<u>**Depressive symptomatology and lifelong music experience: a cross-sectional study**</u>

<u>**by**</u>

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Author's Declaration

I, Jennifer Asselstine, hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

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<u>Dedication</u>

I dedicate this thesis to my Papa, Jack. Thank you for waiting and for helping instill a love of music.

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List of Abbreviations

ANS Autonomic nervous system

CAGE-AID Conjoint screening questionnaires for alcohol and drug abuse

CCHS Canadian Community Health Survey

CESD Center for Epidemiologic Studies Depression Scale

CESD-R Center for Epidemiologic Studies Depression Scale Revised

CI Confidence interval

fMRI Functional magnetic resonance imaging

GAD-7 Generalized anxiety disorder 7-item scale

HPA Hypothalamic-pituitary-adrenal

MBJ Muscle, bone and joint

MHD Mental Health Disorders

MSK Musculoskeletal

MT Music therapy

OR Odds ratio

PSNS Parasympathetic nervous system

SAPS Short Almost Perfect Scale

SNS Sympathetic nervous system

Chapter 1: Introduction

Depression is a serious mental health disorder, with enormous costs to individuals and society. According to the 2012 Canadian Community Health Survey, approximately 1.9 million Canadians have reported a major depressive episode within the last twelve months.[1] While alarming, this figure does not capture the level of subclinical depression (or depressive symptomatology) in the Canadian population. Some estimates have suggested that the prevalence of subclinical depression is much higher, at 22%.[2] Hence, factors that mediate or prevent the development of subclinical depression are of interest. Music therapy has been shown to reduce feelings of depression in elderly patients, but it is unclear what the effect of playing music as a hobby may have on the development of depression.[3-11]

Some research has suggested that musicians may suffer from a disproportionate amount of mental health disorders when compared to their non-musical counterparts.[12-14] Music is frequently used as a way to reduce stress, and it is possible that individuals with serious mental health disorders (MHD) turn to music as a means of escape.[15-17] While several studies have suggested that professional musicians have higher levels of depression than their non-musical counterparts, this research has been conducted in musical professionals alone.[12-14] No study has evaluated the potential relationship between playing music as a hobby and the development of subclinical depression in university students. Based on studies regarding music therapy, it is highly plausible that music may offer a significant means by which to reduce the presence of depressive symptomatology. Further study on the impact of musicianship on the development of mood disorders is warranted.

A cross-sectional survey was used to pose questions to a group of university students regarding their experience playing a musical instrument over their lifetime and depressive symptomatology. Within the musician cohort, a further investigation was conducted into the relationship between improvisational ability and presence of mental health disorders. Additional information regarding potential confounding variables was also captured in the survey. Music has been shown to possess therapeutic qualities in certain demographics, but its association with depressive symptoms in average university students is unknown. [3-11, 18-21] Exploring this association will help to direct larger studies, and will allow us to hypothesize potential roles of music in relation to subclinical depression.

Short-term mood-boosting effects of music have been widely reported in the literature; however, these findings are often studied in a therapeutic context, and not treated as a lifelong exposure.[3-11, 18-21] This study is the first of its kind to employ a cross-sectional survey to ascertain different levels of musical exposure, as well as the musician's improvisatory capabilities. This study attempts to take a sample of average Canadian students and explore the potential relationship between lifelong music exposure and depressive symptomology.

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Chapter 2: Background

2.1 Depression

Depression (also known as "major depressive disorder" or "major depression") is a serious medical condition that is a major public health concern in Canadian society. Depression is characterized as a mood disorder in which an individual experiences changes in daily functioning as a result of altered physical, cognitive, and emotional states.[1-3] Examples of such changes may include decreased appetite, inability to concentrate, loss of energy, a lack of interest in previously enjoyed pastimes, and suicidal thoughts.[1-3] Depression is more than just a case of "the blues"- a depressed person is likely to feel sad, angry, anxious, guilty, ashamed, exhausted, hopeless, and alone.[2] A clinical diagnosis of depression typically involves visiting a trained medical professional, where the physician establishes that the affected individual has been experiencing depressive symptoms for at least two weeks.[3] While the exact biomedical mechanism of depression is unknown, clinicians recognize that it is the result of a complex interaction of genetic, environmental, personal, and emotional factors.[1-3]

Depression most commonly presents itself between the ages of 15-30, creating a vulnerable population in the young adult age group.[2-4] A review of depression studies in university students found that the prevalence of depression in students can range from 10-85%, but that studies are generally methodologically poor in quality.[5] Depression has also been found to be twice as common in females as it is in males.[1-3, 6-8] While each individual experiences depression uniquely, common risk factors include: presence of other mental health disorders (MHD) and conditions, low levels of physical activity, substance abuse, and presence of chronic health conditions.[2, 9-10] A lack of public knowledge and understanding of MHD such as

depression hinders preventative efforts. Considerable social stigma continues to surround mental health, leading to poor disease management and treatment. Due to outdated beliefs that depressive symptoms do not warrant professional help, many individuals choose to ignore or self-manage life-altering depressive symptoms.[1-2]

Presently, approximately 8% of Canadians have suffered from major depression at some point in their lives.[2] In the United States, it is estimated that one in every six Americans will suffer from depression at some point in their life.[3] However, undiagnosed depression also poses a serious public health issue as it also results in a great burden to society, and enormous costs to the health care system.[7, 11] The point prevalence of subclinical depression is difficult to determine, as a clinical diagnosis has generally been required to determine an accurate estimate. A study conducted in a Saskatchewan working population reported a one-week period prevalence of depressive symptomatology of 22.2%.[7]

Depressive symptomatology refers to a set of depressive symptoms frequently seen in major depression.[7] While increased morbidity is associated with major depression, subclinical depression and/or depressive symptomatology is a growing population health concern in society.[7] Depressive symptomatology differs from clinical depression in that any individual may display or feel depressive symptoms, without receiving a clinical diagnosis. It has been shown that subclinical depression is a significant risk factor for the development of major depression.[7, 11] Targeting individuals living with subclinical depression could be used as a form of preventative medicine, where efforts are focused on preventing a medical condition or ailment, rather than responding once the disease has already occurred. Approximately one quarter of the Canadian population could be struggling with subclinical depression, and they represent a high-risk

population that could benefit substantially from intervention efforts. Future health initiatives aimed at the prevention of major depression should focus on this cohort.

2.2 Music and Health

Many pharmacological options for the treatment of clinically diagnosed depressive symptoms exist; however, these medications are often associated with high costs, insurance strains, and many unpleasant and adverse side effects.[1, 3] Further, it often takes a number of months, experimenting with a variety of medications, until an effective pharmacological regimen is identified.[3] Due to the issues surrounding these medications, non-pharmacological avenues are often pursued as a less invasive means to help manage the disorder. One such treatment that is particularly effective in combatting depression is music therapy (MT). MT is an effective therapeutic supplement that has been proven to reduce anxiety, lessen agitation, and increase feelings associated with mood boosting.[12- 23]

The Canadian Association of Music Therapy defines MT as "the skillful use of music and musical elements by an accredited music therapist to promote, maintain, and restore mental, physical, emotional, and spiritual health".[24] MT may be delivered through a variety of modes, and often includes nonverbal, structural, creative, emotional, and spiritual components.[24] Recent attention has focused on evaluating the therapeutic differences between passive and active MT. Passive MT involves the patient listening to music, while active MT actively involves the individual in the music-making process.[25, 26] Some evidence has suggested that the more interactive components of active MT offer unique cognitive advantages to the participant.[25- 28] The act of spontaneously creating music has been argued to have health benefits that extend beyond therapeutic, stress-reducing effects.[25, 27-28]

Regardless of the particular technique employed, MT has proven to serve as an effective therapeutic adjunct for a variety of medical ailments including dementia, Parkinson's Disease, schizophrenia, stroke rehabilitation, epilepsy, pre-operative anxiety, troubled sleeping, and depression.[12-23, 25-27, 29-32] In all of these cases, MT has not been associated with any adverse or harmful phenomenon. In many of these patient populations, improvements in mood are noted via significant improvements in various symptoms associated with depression following the administration of MT.[14-15, 17-19, 22-23, 25-26, 33] A systematic review and meta-analysis conducted by Gold *et al.* (2009) detected significant, dose-dependent improvements in mood-related outcomes, where music therapy was used to specifically improve depressive symptoms.[26] When examining the prevalence of depressive symptoms specifically, Gold *et al.* found that 73% of the variance in prevalence was attributable to the number of MT sessions received.[26] This review was important, as many studies evaluating MT's efficacy do not focus on a single disorder, but rather on a collection of mental health outcomes.[26]

2.3 Biomedical Plausibility

The overwhelming success of MT in reducing depressive symptoms in select patient cohorts has led support for a theory in which everyday exposure to music could also potentially improve mood in a non-therapeutic setting.[26] Playing an instrument has been described as a highly emotional experience for the musician, and is frequently used as a means by which to relieve stress.[21] While an exact biological mechanism for music's health benefits has not been determined, multiple studies have pointed to music's ability to reduce cortisol.[34-36] Cortisol- "the stress hormone"- is a normal hormone all people have, but high levels are linked to a variety of adverse health outcomes.[9, 20, 37]. Chronically elevated levels of cortisol are involved in impaired learning and working memory, reduced immune function, increased cholesterol and blood

pressure, and weight gain.[9, 35, 37] Diminished levels of cortisol (which have been observed following MT administration) are partially responsible for the de-activation of the "fight or flight" actions of the sympathetic nervous system (SNS).[9, 20, 35]

Some evidence suggests that exposure to music results in an activation of the parasympathetic nervous system (PSNS).[34-35, 38] PSNS activation is associated with areas of the brain involved in memory and emotion.[34] Further, increased PSNS tone is seen as a protective factor against the development of some chronic conditions including coronary heart disease, diabetes, and depression.[34-35, 38-39]

The link between autonomic nervous system activity and depression is illustrated through heightened levels of cortisol and dopaminergic mechanisms.[9, 34, 39-40] These two systems are linked through the hypothalamic-pituitary-adrenal (HPA) axis.[9, 41] Stress activates the central nervous system (CNS), which causes corticotropin releasing hormone (CRH) to be released from the hypothalamus.[41] CRH then acts on the anterior pituitary to release adrenal corticotrophic hormone (ACTH) and the adrenal cortex to release cortisol.[9, 41] These pathways have been implicated in mood disorder development, such as major depression.[9]

Listening and playing music has been shown to increase dopamine levels in the brain.[34, 36] According to the monoamine theory of depression, low levels of dopamine within the brain (either as a result of a decrease in dopaminergic receptors or a decrease in the neurotransmitters themselves) may partially contribute to the progression of depression.[9, 40, 42] In fact, most antidepressant medications function by targeting monoamine pathways which then indirectly activate dopaminergic pathways.[40, 42] It is worth noting that dopamine is thought to play a significant role in motivation, concentration, pleasure, and psychomotor speed, which are all

functions that are also involved in playing music.[40] Dopaminergic activity in the brain is directly responsible for inhibition of SNS activities.[20, 36, 38] Therefore, while many view music as an adjunctive, holistic treatment option, there are many plausible biological mechanisms through which exposure to music may exert protective effects against the development of a variety of adverse health outcomes.

