefulness of on-site physical therapy-led triage services for professional orchestral musicians-a national cohort study. Article ID.

Chernenko, A., Meeks, H. and Smith, K. R. 2019. Examining validity of body mass index calculated using height and weight data from the US driver license. *BMC public health*, 19 (1): 1-11.

Chesky, K., Devroop, K. and Ford, J. 2002. Medical Problems of Brass Instrumentalists: Prevalence Rates for Trumpet, Trombone, French Horn, and Low Brass. *Medical Problems of Performing Artists*, 17 (2): 93-98.

Chong, J., Lynden, M., Harvey, D. and Peebles, M. 1989. Occupational health problems of musicians. *Canadian family physician*, 35: 2341.

Collins, I. H. 2013. Available: https://ebookcentral.proquest.com/lib/durbanut-ebooks/detail.action?docID=1501715 (Accessed 16 October 2022).

Crawford, J. O. 2007. The Nordic musculoskeletal questionnaire. *Occupational medicine*, 57 (4): 300-301.

Cruder, C., Barbero, M., Koufaki, P., Soldini, E. and Gleeson, N. 2020. Prevalence and associated factors of playing-related musculoskeletal disorders among music students in Europe. Baseline findings from the Risk of Music Students (RISMUS) longitudinal multicentre study. *PLOS One*, 15 (12): 1-24.

Cruder, C., Falla, D., Mangili, F., Azzimonti, L., Araújo, L. S., Williamon, A. and Barbero, M. 2018. Profiling the Location and Extent of Musicians' Pain Using Digital Pain Drawings. *Pain Practice*, 18 (1): 53-66.

Cruder, C., Koufaki, P., Barbero, M. and Gleeson, N. 2019. A longitudinal investigation of the factors associated with increased RISk of playing-related musculoskeletal disorders in MUsic students (RISMUS): a study protocol. *BMC Musculoskeletal Disorders*, 20 (64): 1-8.

Dahl, A. G., Havang, S. and Hagen, K. 2022. Reliability of a self-administrated musculoskeletal questionnaire: The fourth Trondelag health study. *Musculoskeletal Science & Practice*, 57.

De Barros, E. N. C. and Alexandre, N. M. C. 2003. Cross-cultural adaptation of the Nordic musculoskeletal questionnaire. *International nursing review*, 50 (2): 101-108.

Detari, A., Egermann, H., Bjerkeset, O. and Vaag, J. 2020. Psychosocial Work Environment Among Musicians and in the General Workforce in Norway. *Frontiers in Psychology*, 11: 1-10.

Devroop, K. 2014. Performing arts medicine : a research model for South Africa. *TD :The Journal for Transdisciplinary Research in Southern Africa*, 10 (2): 47-56.

Elam, T., Mowen, S. and Jonas, C. 2022. Occupational injuries in musicians: a literature review. *Military medicine*, 187 (5-6): e619-e623.

Em, S., Oktayoglu, P., Bozkurt, M., Caglayan, M., Karakoc, M., Ucar, D., Verim, S., Yildiz, I., Sariyildiz, M. A., Evliyaoglu, O. and Nas, K. 2015. Serum relaxin levels in benign hypermobility syndrome. *Journal of Back and Musculoskeletal Rehabilitation*, 28: 473-479.

Gasenzer, E. R., Klumpp, M. J., Pieper, D. and Neugebauer, E. A. 2017. The prevalence of chronic pain in orchestra musicians. *German Medical Science*, 15: Doc01.

Gembris, H., Heye, A. and Seifert, A. 2018. Health problems of orchestral musicians from a life-span perspective: results of a large-scale study. *Music & Science*, 1: 1-20.

Glória, J. C., Balestra, A. A., Iasbik, N. S., Douglas-de-Oliveira, D. W., Flecha, O. D. and Gonçalves, P. F. 2018. Prevalence of Orofacial Changes in Wind Instrumentalists: A Cross-Sectional Pilot Study in Brazil. *Medical Problems of Performing Artists*, 33 (1): 1-5.