Since the 1980's, several research endeavors have sought to collect empirical evidence illustrating health benefits resulting from musical training. Long-term benefits of musical training include lowered rates of Alzheimer's Disease and other age-related diseases in elderly individuals (even long after musical training has stopped), as well as increased emotional competence and auditory perception.[43-47] Healthy cognitive aging occurring in individuals who have practiced music as a hobby has been observed, including improved memory and attention to detail.[43, 47] In children, musical training has been associated with higher GPA's, enhanced auditory-speech perception, improved reading abilities, improved proficiency at mastering additional languages, higher IQ's, and improved scores on cognitive tests when compared to peers.[43-52] These academic and intellectual enhancements have been partially attributed to the children's' heightened executive skills, including attention to tasks, self-monitoring of thinking, goal orientation and action planning.[47]

It has even been found that neurological differences exist between musicians and non-musicians. A well-conducted twin study supports the notion that structural differences in the brain are a result of music training itself, and not as a result of pre-existing genetics.[43] In a study involving neuroimaging techniques, the brains of musicians were found to possess higher amounts of gray matter, different cortical profiles, and enhanced synaptic plasticity when compared to non-musicians.[43, 53] These structural changes result in increased capacities to learn

novel processes, improved somatosensory capabilities, and enhanced motor skills.[43, 53] Some of these benefits are a direct result of musicians simply using more of their brains than non-musicians.[43] These differences in functional capacity are noted in both instrumentalists and vocalists, and across both professional and amateur musicians.[43] Further, these trends are found to exhibit a dose-dependent relationship with the number of years the individual has played their instrument, providing evidence that actual musical exposure is responsible for many neurological differences that exist in the musician's brain.[26, 53]

2.4 Musical Improvisation

From an ethnographic perspective, musical improvisation has captured the attention of many since the emergence of jazz music at the beginning of the 20th Century. Musical improvisation represents a true departure from the "Eurological" style of notating music and playing compositions precisely as written.[54] Musical improvisation, as it is seen in jazz music, represents an African-American response to various lived experiences throughout the 20th Century. While any individual may improvise music, it is important to recognize the distinct history and social context of the practice, which was born out of a uniquely, African-American tradition.[54] In the 1940's and 1950's, musical improvisation became a dominant means for disillusioned youth to discuss matters of politics, race, class, war, civil rights, and emotions.[54] As improvisation grew to become a global phenomenon and universal component of music-making, the ability to creatively express complex issues through song remained.[54] The acknowledgement of this "Afrological" past is significant, as musical improvisation remains an important means of emotive experience for all individuals who practice it today.

The concept of musical improvisation is underrepresented in scientific literature, but has started to be analyzed for its application in the neuroscience of human creativity.[54-56] Improvisation is defined as the spontaneous creation of musical ideas and melodies, while still adhering to basic structural principles.[22, 55-59] Musical improvisation involves the perception of music being played, creating a unique melodic idea in contrast to that music, and incorporating "feedback" from the new idea into the next idea.[60] Recent functional magnetic resonance imaging (fMRI) studies show entirely different neural profiles for the brains of improvisers when compared to those of non-improvisers.[54, 61-62] Interestingly, studies have shown that when an individual begins to improvise, a dissociative pattern of activity occurs across the brain, characterized by an activation in the medial prefrontal cortex (an area involved in organization and internal motivation) and a deactivation in the lateral prefrontal cortex regions (an area commonly implicated in conscious self-monitoring).[21, 55-56, 61] Broadly speaking, this refers to a co-operative effort by both the control and the default neural networks, which normally work antagonistically together.[57, 61, 63]

Improvisation is a hallmark of higher-level cognitive functioning, executive control, and divergent thought processes.[56-64] Divergent thinking is broadly studied as a function of creative thinking tasks, and refers to the discovery or identification of multiple solutions to an open-ended problem.[57, 59, 64] Understanding the relevance of differential brain processes associated with creating music may have clinical ramifications when applying this knowledge to the treatment of diseases affecting the mind. It is recognized that in musicians who rely heavily on creative composition (i.e. jazz artists, freestyle rap artists, composers), and have the ability to "let go" and spontaneously create music have a very unique neural profile.[54, 57, 59-60] Evidence has also suggested that spontaneously creating music is an entirely different process than what is

involved in an individual playing a song from memory, or reading music off of a score.[54, 57] This difference has wide-ranging implications for studies that attempt to prove cognitive benefits seen in life-long musicians. It is quite possible that musicians who have drastically different approaches to playing music may differ in terms of long-term health outcomes.

While there have been no fMRI studies on the effects of actively creating music on the brains of individuals with depression, it is evident that important differences exist on a neurological level between differing modes of musical delivery.[54] It is of particular interest to consider the dissociative activity that occurs in the brain during improvisation, with a particular emphasis on the deactivation of the "self-monitoring" centre of the brain, and how this could play a role in mood disorders. Some evidence has supported the notion that the more experienced the improviser, the faster and more direct this local dissociative activity may occur.[57, 60-61] It has also been suggested that musical improvisation inhibits areas of the brain associated with negative emotions.[21]

There has long been discussion on the possibility of a link between high levels of creativity and depression, as well as other serious mental health disorders.[65-66] It has been suggested that the added stress of musicians having to actively create music on the fly may increase anxiety.[21] Spanning hundreds of years and countless musical genres, numerous famous musicians garnered notoriety for their ingenuity as well as their mental health issues: Jim Morrison, Kurt Cobain, Coleman Hawkins, Amy Winehouse, Jimmy Hendrix, Robert Schumann, Chopin, Beethoven and even Mozart, are all examples of mentally ill, yet brilliant musicians.[65-68] A few retrospective case studies have investigated some of these individuals, in an attempt to explain their psychological issues.[67-70] In fact, so many highly creative individuals have suffered mental health disorders, that a popular conviction is that genius is actually a

manifestation of madness.[65-66] No support for this theory has been found and instead, it has been postulated that pre-existing MHD may force an individual to turn to creative outlets (such as music) to express themselves.[65-66, 71] A study investigating the divergent thought processes involved in musical improvisation found support that the relationship between differential brain profiles and musical creativity goes both ways.[64] In this comparison across different musicians, the study suggested that it is possible that individuals with higher divergent thought patterns are more likely to turn to improvisation, but also that musicians who spend quality time practicing music development may train their brains to more effectively execute divergent thought processes.[64] Studies such as the ones highlighted here raise support for the notion that diseases of the mind may be more common in highly creative individuals. It is also thought that highly creative musicians may choose to abstain from medications such as anti-depressants for fears that they will hinder the creative process.[66]

2.5 Musicians and Health

Over the last decade, several case studies have highlighted concerning presentations of various mental health conditions in professional musicians.[66-71] A five year study exploring various health outcomes in Australian professional musicians indicated that 32% of the individuals participating in the cross-sectional survey screened positive for depression.[72] The study also found that professional musicians experience high levels of performance anxiety and feelings of self-consciousness when playing in the professional setting.[72] The findings of this study were novel, in that they demonstrated that the mood-boosting effects commonly brought on by music in a therapeutic setting may not manifest themselves in the same way for the high-stress environment experienced by professional musicians.[72] Similar results were found in a study of professional musicians conducted in Brazil.[73] In this study of music performance

anxiety, 20% of participants had depression.[73] In a more recent Norwegian study, it was found that levels of depression and anxiety were much higher in musicians when compared to the general workforce, citing a prevalence difference of 8.2 percentage points (95% CI [5.6, 10.8]).[8] Across these studies, investigators postulated that a high level of performance anxiety exists in working musical professionals, and that these feelings of anxiety may contribute significantly to feelings of depression.[8, 72-73] Additionally, job instability was thought to also be a significant factor.[8, 72-74] In 1989, being an orchestral member was ranked in the same group of occupational stress as air traffic controllers.[74]

It has been well documented that in addition to increased psychological distress, professional musicians also experience higher levels of musculoskeletal (MSK) injuries and related conditions, as a result of spending countless hours practicing and holding instruments in awkward positions.[72, 75-76] It has been estimated that approximately 80% of professional musicians will suffer an injury or condition that will affect their instrument playing.[72, 75, 77] The psychological distress of suffering from such injuries displays co-morbidity with depression and anxiety.[4, 72, 75] It has been estimated that 50% of individuals who suffer from chronic pain also suffer from depression and/or anxiety.[4] In an American study specifically looking at occupational health hazards of musicians, depression was reported as the second most common condition suffered, following tinnitus.[77] In this study, musicians reporting "feelings of depression" comprised more than half of the sample.[77]

Musical performance anxiety, or "stage fright", is found to be frequently associated with depression and other mental illnesses. It has therefore been postulated that the nature of the musicians' job may cause the individuals to experience a higher prevalence of depression.[73-74, 76, 78] Performance anxiety is characterized by excessive SNS activation including increased

respiration rate, uncoordinated muscular movements, elevated blood pressure, and persistent, worrying thoughts.[74] It can severely impact the level of enjoyment musicians - both professional and amateur - derive out of playing their respective instruments.[74] The Barbar *et al.* (2014) study also looked for differences between self-reported "amateur" and self-reported "professional" performing musicians, and found higher levels of social anxiety and depression in the professional performers.[73]

An investigation of stress, fatigue and depression conducted by Hildebrant *et al.* (2012) showed that first year university students experienced increased levels of fatigue and depression over their first year enrolled as music students.[78] Further, the study found that self-reported performance anxiety increased as students progressed through their studies.[78] Another study found that music majors were statistically more likely to suffer from higher levels of depression and psychological stress when compared with medical students.[4] Conversely, studies conducted on student choirs question this, with participants reporting lower levels of stress.[79] In this study, choir participation as a hobby (not being applied as a therapy) was evaluated. Self-reported mood improvement and stress reduction were noted in participants.[79] Interestingly, women were significantly more likely to report purported health benefits derived from the choir.[79]

In summary, evidence presented by several studies indicates that depression is a significant occupational hazard in professional musicians when compared to the general population.[8, 72-73] However, these results are limited to findings in working musicians, and not individuals who play an instrument as a hobby, or as a part-time performer. Further, many of these studies do not take the potential confounding or mediating effects of other health conditions into account. Playing music has been found to be one of the most common recreational activities for young people.[80] In fact, an estimate from a survey conducted in

Vancouver estimated that 66% of Canadians have played a musical instrument for at least one year.[81] It is unclear whether amateur music players experience the same performance related anxiety felt by their professional counterparts.[73]

When evaluating the role of music in depression symptomatology and onset, it is important to consider the well-documented boosts in mood that are reported following sessions of therapeutic music exposure.[11, 15, 19, 22, 28, 31, 43] Results from these types of studies are encouraging in that they suggest a positive health boost from music exposure albeit, often in elderly populations. Finally, some individuals have suggested that highly creative individuals are more prone to mental health disorders, but this has not been addressed with well-designed studies.[66-67, 71] To our knowledge, there are no studies (in professional or amateur musicians) that examine the association between improvisatory and non-improvisatory musicians and depression.[59] Therefore, due to conflicting evidence suggesting a high level of MHD in professional musicians, there is a need for a study to evaluate the impact of studying music on depression and depressive symptomatology in all musicians- and not just paid professionals.

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Chapter 3: Summary of Thesis

3.1 Summary of Justification for Study

In light of the evidence presented in Chapter 2, a significant gap exists in current understanding regarding the potential association between lifelong exposure to music and depressive symptomatology in professional and amateur musicians alike. Substantial evidence conducted in occupational settings has suggested that professional musicians are more likely than their non-musical counterparts to suffer from a variety of mental health disorders, including depression.[1-3] Cross-sectional and some longitudinal studies have been conducted in these cohorts of working musicians, but none have examined musicians as a broad definition, including amateurs.[1-3] Many longitudinal studies concerning the cognitive benefits of musical training have been conducted, and it is clear that musicians stand to gain in cognitive outcomes. To our knowledge, no longitudinal studies have examined mental health outcomes and specifically depressive symptomatology in lifelong musicians.

Our study attempts to address the gap in the literature in regards to our understanding of the association between depressive symptomatology and lifelong exposure to music. In this study, lifelong exposure to music was measured as a simple yes/no musician status, and as number of years spent playing an instrument. This study further poses an exploratory question related to musician's improvisational capabilities and burden of MHD and depressive symptomatology. The findings from this second paper are exploratory in nature, and provide important hypotheses for future work in the field of musical creativity and mental health outcomes. The study is cross-sectional, and does not attempt to infer causality between either music playing or depressive symptomatology. Rather, the focus of this project was to determine

the important factors in a potential association between playing music and depressive symptoms, and what that association may be. As the first study to attempt to answer these questions, we believe that a cross-sectional study design is warranted, and that the hypothesis exploring nature of the study can help to lay groundwork for future work in the field.

3.2 Objectives

1. The primary objective was to determine the association between lifelong exposure to music and depressive symptomatology in university students.

2. The secondary objective was to explore the association between improvisational musical capability and depressive symptomatology.

3.3 Hypothesis

We believe that musicians will experience lower levels of depressive symptomology compared to non-musicians. It is unlikely that there will be high numbers of professional musicians in a sample of university students, and therefore we hypothesize that higher levels of music exposure will be associated with lower levels of depressive symptomatology. The general mood-boosting effects of playing music are well documented, and thus, we believe that a lifelong hobby of playing music will display this trend.

We hypothesize that musicians who report themselves as being good improvisers may experience higher scores of depressive symptomology and MHD when compared to musicians who report themselves as being poor improvisers. It has been demonstrated in the literature that the burden of MHD in highly creative individuals is higher, and we believe that this will be the same in our sample of students.

3.4 Approach to Thesis

This thesis utilizes a manuscript style approach to present the results of the research questions posed. It is our hope that the findings of this research may be disseminated in the form of journal publication, conference presentations, and other similar events. Therefore, it was deemed most appropriate to organize this thesis into separate papers, as they would appear in an academic journal. Each manuscript is composed of a background, methods, results, discussion, and conclusion section. A comprehensive literature review was presented in Chapter 2, and a general discussion is presented in Chapter 6 to discuss the findings of both manuscripts. The purpose of this thesis is to provide a thorough understanding on the topic of depressive symptomatology and music playing in a sample of Canadian university students. While drafted as two separate manuscripts, this project was completed as a combined project for the purpose of fulfilling the Master's of Health Sciences requirements at Lakehead University.

3.5 Overview of Thesis Contents

The previous two chapters are to serve as a comprehensive background and thorough scoping literature review to discuss relevant research that has already been conducted in the field. The interdisciplinary nature of the relation between music and depression yields a vast field of knowledge, and the purpose of the previous two chapters was to attempt to provide a summary of that literature. The present chapter summarizes the purpose of this thesis, objectives, hypotheses and layout. Following this, Chapter 4 represents the first of the two manuscripts titled "*Lack of association between lifelong music exposure and depressive in university students: a cross-sectional study*". Chapter 5 is concerned with the second major research question of this study, and is titled: "*Increased odds of subclinical depression in musicians who improvise: results from a cross-sectional study*". Following this, there is a discussion section that thoroughly considers each of the research questions posed in the manuscripts. The discussion also covers

topics that were not necessarily presented in either manuscript, but were deemed important to warrant conclusion. For example, we deemed it redundant to present findings from both logistic and linear models in our first manuscript. The Chapter 6 Discussion presents some of the issues that arose with the creation of both sets of models. Following a short Ethical Concerns section in Chapter 7, Chapter 8 discusses the limitations, strengths and relevance of the study. Finally, Chapter 9 serves as an overall Conclusion to the thesis, where future directions and implications of the thesis contribution are discussed. Following each chapter, a reference list of the literature cited is provided.

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Chapter 4: Lack of association between lifelong music exposure and depressive

symptomatology in university students: a cross-sectional study

4.1 Abstract

Background: Depression is a serious mental health condition that creates an overwhelming burden on 1.9 million Canadians annually. Interestingly, this figure does not account for estimated levels of subclinical depression, which are estimated to affect 22% of the population. Problematic pharmacological treatment options for depression have led researchers to discover the potential of music therapy (MT) in improving mood-related outcomes. It is well-established that musical training and listening to music can improve mood, yet being a professional musician is one of the most stressful occupations in the world.

Methods: This study uses a cross-sectional survey administered to Canadian university students to investigate the association between lifelong exposure to music and subclinical depression. Subclinical depression was assessed through the CES-D: a validated and reliable instrument widely used to assess acute depressive symptomatology. Musical exposure was measured as total number of years played and as a dichotomous measure of music playing. Information regarding several potential confounders was also collected: anxiety, substance abuse, presence of serious mental health disorders and chronic illnesses, perfectionism, hours spent in school, and exercise. Data were analyzed using multivariable linear and logistic regression, adjusting for appropriate confounders.

Results: Four hundred and sixty-nine students at the University of Toronto and Lakehead University (54% and 45%, respectively) completed the survey, with 50% of the participants identifying as musicians. The prevalence of subclinical depression in the study sample was 52%. There was no important association between years playing music (OR= 1.00, 95% CI [0.96, 1.04]) or a dichotomous measure of music playing (OR= 0.74, 95% CI [0.41, 1.33]) and

subclinical depression, when controlling for anxiety, perfectionism, substance abuse, mental health disorders, chronic health conditions, age, sex, hours spent studying and exercise.

Conclusion: The findings here suggest that the odds of being a musician are no greater in those with subclinical depression than they are in those without subclinical depression. Concerns surrounding depression susceptibility in musicians are not supported. No association was found between practicing music and subclinical depression. As reported in other studies, the burden of subclinical depression on university campuses is high, and further study should investigate potential preventative efforts for students and mental health outcomes.

4.2 Background

Depression is a serious mental health condition, affecting 1.9 million Canadians annually.[1, 2] It has been estimated that approximately 8% of Canadians have suffered from a major depressive episode at some point in their lives.[22] Interestingly, this figure does not account for estimated levels of subclinical depression, which are likely as high as 22%.[3] Subclinical depression is a critical public health concern, as it has been found that subclinical depression is a risk factor for the development of major depression.[3, 23] While the exact biomedical mechanism behind depression is not fully understood, clinicians recognize that it is a combination of genetic, biological, personal, environmental and social factors that ultimately result in disease manifestation.[1, 22] It becomes of interest to explore preventative efforts targeting both clinical and subclinical depression.

Treatment for clinical depression exists, although ideally, it is of interest to prevent the development of depression before it reaches the point of warranting a clinical diagnosis. Many non-pharmacological methods of preventing depression have been studied, ranging from activities such as exercise, art therapy and meditation. Music therapy has been suggested as a potential protective therapy against the development of depression, after its success in reducing feelings of anxiety and agitation in older adults.[7-16, 24-26]

The success of music therapy in a variety of patient groups has supported the notion that playing music as a hobby is beneficial to overall health. Playing music has long been described as a highly emotional and immersive experience. As such, it has frequently been used as a means by which to combat stress. Biomedically, playing music has been linked to drops in cortisol levels in the human body, which is traditionally seen as the physiological "stress hormone".[27-29]

Further evidence suggests that music may result in an activation of the parasympathetic nervous system (PSNS).[27, 29-30] Increased parasympathetic tone has been seen as a preventative factor in the development of several chronic conditions, including coronary heart disease, diabetes, and depression.[27, 29-31] The monoamine theory of depression suggests that low levels of dopamine may be, in part, able to explain development of depression.[32-34] In addition to autonomic nervous system alterations, music has also been found to be responsible for the release of dopamine within the brain.[27]

Playing music has, in general, been viewed as a positive activity in terms of long-term health benefits and cognitive engagement. Several long-term cohort studies have illustrated that musical training is associated with lower rates of Alzheimer's disease in elderly adults and with increased emotional competence and higher level functioning.[35-38] Playing music is actually encouraged in children, as it has been implicated for its role in higher GPA's, improved reading abilities, and higher scores on cognitive tests when compared to peers.[35-43] There have even been studies conducted comparing the neural matter in musician and non-musician brains. These studies have found structural changes in the brains of musicians suggestive of higher level-functioning, as evidenced through larger amounts of grey matter and enhanced synaptic plasticity.[43-44] With all of the evidence suggesting the overwhelming success of playing music, it seems logical that physicians should be recommending music as a viable intervention for negative health outcomes.

The positive perception of music is reduced when attention is focused on working, professional musicians. Based on the arguments presented above, one would expect professional musicians to experience less job stress, and be in better mental health and functional capacity than their non-musical peers. However, in a five-year study conducted in Australian professional

musicians, it was found that 32% of the participants screened positive for depression, compared to the reported 14% in the general Australian population.[17] Similar findings were reported in analogous studies conducted in Brazil and Norway.[17-19] The consensus of the investigators of these studies was that high levels of performance anxiety and fears over job security could contribute to a higher burden of mental health disorders in professional musicians.[17-19, 45] Interestingly, similar results were found in a study comparing professional musicians and students studying music in university.[46-47] It is therefore important to determine if playing music is a risk factor for the development of depression. In light of all the evidence presented, there is a gap in current understanding of the relationship between playing music as a hobby and mental health outcomes. We proposed to determine the association between playing music as a hobby and depressive symptomatology in a sample of university students.

While the short-term mood-boosting effects of music have been widely reported, these findings are often studied in a therapeutic context, and not treated as a lifelong exposure. The primary objective of this study was to determine the association between exposure to playing music and subclinical depression in university students. We hypothesized that musicians would experience lower levels of depressive symptomatology when compared to non-musicians.