Greer, J. M. and Panush, R. S. 1994. Musculoskeletal problems of performing artists. *Baillière's clinical rheumatology*, 8 (1): 103-135.

Gross, S. A. and Musgrave, G. 2016. Can Music make you sick? Music and Depression. *MusicTank*, Article ID: 1-69.

Guptill, C., Zaza, C. and Paul, S. 2000. An occupational study of physical playing-related injuries in college music students. *Medical Problems of Performing Artists*, 15 (2): 86-90.

Hanania, A. N., Cook, A., Threadgill, M. P., Conway, S. H. and Ludwig, M. 2020. Prevalence of Musculoskeletal Work-related Injuries Among Radiation Therapists. *Radiologic Technology*, 91 (5): 414-421.

Hansen, T., Sevenius Nilsen, T., Knapstad, M., Skirbekk, V., Skogen, J., Vedaa, Ø. and Nes, R. B. 2022. Covid-fatigued? A longitudinal study of Norwegian older adults' psychosocial well-being before and during early and later stages of the COVID-19 pandemic. *European journal of ageing*, 19 (3): 463-473.

Heming, M. J. E. 2004. Occupational injuries suffered by classical musicians through overuse. *Clinical Chiropractic*, 7 (2): 55-66.

Hohls, Q. R. 2010. An investigation into performance related musculoskeletal disorders of professional orchestral string musicians in South Africa. MTech: Chiropractic, Durban University of Technology. Available: https://openscholar.dut.ac.za/handle/10321/542 (Accessed 16 February 2020).

Holst, G. J., Paarup, H. M. and Baelum, J. 2011. A cross-sectional study of psychosocial work environment and stress in the Danish symphony orchestras. *International Archives of Occupational and Environmental Health*, 85: 639-649.

Hutchinson pocket dictionary of classical music, . 2005. Available: https://ebookcentral.proquest.com/lib/durbanut-ebooks/detail.action?docID=268794 (Accessed 09 June 2022).

Independent Financial Consultants. 2022. *2022 Medical Aid Costs in South Africa*. Available: https://www.medicalaid-quotes.co.za/articles/2022-medical-aid-costs-south-africa (Accessed 15 January 2023).

Institute of Regenerative Orthopaedics and Sports Medicine. 2021. *Cubital tunnel syndrome*. Available: https://irosm.com/cubital-tunnel-syndrome/ (Accessed 15 January 2023).

Jabusch, H. C., Müller, S. V. and Altenmüller, E. 2004. Anxiety in musicians with focal dystonia and those with chronic pain. *Movement Disorders: official Journal of the Movement Disorder Society*, 19 (10): 1169-1175.

Jacukowicz, A. 2016. Psychosocial work aspects, stress and musculoskeletal pain among musicians. A systematic review in search of correlates and predictors of playing-related pain. *Work*, 54: 657-668.

Johansson, Y. L. and Theorell, T. 2003. Satisfaction with work task quality correlates with employee health: a study of 12 professional orchestras. *Medical Problems of Performing Artists*, 18: 141-149.

Jones Jr, S. and Hernandez, C. 2010. An investigation of the prevalence of upper limb neuropathies in different types of college musicians by use of neurometrix device. *International Journal of Biology*, 2 (1): 132.

Júdez Torres, M. 2019. Efficacy of night splinting and neurodynamics on cubital tunnel syndrome in musicians: randomized controlled trial. Article ID.

Kahere, M. and Ginindza, T. 2021. The prevalence and risk factors of chronic low back pain among adults in KwaZulu-Natal, South Africa: an observational cross-sectional hospital-based study. *BMC Musculoskeletal Disorders*, 22.

Karabinov, V. and Georgiev, G. P. 2022. Lateral epicondylitis: New trends and challenges in treatment. *World Journal of Orthopedics*, 13 (4): 354.