4.3 Methods

4.3.1 Study Design

The study was conducted using a cross-sectional web-based survey (Appendix 1). The ten minute survey was hosted on the REDCap platform.[48] Ethical approval was obtained for the study from both Lakehead University (REB #: 079 16-17/Romeo File No: 1465418) and the University of Toronto (Reference #: 33703). In order to recruit potential participants, emails

were delivered via listserve provided through departmental records sent on our behalf. In order to establish contact with potential departments, generic emails were sent to all departments listed on the University of Toronto and Lakehead University Programs Webpages. Deans and Chairs who replied first were immediately sent further instructions, the informed consent page, and the survey link to distribute to the students of their faculty or department. Where feasible, deans and chairs were sent a reminder email to forward to their students to remind them to complete the survey after two weeks. A description of the study purpose was included with the electronic link to the survey [See Appendix II]. The survey asked participants to read through the study description and provide informed consent. Following a "YES" answer to this question, the participant was then able to access the remainder of the survey.

4.3.2 Participants

A sample of 209 students from Lakehead University in Thunder Bay, Ontario and 255 students from the University of Toronto in Toronto, Ontario were recruited, yielding a response rate of 6.3%. Any individual included in participating departments contacted by the primary investigator was eligible for inclusion in the study. Once permission from the department chair had been granted, the chair (or other member of the department) was provided with a scripted email explaining the purpose of the study as well as a link to the survey. In order to ensure anonymity of the participants' email addresses from the research team, the department sent out the survey material on the team's behalf. Interested students were then able to follow the link, and after providing informed consent, complete the questionnaire. While no exclusion factors existed, the survey was only available in English. Additionally, interested participants must have been able to complete the survey electronically.

4.3.3 Study Measures

Outcome Measures

Centre for Epidemiologic Studies Depression Scale CES-D: The primary outcome of interest for this study was depressive symptomatology. Subclinical depression was assessed using the CES-D. The CES-D is a twenty question self-report survey first developed in 1977 by Laurie Radloff.[21] The CES-D is a validated and reliable self-report tool, and is widely used to collect information regarding an individual's self-reported burden of a variety of depressive symptoms.[21, 49-53] Multiple studies investigating the scale's factorial and discriminant validity have been completed, including in populations of university students.[49-54] The CES-D also displays high test-retest validity and good internal consistency.[21, 49-55] While it does not serve as a diagnostic tool, the CES-D is used to assess depressive symptomology, and can serve as a suggestive tool for an individual to seek further medical help.[21, 49, 53] To this affect, the survey included a detailed explanation of the CES-D and resources for further professional help. A revised version was completed in 2004; however, this survey version poses questions surrounding self-harm and suicide, and as such, we chose to use the original CES-D instead.[21, 56]

The symptoms that the survey addresses are those commonly seen in clinical cases of depression, covering nine different domains of depression, including: sadness, loss of interest, appetite, sleep, concentration, guilt, fatigue, movement, and suicidal ideation.[21, 56] When participants are presented with each question, they are asked to rank their agreement with the statement on a Likert scale. Scores are then summed based on how many days the participant reports they have agreed with each statement. Scores range from 0-60, with higher scores

indicating more depressive symptoms.[21] Scores above the conventional 16 cut-point are considered subclinical depression.[3, 21, 57]

Exposure Measures

Playing music: The primary exposure of interest, music exposure, was captured as a dichotomous value. To ascertain whether or not an individual played music, participants were asked to identify as an instrumentalist or as a singer. Those who did were labelled as a "musician". Any individual who did not identify as a singer or as an instrumentalist was labelled a "non-musician".

Years Played: We also assessed time spent playing a musical instrument or singing. Lifelong exposure to music may be assessed in a number of ways. Previous assessments have approached this question from a variety of directions.[46, 47, 58] As this study was focused on students, we believed that it would be best to ask individuals for the total number of years they had been playing a musical instrument/singing, as this approach has been used elsewhere.[46-48] If an individual played more than one instrument, he or she was asked to indicate the total number of years playing any instrument, including overlapping years. For example, if someone played violin for three years, and at the same time played piano and then played piano two years beyond this, they would say they were engaged in music for five years. As we were not interested in discerning between differences in skill levels, the survey question was able to include both self-taught and professionally trained musicians. Additionally, the question asked about playing music in general, and not about time spent playing one specific instrument. The approach to this question was justified, as many musicians play more than one instrument, and no difference in mental health conditions between playing different instruments has been documented.[17] Only

participants who indicated that they were a musician subsequently indicated their total number of years playing. We assumed that respondents who indicated they were a non-musician also played music for zero years.

Confounders

Several variables were assessed for their potential confounding effects on the association between playing music and depressive symptomatology. Standard demographic information, such as age and gender, was included as confounders. Additional potential confounders included: smoking status, number of hours spent studying each week, number of hours spent in class each week, and number of hours exercising each week. In addition, several additional confounders were assessed using established instruments:

Anxiety: Depression and anxiety frequently occur together, and therefore it is important to collect information regarding anxiety symptoms for possible confounding or interaction.[17, 19, 46-47, 58] Anxiety was assessed using the Generalized Anxiety Disorder (GAD-7) scale.[59-60] The GAD-7 has been proven to be both reliable and valid in a population setting.[59-61] Further, the GAD-7 displays good agreement between self-report data and clinician diagnosis.[59]

Perfectionism: Perfectionism has been found to be increasingly associated with a variety of MHD.[62] Perfectionism was assessed using the Short-Almost Perfect scale (SAPS).[63] The SAPS is frequently used to assess feelings of personal aspirations and perfectionism.[62] SAPS scores were summed as two separate dimensions: standards (high performance expectations) and discrepancies (self-critical performance evaluations).[63] Higher scores on SAPS standards indicate more beneficial perfectionistic mannerisms, while higher scores on SAPS discrepancies indicate

more problematic perfectionism.[63] The SAPS has been deemed to be valid and reliable in students, and possesses good psychometric properties.[62-63]

Substance Abuse: Substance abuse was assessed using the CAGE-AID assessment scale. The CAGE-AID is a brief, self-report tool that has been validated in a young adult population cohort.[64] The scale examines both alcohol and drug abuse.[65] A score of one indicates a possible substance abuse problem, while a score of two or more indicates a probable problem.[65] The CAGE-AID exhibits 71% sensitivity and 76% specificity in populations of young adults and adults.[65]

Presence of chronic health conditions: Other co-morbid conditions that may act as confounding variables to the association of interest were addressed using the Comorbidity Questionnaire. The Comorbidity Questionnaire is a patient-centered, self-report measure of health problems.[66] The instrument has acceptable test-retest reliability during a fourteen day-period with item-specific weighted kappa coefficients above 0.56, indicating moderate agreement with physician-reported health issues.[66] It has also been shown to have adequate face, concurrent, and convergent validities.[67] The Comorbidity Questionnaire has been used elsewhere, and is an acceptable method to ascertain chronic disease burden.[67-68]

Presence of other serious mental health disorders: Participants were asked if they have ever, or in the past six months, been diagnosed with various categories of MHD. These groupings are drawn from the Canadian Community Health Survey.[70] The Canadian Community Health Survey is a cross-sectional, population-based survey that is conducted on an annual basis in co-ordination with Statistics Canada.[70] The survey questions have been deemed valid and reliable, with efforts taken to ensure high accuracy.[69]

4.3.4 Analysis

All data were analyzed using Stata version 13.[71] Data were cleaned and examined prior to analysis for missing, incomplete and/or inaccurate information. All analyses were repeated with and without missing values included, and then compared for significant difference. Individuals who opened the survey but did not complete any questions were removed from the analysis. A univariate descriptive analysis was completed on all variables and obvious outliers were removed. This included an instance where an individual had suggested they study and exercise in excess of 100 hours each week. Crude odds ratios were calculated using contingency tables and statistical significance was assessed with a chi-square analysis. Bivariate analyses were completed between all confounders and outcome variables.

To achieve the primary objective, adjusted odds ratios were calculated using multivariable logistic regression. To identify important confounding variables, we used a modelling strategy outlined by Greenland *et al.* (2016) that includes important covariates based on the mean squared error.[72] CES-D scores were analyzed dichotomously, with the standard 16 cut-point for those considered to have the outcome of interest. *The CES-D scores were also analyzed as a continuous score using multivariable linear regression. Further discussion on this analysis and the findings from this are included in Appendix III & IV, and will not be discussed further in this thesis chapter.* Once the models were created, several tests (Goodness-of-fit test for binary response models using survey data with grouped tables, multicollinearity) were conducted to ensure that the fit of the models was satisfactory. Interaction terms were included in the final models, and those with significant interaction effects ($p<0.05$) were included in the models.

4.4 Results

Participants and Demographics

Of the 9, 151 potential participants contacted, we received responses from 579 individuals (response rate of 6.3%) (Figure 1). After removing answers with fully missing values, we were left with a remaining sample size of 469 participants. Baseline demographics are reported in Table 1.

Figure 1: *Flow-chart of participants and sample recruiting process*

Total number of students eligible
(approximate):

~95, 019

Total number of students receiving
survey link:

9, 151

Total number of students who
opened survey:

n= 579

(Response rate: **6.33%**)

110 students opened
survey and did not
complete anything

Total number of completed student
responses:
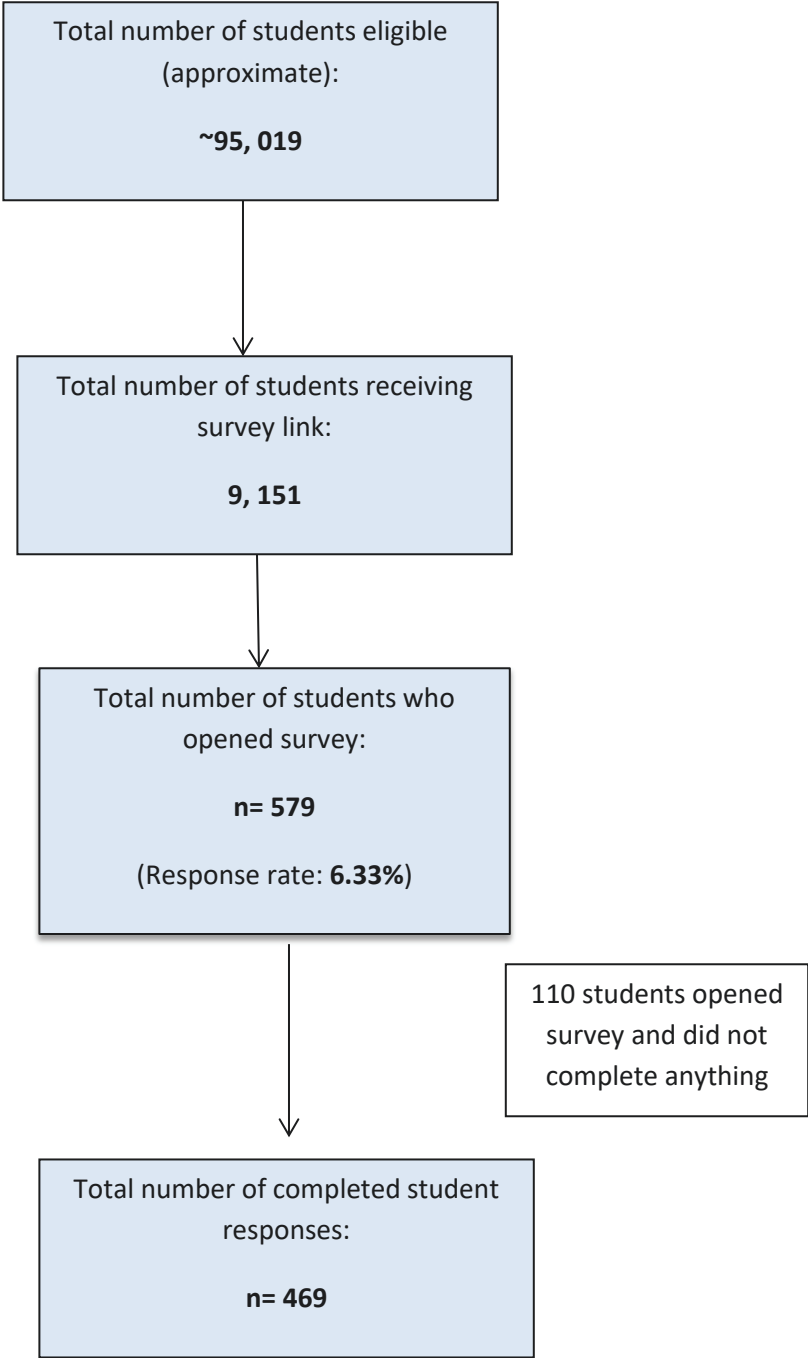
n= 469