Kaselouris, E., Bakarezos, M., Tatarakis, M., Papadogiannis, N. A. and Dimitriou, V. 2022. A Review of Finite Element Studies in String Musical Instruments. *Acoustics*, 4 (1): 183-202.

Kaufman-Cohen, Y. and Ratzon, N. Z. 2011. Correlation between risk factors and musculoskeletal disorders among classical musicians. *Occupational Medicine*, 61 (2): 90-95.

Kaur, J. and Singh, S. 2016. Neuromusculoskeletal problems of upper extremities in musicians-a literature review. *International Journal of Therapies and Rehabilitation Research*, 5 (2): 14.

Kenny, D. and Ackermann, B. 2015. Performance-related musculoskeletal pain, depression and music performance anxiety in professional orchestral musicians: A population study. *Psychology of Music*, 43 (1): 43-60.

Kenny, D., Driscoll, T. and Ackermann, B. 2012. Psychological Well-being in professional orchestral musicians in Australia: A descriptive population study. *Psychology of Music*, Article ID: 1-23.

Kirsch Micheletti, J., Bláfoss, R., Sundstrup, E., Bay, H., Pastre, C. M. and Andersen, L. L. 2019. Association between lifestyle and musculoskeletal pain: cross-sectional study among 10,000 adults from the general working population. *BMC Musculoskeletal Disorders*, 20 (1): 1-8.

Kochem, F. B. and Silva, J. G. 2018. Prevalence of Playing-related Musculoskeletal Disorders in String Players: A systematic Review. *Journal of Manipulative and Physiological Therapeutics*, Article ID: 1-10.

Kok, L. M., Huisstede, B. M. A., Voorn, V. M. A., Schoones, J. W. and Nelissen, R. G. H. H. 2016. The occurrence of musculoskeletal complaints among professional musicians: a systematic review. *International Archives of Occupational and Environmental Health*, 89 (3): 373-396.

Kok, L. M., Vlieland, T. P. M., Fiocco, M., Kaptein, A. A. and Nelissen, R. G. H. H. 2013a. Musicians' illness perceptions of musculoskeletal complaints. *Clinical Rheumatology*, 32: 487-492.

Kok, L. M., Vlieland, T. P. M. V., Fiocco, M. and Nelissen, R. G. H. H. 2013b. A comparative study on the prevalence of musculoskeletal complaints among musicians and non-musicians. *BMC Musculoskeletal Disorders*, 14 (1): 9.

Lamb, N. and Cook, S. J. L. 2002. *Guide to teaching strings*. McGraw-Hill Humanities Social.

Lamontagne, V. and Belanger, C. 2012. Development and Validation of a Questionnaire on Musculoskeletal Pain in Musicians. *Medical Problems of Performing Artists*, 27 (1): 37-42.

Lamprecht, A. and Padayachy, K. 2019. The epidemiology of work-related musculoskeletal injuries among chiropractors in the eThekwini municipality. *Chiropractic & Manual Therapies*, 27: 18.

Larsen, B. 2020. Examining music therapists' singing and playing-related injuries: A collective case study. Masters of Arts Degree, Saint Mary of the Woods College. Available: https://scholars.smwc.edu/bitstream/handle/20.500.12770/168/Larsen%2C%202020.pdf?sequence=1&isAllowed=y (Accessed 23 September 2022).

Leaver, R., Harris, E. C. and Palmer, K. T. 2011. Musculoskeletal pain in elite professional musicians from British symphony orchestras. *Occupational Medicine*, 61 (8): 549-555.

Lederman, R. J. 2003. Neuromuscular and musculoskeletal problems in instrumental musicians. *Muscle & Nerve: Official Journal of the American Association of Electrodiagnostic Medicine*, 27 (5): 549-561.

Lederman, R. J. 2006. Focal peripheral neuropathies in instrumental musicians. *Physical Medicine and Rehabilitation Clinics*, 17 (4): 761-779.

Liu, Y., Liu, G., Wei, D., Li, Q., Yuan, G., Wu, S., Wang, G. and Zhao, X. 2018. Effects of Musical Tempo on Musicians' and Non-musicians' Emotional Experience When Listening to Music. *Frontiers in Psychology*, 9: 2118.

Llobet, R. 2004. Musicians health problems and in their relation to musical education. *The ISME Commission for Education of the Professional Musician. Preparing Musicians: Making Sound Worlds*, Article ID: 195-209.

Lukomski, L. 2004. Common Injuries of Musicians. Honours, Western Michigan University. Available: https://scholarworks.wmich.edu/cgi/viewcontent.cgi?article=2666&context=honors_theses (Accessed 07 January 2023).

Mäntyniemi, A., Oksanen, T., Salo, P., Virtanen, M., Sjösten, N., Pentti, J., Kivimäki, M. and Vahtera, J. 2012. Job strain and the risk of disability pension due to musculoskeletal disorders, depression or coronary heart disease: a prospective cohort study of 69 842 employees. *Occupational and Environmental Medicine*, 69 (8): 574-581.

Marić, D., Stojić, M. D., Maric, M., Susnjevic, S., Radošević, D. and Knezi, N. 2019. A Painful Symphony: The Presence of Overuse Syndrome in Professional Classical Musicians. *International Journal of Morphology*, 37: 1118-1122.

Maric, D. L., Stojic, M., Maric, D. M., Susnjevic, S., D., R. and Knezi, N. 2019. A painful symphony: The presence of overuse syndrome in professional classical musicians. *International Journal of Morphology*, 37 (3): 1118-1122.

Marjoua, Y. 2023. *Tennis Elbow*. Available: https://marjouamd.com/tennis-elbow/ (Accessed 15 January 2023
).

Matei, R., Broad, S., Goldbart, J. and Ginsborg, J. 2018. Health Education for Musicians. *Frontiers in Psychology*, 9.

Mátó, V., Tarkó, K., Lippai, L., Nagymajtényi, L. and Paulik, E. 2021. Psychosocial work environment risk factors among university employees–A cross-sectional study in Hungary. *Slovenian Journal of Public Health*, 60 (1): 10-16.

Mayo Clinic. 2022. *Thoracic outlet syndrome*. Available: https://www.mayoclinic.org/diseases-conditions/thoracic-outlet-syndrome/symptoms-causes/syc-20353988 (Accessed 20 January 2023).

Mayo Clinic. 2023. *Medial epicondylitis A.K.A Golfer's elbow*. Available: https://www.nolasportsmedicine.com/blog/medial-epicondylitis-aka-golfers-elbow (Accessed 15 January 2023).

Mazzara, J. 2023. *Cubital Tunnel Syndrome*. Available: https://hartfordsportsorthopedics.com/cubital-tunnel-syndrome-ulnar-nerve-compression-south-windsor-enfield-glastonbury-ct/ (Accessed 15 January 2023).

Meisha, D. E., Alsharqawi, N. S., Samarah, A. A. and Al-Ghamdi, M. Y. 2019. Prevalence of work-related musculoskeletal disorders and ergonomic practice among dentists in Jeddah, Saudi Arabia. *Clinical, Cosmetic and Investigational Dentistry*, 11: 171.

Meissner, H. and Timmers, R. 2020. Young Musicians' Learning of Expressive Performance: The Importance of Dialogic Teaching and Modeling. *Frontiers in Education*, 5.

Mekonnen, T. H., Kekeba, G. G., Azanaw, J. and Kabito, G. G. 2020. Prevalence and healthcare seeking practice of work-related musculoskeletal disorders among informal sectors of hairdressers in Ethiopia, 2019: findings from a cross-sectional study. *BMC Public Health*, 20 (1): 718.

Merriam-Webster. 2023. Available: https://www.merriam-webster.com/dictionary/tutti (Accessed 02 February 2023).