Table 1: *Baseline Characteristics of Participants (%, 95% Confidence interval)*

Characteristic	Number of Participants n= 469	Proportion of Responses (%, 95% Confidence Interval)
University		
University of Toronto	255	54% [50% to 59%]
Lakehead University	209	45% [40% to 0.49%]
Other	5	1% [0.4% to 2.5%]
Missing	0	--
Department		
Art, Film, Language, History or Art & Science	20	4.42%
Biology	41	9.1%
Business	8	1.8%
Chemistry	20	4.4%
Earth Sciences	13	2.9%
Engineering	107	24%
Health/Life Sciences/Public Health	31	6.9%
Kinesiology	27	6.0%
Music	54	12%
Nursing	63	14%
Outdoor Rec	5	1.1%
Psychology, Sociology, Women's Studies	25	5.5%
Religion	23	5.1%
Statistics	15	3.3%
Missing	121	--
Age (mean= 23, sd=5.6)		
0-20	128	32% [28% to 37%]
21-30	245	62% [57% to 66%]
31-40	18	4.5% [2.9% to 7.1%]
41-50	3	0.8% [0.2% to 2.3%]
50+	4	1.0% [0.4% to 2.7%]
Missing	71	--
Sex		
Female	263	62% [58% to 67%]
Male	153	36% [32% to 41%]
Chose not to answer	5	1.2% [0.5% to 2.8%]
Missing	48	--

Gender

Man	152	36% [32% to 41%]
Woman	258	61% [57% to 66%]
Trans Man, Trans Woman, or Two Spirit	1	0.2% [0.0% to 2.0%]
Gender Neutral or Gender Free	5	1.2% [0.0% to 3.0%]
An identity not listed here	1	0.2% [0.0% to 2.0%]
Chose not to answer	4	1% [0.0% to 3.0%]
Missing	48	--

Highest Level of Education

High School	215	51% [46% to 56%]
College/Diploma Program	47	11% [9.0% to 15%]
University Degree	124	30% [25% to 34%]
Master's Degree	28	6.8% [5.0% to 9.0%]
PhD	4	1% [0.0% to 3.0%]
Professional School	2	0.5% [0.0% to 2.0%]
Missing	49	--

Education Payment

Parents Pay Tuition	117	25% [21% to 29%]
Parents and Student Pay Tuition	122	26% [22% to 30%]
Student Pays Tuition	123	26% [22% to 30%]
Scholarships and Awards	198	42% [38% to 47%]
Student Loans	181	39% [34% to 43%]
Funding	49	10% [8.6% to 14%]

Hours Spent in Class per week
(Mean=17, sd= 11.7)

<1	31	7.4% [5.2% to 10%]
1-10	108	26% [22% to 30%]
11-20	154	37% [32% to 42%]
21-30	84	21% [17% to 24%]
31-40	32	7.7% [5.5% to 11%]
41-50	4	1.0% [0.36% to 2.5%]
50+	3	1.0% [0.23% to 2.2%]
Missing	53	--

Hours Spent Studying per week
(Mean= 19, sd=14.5)

<1	6	1.9% [1.0% to 3.8%]
1-10	155	37% [32% to 42%]
11-20	131	32% [27% to 36%]
21-30	58	14% [11% to 18%]
31-40	38	9.2% [6.7% to 12%]

41-50	15	3.6% [2.2% to 5.9%
51+	11	2.7% [1.5% to 4.7%]
Missing	55	--

Hours Spent Exercising Over Two Weeks
(Mean= 7.7, sd= 9.5)

<1	50	12% [9.2% to 15%]
1-5	165	39% [35% to 44%]
6-10	109	26% [22% to 31%]
11-15	52	12% [9.6% to 16%]
16-20	21	5.0% [3.3% to 7.6%]
21-25	7	1.7% [0.80% to 3.5%]
26-30	8	1.9% [1.0% to 3.8%]
30+	6	1.4% [0.64% to 3.2%]
Missing	51	--

International Student	40	9.5% [7.1% to 13%]

Smoking

Never	347	83% [79% to 86%]
Occasionally	49	12% [8.9% to 15%]
Daily	23	5.5% [3.7% to 8.1%]
Missing	50	--

Presence of Mental Health Disorders
(Any)	70	17% [13% to 20%]

Schizophrenia	2	0.5% [0.12% to 1.9%]
Mood Disorders	35	8.2% [5.9% to 11%]
Anxiety	43	10% [7.5% to 13%]
Substance Abuse	2	0.5% [0.12% to 1.9%]
Post-traumatic Stress Disorder	12	2.8% [1.6% to 4.9%]
Learning Disability	13	3.1% [1.8% to 5.2%]
Attention Deficit Disorder	10	2.3% [1.3% to 4.3%]
Eating Disorder	4	0.9% [0.35% to 2.5%]

Presence of Chronic Health Conditions
(Any)	304	72% [67% to 77%]

Bone, Muscle & Joint Problems	134	32% [27% to 36%]
Allergies	155	36% [32% to 41%]
Breathing Problems	60	14% [11% to 18%]
Blood Pressure	10	2.4% [1.3% to 4.4%]
Cardiovascular Disease	11	2.6% [1.4% to 4.6%]
Digestion	35	8.3% [6.0% to 11%]
Diabetes	6	1.4% [0.64% to 3.1%]
Urogenital Problems	9	2.1% [1.1% to 4.1%]
Neurological Problems	9	2.1% [1.1% to 4.0%]
Headaches	173	41% [36% to 0.46]

| Cancer | 1 | 0.2% [0.03% to 1.7%] |

Univariate descriptive statistics were completed on 469 participants. Fifty-two percent of participants had CES-D scores of at least 16 or greater, exceeding the cut-point for subclinical depression (Table 2). It should also be noted that the CES-D score distribution was right-skewed with a mean score of 19 and standard deviation of 11.9. While the survey was not used as a diagnostic tool, 35 participants (8.2%) identified themselves as having a professionally diagnosed mood disorder. Fifty-three percent of the participating students identified as musicians (Table 2). Of the 240 musicians, the average number of years played was eleven (sd=6.4). The average number of hours per week spent playing by the musicians was three (sd=5.1).

Table 2- *Prevalence of subclinical mental health disorders and music exposure*

Outcome and Exposure Measures	Number of Students (N=469)	Proportion of students (95% Confidence Interval)
CES-D Score		
No clinical significance (<16)	224	48% [43% to 52%]
Possible subclinical depression (>16)	245	52% [48% to 57%]
GAD-7 Anxiety Score		
No clinical significance (<10)	294	68% [63% to 72%]
Possible anxiety (>10)	140	32% [28% to 37%]
Missing	35	--
CAGE-AID Score		
No clinical significance (<2)	369	88% [85% to 91%]
Clinically significant (>2)	49	12% [9.0% to 15%]
Missing	51	--
Mental Health Disorder		
No	352	83% [80% to 87%]
Yes	70	17% [13% to 20%]
Missing	47	--
Chronic Health Disorder		
No	121	28% [24% to 33%]
Yes	304	72% [67% to 76%]
Missing	44	--
Plays Instrument		
Yes	228	50% [45% to 55%]
No	228	50% [45% to 55%]
Missing	13	--
Sings		
Yes	69	15% [12% to 19%]
No	385	85% [81% to 10%]
Missing	15	--
Musician	240	53% [48% to 57%]
Non-musician	216	47% [43% to 52%]
Missing	13	--

Music and Depression

Crude odds ratios between music and depressive symptomatology indicated marginally statistically significant, protective associations (Table 3). The unadjusted OR between playing music and depressive symptomatology was 0.69 (95% CI: 0.48, 1.01). The unadjusted OR for the association between number of years playing and subclinical depression was 0.97 (95% CI: 0.95, 1.0).

Table 3. *Unadjusted Crude Odds Ratios between selected variables and subclinical depression*

Characteristic	Odds Ratio	95% CI for OR
Years Playing ±	0.97	0.95, 1.00
Musicianship		
Non-musician	1.00	--
Musician	0.69	0.48, 1.01
Anxiety (GAD-& Split)		
No anxiety	1.00	--
Anxiety	11.67	6.74, 20.21
SAPS Perfectionism		
SAPS Discrepancy ±	0.96	0.92, 1.00
SAPS Standard ±	1.15	1.11, 1.19
CAGE-AID Substance Abuse		
No substance abuse	1.00	--
Possible Abuse	2.51	1.31, 4.83
Mental Health Disorders		
No	1.00	--
Yes	3.45	1.92, 6.20
Chronic Health Conditions		
No	1.00	--
Yes	1.29	0.85, 1.97
Muscle/Bone/Joint Problems		
No	1.00	--
Yes	1.84	1.21, 2.80
Age ±	0.97	0.93, 1.00

Sex		
Male	1.00	--
Female	1.37	0.92, 2.04
Hours in Class ±	1.00	0.98, 1.01
Hours Studying ±	1.00	0.99, 1.02
Hours Exercising ±	0.96	0.94, 0.99
Hours Playing/Practicing±	0.90	0.82, 0.99

± Represents a continuous variable. Each unadjusted odds ratio represents one unit change in that continuous variable and the odds of subclinical depression.

Two multivariable logistic regression models were created using the variable selection strategy as outlined by Greenland.[72] (Table 4) The first logistic model examined music as a dichotomous variable and the second logistic model examined music on a continuous scale (by number of years spent playing a musical instrument). There were no important associations in either model, OR =0.74, 95% CI [0.41 to 1.33] for dichotomous exposure, and OR=1.00, 95% CI [0.96 to 1.04] for continuous exposure (Table 5). Potential interaction terms were assessed for significance within the final models and none warranted inclusion.