Mishra, W., De, A., Gangopadhyay, S. and Chandra, A. M. 2013. Playing-related musculoskeletal disorders among Indian tabla players. *Medical Problems of Performing Artists* 28 (2): 107-111.

Mizrahi, J. 2021. Identifying and Evaluating Vocation-Related Neuro-Musculoskeletal Deficiencies in Professional Musicians: A Review. *Applied Sciences*, 11 (5): 2035.

Moodley, R. and Naidoo, S. 2015. The prevalence of musculoskeletal disorders among dentists in KwaZulu-Natal : research. *South African Dental Journal*, 70 (3): 98-103.

Moraes, G. F. d. S. and Antunes, A. P. 2012. Musculoskeletal disorders in professional violinists and violists: Systematic review. *Acta ortopedica brasileira*, 20: 43-47.

Nawrocka, A., Mynarski, W., Powerska, A., Grabara, M., Groffik, D. and Borek, Z. 2014. Health-oriented physical activity in prevention of musculoskeletal disorders among young Polish musicians. *International Journal of Occupational Medicine and Environmental Health*, 27 (1): 28-37.

New York Jazz Workshop. 2023. *Alexander Technique for Musicians*. Available: https://newyorkjazzworkshop.com/alexander-technique-musicians/#:~:text=The%20Alexander%20Technique%20relates%20to,limits%20to%20prevent%20overuse%20injuries. (Accessed 15 January 2023).

Nuzzo, J. 2021. Volunteer Bias and Female Participation in Exercise and Sports Science Research. *Quest*, 73 (1): 82-101.

Nyman, T., Wiktorin, C., Mulder, M. and Johansson, Y. L. 2007. Work postures and neck–shoulder pain among orchestra musicians. *American journal of industrial medicine*, 50 (5): 370-376.

O'Neill, J. 2019. A study of performance-related injuries among BMus violin students in South Africa. Article IDStellenbosch: Stellenbosch University. Available: https://core.ac.uk/download/pdf/196259847.pdf (Accessed 15 January 2022).

Ohlendorf, D., Maurer, C., Bolender, E., Kocis, V., Song, M. and Groneberg, D. A. 2018. Influence of ergonomic layout of musician chairs on posture and seat pressure in musicians of different playing levels. *PLOS One*, 13 (12): 1-14.

Ojukwu, C. P., Anyanwu, G. E., Eze, B., Chukwu, S. C., Onuchukwu, C. L. and Anekwu, E., Morris. 2021. Prevalence, pattern and correlates of work-related musculoskeletal disorders among school teachers in Enugu, Nigeria. *International Journal of Occupational Safety and Ergonomics*, 27 (1).

Otufowora, A., Liu, Y., Young, H., Egan, K. L., Varma, D. S., Striley, C. W. and Cottler, L. B. 2021. Sex differences in willingness to participate in research based on study risk level among a community sample of African Americans in North Central Florida. *Journal of immigrant and minority health*, 23: 19-25.

Oxford South African Concise Dictionary Second Edition. 2010. 2nd ed. Cape Town, South Africa: Oxford University Press Southern Africa.

Paarup, H. M., Baelum, J., Holm, J. W., Manniche, C. and Wedderkopp, N. 2011. Prevalence and Consequences of musculoskeletal symptoms in symphony orchestra musicians vary by gender: a cross-sectional study. *BMC Musculoskeletal Disorders*, 12: 223.

Papandreou, M. and Vervainioti, A. 2010. Work-related musculoskeletal disorders among percussionists in Greece: a pilot study. *Medical Problems of Performing Artists*, 25 (3): 116-119.

Parker, R. and Jelsma, J. 2010. The prevalence and functional impact of musculoskeletal conditions amongst clients of a primary health care facility in an under-resourced area of Cape Town. *BMC Musculoskeletal Disorders*, 11 (1): 1-7.

Parmar, B. A. and Shukla, Y. U. 2020. Effect of Eccentric versus Concentric Exercise on Pain, Grip Strength and Function in Lateral Epicondylitis-A Comparative Study. *International Journal of Science and Healthcare Research*, 5 (2): 98-109.

Pascarelli, E. F. and Hsu, Y.-P. 2001. Understanding work-related upper extremity disorders: clinical findings in 485 computer users, musicians, and others. *Journal of Occupational Rehabilitation*, 11 (1): 1-21.

Pratt, E., Vauth, H., McIlvain, G. and Timmons, M. K. 2020. Musicians Have Thicker Median Nerve Cross Sectional Area and More Symptoms of Carpal Tunnel Than Non-Musicians. *Medical Problems of Performing Artists*, 35 (3): 138-144.

Quarrier, N. F. 2013. Musicians are Athletes Too. *Journal of Yoga and Physical Therapy*, 3: 3.

Quartz. 2018. *Here's what the stark gender disparity among top orchestra musicians looks like*. Available: https://qz.com/work/1393078/orchestras#:~:text=Bassoon%20(86%25%20male)%2C,skewed%20in%20the%20other%20direction. (Accessed 17 December 2022).

Questionpro Survey Software. 2022. *Quantitative Research: What it is, Tips & Examples*. Available: https://www.questionpro.com/blog/quantitative-research/ (Accessed 12 December 2022).

Rahimi, F., Kazemi, K., Zahednejad, S., López-López, D. and Calvo-Lobo, C. 2018. Prevalence of Work-Related Musculoskeletal Disorders in Iranian Physical Therapists: A Cross-sectional Study. *Journal of Manipulative and Physiological Therapeutics*, 41 (6): 503-507.

Redivo, V. S. and Olivier, B. 2021. Time to re-think our strategy with musculoskeletal disorders and workstation ergonomics. *The South African Journal of Physiotherapy*, 77 (1): 1490.

Rickert, D. L., Barrett, M. S. and Ackermann, B. 2013. Injury and the orchestral environment: Part I. *Med Probl Perform Art*, 28 (4): 219-229.

Rickover, R. 2023. *How the Alexander Technique can help Musicians*. Available: https://alexandertechnique.com/musicians/ (Accessed 05 January 2023).

Rietveld, A. B. M. 2013. Dancers' and musicians' injuries. *Clinical Rheumatology*, 32 (4): 425-434.

Rodríguez-Gude, C., Sousa, C. M., Taboada-Iglesias, Y. and Pino-Juste, M. 2022. Musculoskeletal pain in musicians: does playing more than one instrument have more effect? *International Journal of Occupational Safety and Ergonomics*, Article ID: 1-6.

Rodríguez-Gude, C., Taboada-Iglesias, Y. and Pino-Juste, M. 2022. Musculoskeletal pain in musicians: prevalence and risk factors – a systematic review. *International Journal of Occupational Safety and Ergonomics*, Article ID: 1-19.

Rotter, G., Noeres, K., Fernholz, I., Willich, S. N., Schmidt, A. and Berghofer, A. 2020. Musculoskeletal disorders and complaints in professional musicians: a systematic review of prevalence, risk factors, and clinical treatment effects. *International Archives of Occupational and Environmental Health*, 93: 149-187.

Schalow, P. R. 2020. Chiropractic Management of Performance Related Musculoskeletal Disorder in a Career Violist. *American Journal of Case Reports*, 21: 1-6.

Sergeant, D. C. and Himonides, E. 2019. Orchestrated sex: The representation of male and female musicians in world-class symphony orchestras. *Frontiers in Psychology*, 10: 1760.

Setia, M. S. 2016. Methodology series module 3: Cross-sectional studies. *Indian journal of dermatology*, 61 (3): 261.

Smith, F. W. and Smith, P. A. 2002. Musculoskeletal differences between males and females. *Sports Medicine and Arthroscopy Review*, 10 (1): 98-100.