Table 4. *Variable selection strategy to determine adjusted odds ratio's between playing music and subclinical depression.*

Model	Model Variables	SE for coefficient	OR	95% CI for OR
1(a). Basic (cesd_spl)	Played music	0.14	0.71	0.49, 1.03
1(b). Forward RMSE	Played music Anxiety	0.20	0.82	0.51, 1.32
1(c). Forward RMSE	Played music Anxiety SAPS Discrepancy	0.18	0.71	0.43, 1.17
1(d). Forward RMSE	Played music Anxiety SAPS Discrepancy Age	0.20	0.75	0.44, 1.27
1(e). Forward RMSE	Played music Anxiety SAPS Discrepancy Age SAPS Standard	0.21	0.73	0.43, 1.27
1(f). Forward RMSE	Played music Anxiety SAPS Discrepancy Age SAPS Standard Sex	0.22	0.77	0.45, 1.34
1(g). Forward RMSE	Played music Anxiety SAPS Discrepancy Age SAPS Standard Sex CAGE-AID Abuse	0.22	0.77	0.44, 1.34
1(h). Forward RMSE	Played music Anxiety SAPS Discrepancy Age SAPS Standard Sex CAGE-AID Abuse Hours in Class	0.22	0.75	0.42 , 1.32
1(i). Forward RMSE	Played music Anxiety SAPS Discrepancy Age SAPS Standard Sex CAGE-AID Abuse Hours in Class Hours Exercising	0.21	0.71	0.40, 1.27

1(j). Forward RMSE	Played music Anxiety SAPS Discrepancy Age SAPS Standard Sex CAGE-AID Abuse Hours in Class Hours Exercising Mental Health Disorder	0.22	0.73	0.41, 1.30
1(k). Forward RMSE	Played music Anxiety SAPS Discrepancy Age SAPS Standard Sex CAGE-AID Abuse Hours in Class Hours Exercising Mental Health Disorder Muscle/Bone/Joint Problem	0.22	0.72	0.40, 1.30
1(l). Forward RMSE	Played music Anxiety SAPS Discrepancy Age SAPS Standard Sex CAGE-AID Abuse Hours in Class Hours Exercising Mental Health Disorder Muscle/Bone/Joint Problem Hours Studying	0.22	0.74	0.41, 1.33
1 (m). Forward RMSE	Played music Anxiety SAPS Discrepancy Age SAPS Standard Sex CAGE-AID Abuse Hours in Class Hours Exercising Mental Health Disorder Muscle/Bone/Joint Problem Hours Studying Chronic Health Disorder	0.22	0.74	0.41, 1.33

***Table 5.** Variable selection strategy to determine adjusted Odds Ratio's between number of years playing music and subclinical depression.*

Model	Model Variables	SE for coefficient	OR	95% CI for OR
2(a). Basic (cesd_spl)	Years Playing Music	0.01	0.94	0.95, 1.00
2(b). Forward RMSE	Years Playing Music Anxiety	0.02	0.99	0.96, 1.02
2(c). Forward RMSE	Years Playing Music Anxiety SAPS Discrepancy	0.02	0.98	0.95, 1.02
2(d). Forward RMSE	Years Playing Music Anxiety SAPS Discrepancy Age	0.02	0.99	0.96, 1.03
2(e). Forward RMSE	Years Playing Music Anxiety SAPS Discrepancy Age SAPS Standard	0.02	0.99	0.96, 1.03
2(f). Forward RMSE	Years Playing Music Anxiety SAPS Discrepancy Age SAPS Standard Hours Studying	0.02	1.00	0.96, 1.04
2(g). Forward RMSE	Years Playing Music Anxiety SAPS Discrepancy Age SAPS Standard Hours Studying CAGE-AID Abuse	0.02	1.00	0.96, 1.03
2(h). Forward RMSE	Years Playing Music Anxiety SAPS Discrepancy Age SAPS Standard Hours Studying CAGE-AID Abuse Hours Exercising	0.02	1.00	0.96, 1.03
2(i). Forward RMSE	Years Playing Music Anxiety SAPS Discrepancy Age SAPS Standard Hours Studying CAGE-AID Abuse Hours Exercising Muscle/Bone/Joint Problem	0.02	1.00	0.96, 1.04

2(j). Forward RMSE	Years Playing Music Anxiety SAPS Discrepancy Age SAPS Standard Hours Studying CAGE-AID Abuse Hours Exercising Muscle/Bone/Joint Problem Mental Health Disorder	0.02	1.00	0.96, 1.03
2(k). Forward RMSE	Years Playing Music Anxiety SAPS Discrepancy Age SAPS Standard Hours Studying CAGE-AID Abuse Hours Exercising Muscle/Bone/Joint Problem Mental Health Disorder Hours in Class	0.02	1.00	0.96, 1.04
2(l). Forward RMSE	Years Playing Music Anxiety SAPS Discrepancy Age SAPS Standard Hours Studying CAGE-AID Abuse Hours Exercising Muscle/Bone/Joint Problem Mental Health Disorder Hours in Class Sex	0.02	1.00	0.96, 1.04
2(m). Forward RMSE	Years Playing Music Anxiety SAPS Discrepancy Age SAPS Standard Hours Studying CAGE-AID Abuse Hours Exercising Muscle/Bone/Joint Problem Mental Health Disorder Hours in Class Sex Chronic Health Disorder	0.02	1.00	0.96, 1.04

Table 6: *Model-adjusted associations of CES-D scores and musicianship.*

Model	OR	95% CI for OR
1. Model 1(m) CES-D binary; Music binary	0.74	0.41, 1.33
2. Model 2(m) CES-D binary; Music continuous	1.00	0.96, 1.04
Models run with anxiety term removed		
Model 1(m) CES-D binary; Music binary	0.60	0.37, 0.98
Model 2(m) CES-D binary; Music continuous	0.97	0.94, 1.01

In all models, no relationship was found between musicianship status (through dichotomous score or as number of years playing) and CES-D score. The logistic models did not include any significant interaction terms, nor did they display evidence of multicollinearity. Final models were tested for goodness of fit, and the logistic models fit their model assumptions well (Appendix V).

Impact of Anxiety

It should be noted that CES-D scores had a high correlation ($r > 0.70$) with the GAD-7 anxiety scores, in all models. This has frequently been reported elsewhere, and all models in this report were assessed for multicollinearity, and were run with the anxiety term removed. In both logistic models, the protective effect of music was more pronounced following the removal of the anxiety term. The first model showed a statistically significant association with anxiety removed, OR= 0.60, 95% CI [0.37, 0.98]. The second model (measuring musical exposure as number of years played) had an OR of 0.97, 95% CI [0.94, 1.01].

4.5 Discussion

No important association was found between playing music and subclinical depression with either a dichotomous or continuous measure of music exposure. While the adjusted odds ratio for the association between having ever played music and depressive symptomatology was less than 1.00, the results were not statistically significant. The findings here suggest that no relationship between playing music and depressive symptomatology exists.

Few studies have looked at a causal relationship between playing music as a hobby and subclinical depression. Previous studies interested in depression in musicians have focused exclusively on professional musicians and/or music majors, and the lack of a control group has

been a methodological issue.[46-47, 58, 73] This is a problem, as it is clear that playing an instrument as an enjoyable pastime is entirely different from being a member of an orchestra and making a living by playing that instrument. Further, previous studies have not included a comprehensive set of confounding variables in their analyses.[46-47, 58, 73] While the purpose of this study was to determine the potential association between playing music and depressive symptomatology, a lack of literature on the subject made confounder selection difficult. In an effort to be comprehensive in all potential confounders, we ended up including twelve variables in our initial model. After completing a conservative variable selection strategy, we were surprised that none of the confounders warranted removal. This suggests that a wide array of correlates for subclinical depression exist in university students. Some of the confounders we included likely require further investigation in their own right. For example, this was the first study of musicians that included information on perfectionism discrepancies (maladaptive thoughts related to overexerting pressure on oneself to do better). This variable was actually one of the strongest correlates in both models, and we would advise similar studies in the future to include the SAPS questions.

An interesting finding worth discussing here is the alarming prevalence of mental health symptomatology in university students. While this study was interested in investigating depressive symptoms in their relationship to music, what was more concerning was the burden of depressive symptoms we saw in our sample of university students. Recent literature has suggested that more students today suffer from high anxiety and stress than did their predecessors, but we saw an exaggeration of this in our sample.[58, 74] We found that 52% of our sample was over the threshold for possible subclinical depression. The mean CES-D score across

our 469 person sample was 19, which is over the threshold for subclinical depression.[3, 21] Importantly, these numbers were consistent across diverse departments.

Previous studies that have focused only on mental health outcomes in music undergraduate students reported similar findings, and suggested that music students in particular suffer from higher rates of depression and anxiety.[46-47, 58] Interestingly, Demirbatir's study of depression, anxiety and stress in Turkish university music students also detected a prevalence of depression of 52%, with a response rate of 92%.[58] We were surprised to detect the same prevalence, but across students of all academic departments. This suggests that perhaps student life, and not music programs specifically, is associated with high levels of anxiety and depression. The burden of school work is likely to be a source of considerable worry to students. In our sample, students spent an average of 17 hours in class and 19 hours studying outside of class. This combined with a part-time job, volunteer activities, and a social life could cause significant strain on a student's ability to relax. In light of topical tragedies seen on university campuses, the findings of this study highlight the concern for MHD resources on university campuses. University students represent an already vulnerable age group at high risk for developing MHD, and coupled with the stress of academic demands, are of high concern.[75] Further mental wellbeing efforts should target efforts on University campuses.

In comparison to what has been found elsewhere, this study did not find that depressive symptoms are more likely in musicians than their non-musician counterparts.[46, 58] This study never attempted to discern a causal relationship, but the findings presented here justify further research. Some studies have examined basic prevalence rates of anxiety and depression in music students.[46, 58, 76] With our sample, which included students from a wide array of academic departments, we did not find reason to believe that higher prevalence rates of depression and

anxiety symptomatologies are associated with playing a musical instrument. The findings here cast doubt on the previously asserted beliefs that musicians experience more work and school related stress than their non-musical counterparts.[46, 58]

In an effort to address a gap in the literature, we chose to investigate depressive symptomatology in isolation from anxiety. Substantial evidence has discussed the limitations of examining depression and anxiety as a joint condition, and while we hoped to address a gap by focusing specifically on depression, the two conditions' co-occurrence cannot be ignored.[46, 58] In hindsight, perhaps the two conditions are so highly correlated (we calculated a correlation coefficient of 0.71), that to attempt to analyze them in isolation was a mistake. We did find that the protective association between music and depressive symptomatology became more pronounced with the removal of the anxiety term from the models. Due to the strong correlation between depressive symptomatology and anxiety, it is possible that the anxiety masked much of the association between music and depression symptoms. If a study similar to this is to be repeated, it is our recommendation that separate, but equally robust tools are utilized to capture depression and anxiety separately. While the GAD-7 is a valid and reliable tool, a more stringent instrument may have reduced some potential misclassification resulting from the use of a dichotomized variable [59].

In light of the evidence presented above, we recommend that future studies consider collecting more detailed musical exposure information, and that the general population be used as a sample population. As our study was cross-sectional in design, we could not include any time-related information. Future longitudinal studies investigating a temporal relationship between playing music and depressive symptoms would be of interest. It would be interesting to compare depressive symptomatology between musicians with heavier practice regimes compared

to those without. Our findings here suggest that no statistically significant association exists between years playing a musical instrument or musicianship and subclinical depression. However, high prevalence rates of subclinical depression and anxiety on Canadian university campuses highlight the need for further epidemiological inquiry into activities and interventions that help students manage stress. We recommend longitudinal studies be conducted to investigate the potential therapeutic nature music may have on depression management.