Sousa, C. M., Machado, J. P., Greten, H. J. and Coimbra, D. 2017. Playing-Related Musculoskeletal Disorders of Professional Orchestra Musicians from the North of Portugal: Comparing String and Wind Musicians. *Acta Med Port*, 30 (4): 302-306.

Stanhope, J. 2018. University woodwind students' playing-related injuries: a pilot study investigating beliefs, attitudes and prevention strategies. *Australian Journal of Music Education*, 52 (1): 29-42.

Stanhope, J., Milanese, S. and Grimmer, K. 2014. University woodwind students' experiences with playing-related injuries and their management: a pilot study. *Journal of pain research*, 7: 133-148.

Stanhope, J., Pisaniello, D. and Weinstein, P. 2020. The effect of strategies to prevent and manage musicians' musculoskeletal symptoms: A systematic review. *Archives of Environmental and Occupational Health*, Article ID: 1-24.

Stanhope, J., Pisaniello, D. and Weinstein, P. 2021. What do musicians think caused their musculoskeletal symptoms? *International Journal of Occupational Safety and Ergonomics*, Article ID: 1-10.

Stanhope, J., Tooher, R., Pisaniello, D. and Weinstein, P. 2019. Have Musicians' Musculoskeletal Symptoms been thoroughly adressed? A systematic mapping review. *International Journal of Occupational Medicine and Environmental Health*, 32 (3): 291-331.

Stanhope, J., Weinstein, P. and Pisaniello, D. 2020. What can musicians' claims data reveal about their musculoskeletal conditions? *Archives of Environmental & Occupational Health*, 75 (3): 177-190.

Steinmetz, A., Scheffer, I., Esmer, E., Delank, K. S. and Peroz, I. 2015. Frequency, severity and predictors of playing-related musculoskeletal pain in professional orchestral musicians in Germany. *Clinical Rheumatology*, 34 (5): 965-973.

Steinmetz, A., Stang, A., Kornhuber, M., Röllinghoff, M., Delank, K.-S. and Altenmüller, E. 2014. From embouchure problems to embouchure dystonia? A survey of self-reported embouchure disorders in 585 professional orchestra brass players. *International Archives of Occupational and Environmental Health*, 87 (7): 783-792.

Sukamolson, S. 2007. Fundamentals of quantitative research. *Language Institute Chulalongkorn University*, 1 (3): 1-20.

Taylor, D. 2020. How Classical musicians can make money online with Patreon. Available: https://dittomusic.com/en/blog/how-to-make-more-money-with-patreon-for-musicians/ (Accessed 9 August 2022).

Temple Health. 2022. *Is Your Wrist Pain a Sign of Carpal Tunnel Syndrome?* Available: https://www.templehealth.org/about/blog/is-your-wrist-pain-carpal-tunnel-syndrome (Accessed 15 January 2023).

Tripepi, G., Jager, K. J., Dekker, F. W. and Zoccali, C. 2010. Selection Bias and Information Bias in Clinical Research. *Nephron Clinical Practice*, 115 (2): c94-c99.

United States Department of Labour. 2007. *Musicians, singers and related workers.* Available: http://www.bls.gov/oco/ocos095.htm (Accessed 07 January 2023).

University of Bath. 2021. *South Africa- Country Profile*. Available: https://tobaccotactics.org/wiki/south-africa-country-profile/ (Accessed 02 November 2022).

Usarov, G. and Ismoilova, M. 2022. Symphony Orchestra and its Instruments. *International Journal of Inclusive and Sustainable Education*, 1 (5): 140-142.

Vaag, J., Bjerkeset, O. and Sivertsen, B. 2021. Anxiety and Depression Symptom Level and Psychotherapy Use Among Music and Art Students Compared to the General Student Population. *Frontiers in Psychology*, 12: 1-8.

Van Hees, O. S. 1997. Physical exercise as prevention for musculoskeletal problems in musicians: a panacee demasque. In: Proceedings of *Proceedings of Health and the Musician Conference*. British Performing Arts Medicine Trust New York, A1. 20-A21. 30.

van Selms, M. K. A., Wiegers, J. W., van der Meer, H. A., Ahlberg, J., Lobbezoo, F. and Visscher, C. M. 2020. Temporomandibular disorders, pain in the neck and shoulder area, and headache among musicians. *Journal of Oral Rehabilitation*, 47 (2): 132-142.

Victor, E. A., Valeria, U. K., Ebere, I. Y., Echezona, E. N. and Okoroafor, A. U. 2016. Musculoskeletal symptoms among string instrumentalists in the Nigerian population: a cross-sectional study of prevalence and associated risk factors. *International journal of Human Factors and Ergonomics*, 4 (2): 169.

Wilke, J., Vleeming, A. and Wearing, S. 2019. Overuse Injury: The Result of Pathologically Altered Myofascial Force Transmission? *Exerc Sport Sci Rev*, 47 (4): 230-236.

Wilson, R. J., Watson, J. T. and Lee, D. H. 2014. Nerve entrapment syndromes in musicians. *Clinical Anatomy*, 27 (6): 861-865.

Wolf, J. M., Cameron, K. L. and Owens, B. D. 2011. Impact of Joint Laxity and Hypermobility on the Musculoskeletal System. *JAAOS - Journal of the American Academy of Orthopaedic Surgeons*, 19 (8): 463-471.

Wolff, A. M. 2020. The epidemiology of work related back pain in full-time restaurant waitron staff within the eThekwini Municipality. Article ID. Available: https://openscholar.dut.ac.za/handle/10321/3972 (Accessed 24 November 2022).

Wu, J. S. 2007. Occupational risk factors for musculoskeletal disorders in musicians: A systematic review. *Medical Problems of Performing Artists*, 22: 43-51.

Xiong, J., Lipsitz, O., Nasri, F., Lui, L. M. W., Gill, H., Phan, L., Chen-Li, D., Iacobucci, M., Ho, R. and Majeed, A. 2020. Impact of COVID-19 pandemic on mental health in the general population: A systematic review. *Journal of Affective Disorders*, 277: 55-64.

Yang, N., Fufa, D. T. and Wolff, A. L. 2021. A musician-centered approach to management of performance-related upper musculoskeletal injuries. *Journal of Hand Therapy*, 34 (2): 208-216.

Yongolo, N. M., Halliday, J., Bunn, C., Mtesha, B., Kelly, C., Krauth, S. J., Mwingwa, A., Biswaro, S. M., Siebert, S. and Kipengele, A. H. 2022. *Estimating prevalence and predictors of musculoskeletal disorders in Tanzania–A pilot study*. Available:

https://www.researchsquare.com/article/rs-1645605/latest.pdf (Accessed 16 December 2022).

Yoshimura, E., Fjellman-Wiklund, A., Mia Paul, P., Aerts, C. and Chesky, K. 2008. Risk factors for playing-related pain among piano teachers. *Medical Problems of Performing Artists*, 23 (3): 107-113.

Zaza, C. 1998. Playing-related musculoskeletal disorders in musicians: a systematic review of incidence and prevalence. *Canadian Medical Association Journal*, 158 (8): 1019-1025.

Zaza, C., Charles, C. and Muzynski, A. 1998. The meaning of playing-related musculoskeletal disorders to Classical Musicians. *Social Science and Medicine*, 47 (12): 2013-2023.

Zięba, E., Zieliński, G. and Ginszt, M. 2019. Etiology and epidemiology of playing-related musculoskeletal disorders–a systematic review. *Journal of Education, Health and Sport*, 9 (7): 115-135.

Zunjic, A. 2017. A new definition of ergonomics. *IETI transactions on Ergonomics and Safety*, 1 (1): 1-6.