Strengths and Limitations:

The possibility of selection bias was a concern in this study. While we anticipated a low response rate, we ended up with a response rate even lower than what we expected. Despite our low participation rate, we do not believe that individuals who chose to participate may have had a particular reason for doing so. Participants were told that they would be participating in a study of music and health outcomes, and the observed prevalence of clinical MHD in our sample echo those of national averages (Table 1). Further, our findings echoed similar studies conducted elsewhere, that boasted participation rates over 90%.[46, 58] Potential misclassification bias may have occurred when ascertaining exposure status. As few previous studies have attempted to assess the association between lifelong, amateur exposure to music and subclinical depression, there were no validated scales or questionnaires for measuring music exposure. However, we do believe that the questions that we designed were comprehensive, and that they were created based on the best available evidence following our literature review. We also found that both of our methods of ascertaining musical exposure were in accord with one another when answering the research question. Finally, the cross-sectional design of this study prevents the ability to address causality.

This study also has several strengths. First, this is the first study to assess the association between lifelong musical exposure in average university students and depressive symptomatology. Second, it is likely that the students in our sampling frame were similar in many characteristics, creating a homogeneous sample, and lowering the risk of uncontrolled confounding by other demographic features not measured here. Great care was taken to include and consider all potential extraneous variables. This is also one of the first studies in this field to employ the use of separate, validated and reliable instruments to consider depression as a distinct outcome.

4.6 Conclusion

This study is the first to assess the association between lifelong musical experience and depressive symptomatology in a sample of Canadian university students. No important association was found between practicing music and depressive symptomatology. There is no justifiable cause to suggest that playing music is associated with depressive symptoms.

4.7 References

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Chapter 5: Increased odds of subclinical depression in musicians who improvise: results from a cross-sectional study

5.1 Abstract

Background: Mental health disorders (MHD) are an important public health concern in Canada and globally. In Canada, it is estimated that one in five individuals experience a mental health or addiction problem annually. It is well-established that music helps improve mood and reduce feelings of anxiety. Recent attention has focused on differential thought processes that occur in musicians who spontaneously improvise music. Due to the significant neurological differences found between those who improvise and those who do not, it is possible that MHD may manifest differently between improvisers and non-improvisers. No studies of mental health outcomes have attempted to compare different improvisatory backgrounds between musicians.

Methods: A cross-sectional web-based survey was completed by 240 student musicians. Musicians were asked several questions related to their musical training, as well as to report their improvisational ability, time spent improvising, and whether or not they were a jazz musician. Multivariable logistic regression was used to explore the association between improvisational ability and MHD as well as improvisational ability and depressive symptomatology, while controlling for important confounders.

Results: Serious MHD were more likely to be reported in individuals reporting higher improvisational ability, although this finding was not statistically significant (OR= 1.89, 95% CI [0.93, 3.88]). A statistically significant increased odds of subclinical depression was found in improvisers (OR=1.87, 95% CI [1.07, 3.26]).

Conclusion: In this sample of musicians, those indicating depressive symptomatology were more likely to report highly creative backgrounds compared to those without depressive symptomatology. It is likely that creating music serves as an emotional outlet for troubled

students. It is also possible that highly creative musicians may be at a higher risk of developing

depression.

5.2 Background

The burden of serious mental health disorders (MHD) in Canada is alarming. In 2015, 12% of the Canadian population (3.7 million people) reported that they had received a clinical diagnosis for a mood disorder.[17] Another 3.4 million Canadians reported that they have seriously contemplated suicide at least once in their lifetime.[17] Half of Canadians aged 40 and older will have experienced a mental illness.[1] Serious MHD most commonly presents in young adults, between the ages of 15-30.[1, 17-19]

In order to help target preventative efforts, it is important for health researchers to identify population groups that are at high risk of developing MHD. Over the last decade, several studies have highlighted concerning presentations of mental health conditions in professional musicians.[19-25] A five year study of professional musicians in Australia reported that 32% of the individuals participating in the cross-sectional survey screened positive for depression.[26] Similar findings were reported in studies conducted in Brazil and in Norway, where professional musicians were found to suffer from a disproportionately higher amount of MHD.[27-28] Results from studies completed in university music students have shown even more troubling findings. In a study conducted in Turkish music students, self-reported depression and anxiety exceeded 50%.[29] A similar study conducted in Switzerland reported comparable findings, and found that the burden of stress only seemed to increase as the students moved through university.[30] Interestingly, this study implicated performance anxiety as being a leading factor in the concerning prevalence of mental illness amongst musicians.[30] All of these findings are contradictory to the overwhelming evidence presented by studies examining the efficacy of music therapy. Countless studies have reported that when delivered therapeutically, music has resulted in increased mood, lowered anxiety, and reduced agitation.[3-14] Further, music therapy

has been shown to help individuals struggling with schizophrenia, bipolar disease, depression, and anxiety.[9-10, 12-13, 31-32] No reports of adverse outcomes resulting from the musical interventions were reported in any of these studies.

There has long been discussion surrounding the possibility of a link between high levels of creativity and depression, as well as other serious MHD.[20, 33] Numerous famous musicians have garnered notoriety for their genius as well as their mental illness. Prominent examples include Charlie Parker, Jimmy Hendrix, and Amadeus Mozart.[20-22, 33]While the relationship between musical ingenuity and mental illness is well documented (especially in the media), it is difficult to determine the causality of this relationship. It is suggested that individuals who struggle with anxiety, stress and other mental illnesses may be more likely to turn to creative outlets to express themselves.[19-21]

Structural differences have been found when comparing the brains of musicians to those of non-musicians.[14-16] Studies have found that musicians have more grey matter, enhanced synaptic plasticity, and different cortical profiles altogether when compared to non-musicians.[14-15] More recently, neurologists have now started to examine musicians' brains to help understand the process of human creativity.[34-36] Musical improvisation is defined as the spontaneous creation of musical ideas, combining instrumental technique with communication of emotions.[34-39] Thanks to functional magnetic resonance imaging (fMRI), scientists have been able to demonstrate that improvisers have entirely different neural profiles when compared to non-improvisers.[34, 40] Using brain scans from fMRI studies, it has been found that a local dissociation occurs in the frontal region of the brain during the improvisation process.[11, 34-35, 40] When an individual begins to spontaneously create music, the medial prefrontal cortex (which is associated with organization and internal motivation) is activated.[11, 34-35, 40] Conversely, the

lateral prefrontal cortex (an area involved in self-awareness and monitoring) is deactivated. These findings are novel, as this co-operative effort between these two neural regions does not occur under normal physiological conditions. It appears that this local dissociation works in perfect harmony to allow the individual to create spontaneous ideas.[34-36, 40-41]

Musical improvisation is a specific example of the higher-level cognitive functioning and divergent thought-processing that occurs when an individual is actively creating something.[35-38, 40, 42] The type of executive control that occurs during a creative process is similar to the notion of an individual creating many solutions to a problem, and then selecting the optimal solution for that problem.[36, 38, 43] Understanding the relevance of differential brain processes associated with creating music may have clinical ramifications when applying this knowledge to the treatment of diseases affecting the mind. While there have been no fMRI studies on musical creativity in individuals with MHD, it is evident that important differences exist on a neurological level between differing modes of musical practice.[34] It is of particular interest to consider the dissociative activity that occurs in the brain during improvisation, with a particular emphasis on the deactivation of the "self-monitoring" centre of the brain, and how this could play a role in mood disorders.

Spontaneous creation of music differs drastically from playing from a sheet of music or memory such that it warrants further study. This has potentially wide-ranging consequences for our current understanding of health benefits derived from music. When compared to the general population, professional musicians suffer from a disproportionally higher level of MHD.[19-25] However, no study has compared potential differences in MHD burden between amateur musicians of varying improvisational backgrounds. Due to the significant neurological

differences found between the two groups of musicians, it is possible that MHD may manifest differently between improvisers and non-improvisers.

The purpose of this study is to explore the association between musical improvisation and mental health outcomes. Specifically, this study will explore two research questions:

1) What is the association between self-reported musical improvisatory capabilities and depressive symptomatology? and;

2) What is the association between self-reported musical improvisatory capabilities and serious mental health conditions?

We hypothesize that both the prevalence of depressive symptoms and serious mental health conditions will be higher in musicians who improvise. Therefore, we hypothesize that those who are good at improvising music will be associated with more depressive symptoms and suffer from more MHD.

5.3 Methods

5.3.1 Study Design

We conducted a cross-sectional web-based survey in university students (Appendix I). The ten minute survey was hosted on the REDCap platform.[44] Departments from the University of Toronto and Lakehead University were contacted via email through a random selection process. These generic emails were sent to various academic departments, and those who replied were sent further instructions, including the survey link and a detailed study description. The department contact was then responsible for distributing the study material to their students via listserve. By this method, all potential participants were kept anonymous to the research team.

Reminder emails to participate were sent out via the departmental contact after two weeks. Once an interested participant clicked on the survey link, he or she was directed to a description of the study purpose (See Appendix II). The survey then asked the participant if he or she had read the study description and to provide their informed consent. Following a "YES" answer to this question, the participant was then able to access the remainder of the survey.

5.3.2 Participants

A sample of university students who play music was established from a cross-sectional survey on music exposure and health outcomes completed by a self-selected sample of Canadian university students. Any individual who received a survey link and invitation to participate in the study was eligible. All participants were kept anonymous to the research team, as a result of the study material being distributed on our behalf through the departmental contact. Interested students were able to follow the survey link, and after providing informed consent, complete the questionnaire. The survey was only made available in English, and required the participants to have a working computer, with an adequate network connection.

Over 9,100 students were sent emails containing the survey link. We obtained a response rate of 6.3%, with a total of 579 students following the survey link. Of these 579 participants, 240 identified as musicians. This group represents the sample used for this analysis.

5.3.3 Study Measures

Outcome Measures

Presence of serious mental health disorders: Participants were asked if they have, in the past six months, been diagnosed with various categories of MHD. These groupings are drawn from the

Canadian Community Health Survey.[45] The Canadian Community Health Survey is a cross-sectional, population-based survey that is conducted on an annual basis in co-ordination with Statistics Canada.[45] The questions included on the Canadian Community Health Survey have been validated, and are deemed reliable, based on analyses conducted between years of the survey.[17] For each group of conditions posed, the participant answered with YES, NO, I DON'T KNOW, or I CHOOSE NOT TO ANSWER. For the purposes of this study, only YES and NO answers were analyzed. This was done so that this variable could be treated as a dichotomous outcome.

Depressive symptomatology: The Centre for Epidemiologic Studies Depression Scale (CES-D) is a validated and reliable self-report tool, and is used widely to collect information regarding an individual's self-reported burden of a variety of depressive symptoms.[46-52] Multiple studies investigating the scale's factorial and discriminant validity have been completed, including in populations of university students.[47-53] The CES-D also displays high test-retest validity and good internal consistency.[46-52, 54] The CES-D is used to assess symptoms of depression, and cannot take the place of a clinical diagnosis.[46, 48, 52] When participants are presented with each question, they are asked to rank their agreement with the statement on a Likert scale. Summed scores range from 0-60, with higher scores indicating more depressive symptoms.[46] The summed score has been criticized in the literature, and thus, the common conventional cut-point of 16 will serve as a "subclinical depression" score.[46, 55-56]

Exposure Measures

Musical Improvisation: Improvisation was measured in three ways, as there is no existing validated measure. All three questions rely on self-report data. The first question asked the

participants who had identified as musicians to rate their improvisatory capabilities on a simple scale. This ranged from **0= I do not improvise; 1= Poor; 2= Satisfactory; 3= Good; 4= Excellent; or I do not know.** Those who answered "I do not know" were excluded from analysis. The next question asked participants to identify how much of their practice time is spent improvising. Answers to this question were categorized ordinally: **0-25%; 25-50%; 50-75%; 75-100%**. A final question asked participants to dichotomously identify as a jazz musician. This was done as jazz is a genre of music that relies almost exclusively on improvisation.[34]

Confounding Variables

Several variables were assessed for their potential confounding effects on the associations between music and depressive symptomatology and MHD. These included age, gender, smoking status, number of hours spent studying each week, number of hours spent practicing each week, and whether the individual suffered from performance anxiety. Several additional confounders were assessed using established instruments:

Anxiety: Anxiety was assessed using the Generalized Anxiety Disorder (GAD-7) scale.[57-58] The GAD-7 consists of seven anxiety symptoms, where the respondent indicates the number of days over the past two weeks he or she has experienced that symptom.[57-58] The scores were summed, and scores exceeding ten were considered possible subclinical anxiety, as per the common convention.[57-58] The GAD-7 has been proven to be both reliable and valid in a population setting, with a sensitivity of 89% and specificity of 82% for detecting generalized anxiety disorder.[57-59] Further, the GAD-7 displays good agreement between self-report data and clinician diagnosis.[57]

Perfectionism: Participants' prevalence of perfectionism was assessed using the Short-Almost Perfect scale (SAPS).[60] The SAPS is frequently used to assess feelings of personal aspirations and perfectionism.[61] SAPS scores were summed as two dimensions: standards (high performance expectations) and discrepancies (self-critical performance evaluations).[60] Higher scores on SAPS Standards indicate more beneficial perfectionistic mannerisms, while high scores on SAPS discrepancies indicate more problematic perfectionism.[60] The SAPS has been deemed to be valid and reliable, and possesses good psychometric features in young adults.[60]

Substance Abuse: Substance abuse was assessed using the CAGE-AID assessment scale. The CAGE-AID is a brief, self-report tool that has been validated in a young population cohort.[62] The scale examines both alcohol and drug abuse.[63] A score of one indicates a possible substance abuse problem, while a score of two or more indicates a probable problem.[63] The CAGE-AID exhibits 71% sensitivity and 76% specificity.[63] This scale was specifically designed to target young adult and adult populations.[63]

Presence of chronic health conditions: Other co-morbid conditions that may act as confounding variables to the association of interest were addressed using the Comorbidity Questionnaire. The Comorbidity Questionnaire is a patient-centered, self-report measure of health problems.[64] The instrument has acceptable test-retest reliability during a fourteen day-period with item-specific weighted kappa coefficients above 0.56, indicating moderate agreement with physician-reported health issues.[64] It has also been shown to have adequate face, concurrent, and convergent validities.[65] The Comorbidity Questionnaire has been used elsewhere, and is an acceptable method to ascertain chronic disease burden.[65-66]

5.3.4 Analysis

All data were analyzed using Stata statistical software, version 13.[67] Prior to analysis, all data were cleaned and examined for missing, incomplete and/or inaccurate information. Any individual who did not identify as a musician was excluded from subsequent analysis. A univariate descriptive analysis was completed on all variables to determine outliers and examine distribution patterns. A contingency table chi-square analysis was conducted to determine crude odds ratios. Basic bivariate tests of association were run between exposure and confounding variables. In order to dichotomize improvisation for the bivariate analysis, all individuals who indicated "Excellent" or "Good" improvisatory capabilities were considered "improvisers", and those who indicated "Satisfactory", "Poor", or "I do not improvise" were considered to be non-improvisers.

To answer both of the research questions, multivariable logistic regression was used to calculate adjusted odds ratios. To complete the logistic regression, a variable selection strategy was used as outlined by Greenland *et al.* (2016).[68] In order to create a dichotomous variable representing presence of serious MHD as determined through the CCHS questions, any individual who had indicated a "YES" response to presence of one of the serious MHD was considered to possess the outcome of interest. CES-D scores were analyzed dichotomously, with the standard cut-point of 16 indicating those considered to have the outcome of interest.[55] This variable was modelled using the same strategy as outlined above. Interaction terms were assessed for significance within the model using a p value of <0.05. Once the final models were created, several tests (Goodness-of-fit test for binary response models using survey data with grouped tables, multicollinearity) were conducted to ensure that the fit of the models were satisfactory.

5.4 Results

Approximately 9, 100 students received emails inviting them to participate in the survey. We received responses from 579 individuals, indicating a response rate of 6.3%. Of these, 240 were self-taught, amateur, or professional musicians and comprise the sample for this study (Table 1).

Table 1: *Characteristics of Participants (%, 95% Confidence interval)*

	Number of Students (N=240)	Proportion of students Percentage and 95% CI
Plays Instrument		
Yes	228	95% [91% to 97%]
No	12	5.0% [2.8% to 8.6%]
Missing	0	--
Sings		
Yes	69	29% [23% to 35%]
No	170	71% [65% to 77%]
Missing	1	--
Number of Years Playing		
(Mean= 11, sd= 6.1)		
0- 5	48	21% [16% to 27%]
6- 10	68	30% [24% to 36%]
11-15	68	30% [24% to 36%]
16-20	36	16% [12% to 21%]
21-25	6	2.6% [1.2% to 5.7%]
26-30	2	1.0% [0.22% to 3.5%]
35-40	0	0%
41-45	0	0%
46-50	1	0.44% [0.06% to 3.1%]
Missing	11	--
Jazz Musician		
No	222	92.5% [88% to 95%]
Yes	18	7.5% [4.8% to 95%]
Missing	0	--
Hours Per Week Practicing		
(Mean= 3, sd= 5.4)		
Less than 1 hour	45	30% [23% to 38%]
1-5 hours	85	57% [49% to 65%]
6-10 hours	11	7.4% [4.1% to 13%]
11-15 hours	1	0.7% [0.09% to 4.7%]
16-20 hours	3	2.0% [0.64% to 6.1%]
21-25 hours	3	2.0% [0.64% to 6.1%]
36-40 hours	1	0.7% [0.09% to 4.7%]
Missing	91	

Musicians' Improvisation

I do not improvise	44	19% [14% to 25%]
Poor	66	29% [23% to 35%]
Satisfactory	60	26% [21% to 32%]
Good	44	19% [14% to 25%]
Excellent	17	7.4% [4.6% to 12%]
I do not know (considered missing)	9	

Musician Time Improvising

0-25%	106	58% [50% to 65%]
25-50%	41	22% [17% to 29%]
50-75%	24	13% [8.9% to 19%]
75-100%	13	7.1% [4.1% to 12%]
Missing	56	--

Performance Anxiety

No	136	60% [53% to 66%]
Yes	92	40% [34% to 47%]
Missing	12	--

School

Lakehead University	81	34% [28% to 40%]
University of Toronto	157	66% [60% to 72%]
Other	2	1% [0.2% to 3.3%]

Age
(Mean= 23, sd= 5.7)

0-20	80	37% [31% to 44%]
21-30	127	59% [52% to 65%]
31-40	5	2.3% [1.0% to 5.5%]
41-50	1	0.5% [0.01% to 3.3%]
50+	3	1.4% [0.4% to 4.3%]
Missing	24	--

Sex

Female	144	65% [58% to 71%]
Male	78	35% [29% to 42%]
Chose not to answer	4	1.8% [1.0% to 4.7%]
Missing	14	--

Gender

Man	78	35% [29% to 41%]
Woman	139	62% [55% to 68%]
Trans Man, Trans Woman, or Two Spirit	1	0.4% [0.06% to 3.1%]
Gender Neutral or Gender Free	5	2.2% [1.0% to 5.2%]
Chose not to answer	3	1.3% [0.43% to 4.1%]
Missing	14	--

Sexuality

Heterosexual/Straight	184	77% [71% to 82%]
Bisexual	20	8.3% [5.4% to 13%]

Gay	7	2.9% [1.4% to 6.0%]
Lesbian	6	2.5% [1.1% to 5.5%]
Queer	10	4.2% [2.2% to 7.6%]
Questioning	5	2.1% [1.0% to 4.9%]
Another sexual orientation not listed here	4	1.7% [1.0% to 4.4%]
I choose not to answer	6	2.5% [1.1% to 5.5%]
Highest Level of Education		
High School	127	56% [50% to 63%]
College/Diploma Program	21	9.3% [6.1% to 14%]
University Degree	65	29% [23% to 35%]
Master's Degree	10	4.4% [2.4% to 8.1%]
PhD	2	1.0% [0.22% to 3.5%]
Missing	15	--
Education Payment		
Parents Pay Tuition	76	32% [26% to 38%]
Parents and Student Pay Tuition	63	26% [21% to 32%]
Student Pays Tuition	65	27% [22% to 33%]
Scholarships and Awards	116	48% [42% to 55%]
Student Loans	95	40% [34% to 46%]
Funding	28	12% [8.2% to 16%]
Hours Spent Exercising Over Two Weeks *(Mean= 8, sd= 9.7)*		
<1	26	12% [8.0% to 16%]
1-5	88	39% [33% to 46%]
6-10	55	24% [19% to 31%]
11-15	28	12% [8.7% to 17%]
16-20	19	8.4% [5.4% to 13%]
21-25	3	1.3% [0.43% to 4.1%]
26-30	2	1.0% [0.22% to 3.5%]
30+	4	1.8% [1.0% to 4.7%]
Missing	15	--
International Students	21	9.3% [6.1% to 14%]
Smoking		
Never	181	80% [74% to 85%]
Occasionally	31	14% [9.8% to 19%]
Daily	14	6.2% [3.7% to 10%]
Missing	14	--
Presence of Mental Health Disorders	38	17% [12% to 22%]
(Those who answered YES)		
Schizophrenia	1	0.4% [0.01% to 3.1%]
Mood Disorders	19	8.3% [5.3% to 13%]
Anxiety	26	11% [7.8% to 16%]
Substance Abuse	2	1.0% [0.2% to 3.5%]
Post-traumatic Stress Disorder	8	3.5% [1.7% to 6.9%]
Learning Disability	7	3.1% [1.5% to 6.3%]

Attention Deficit Disorder	3	1.3% [0.4% to 4.0%]
Eating Disorder	1	0.4% [0.01% to 3.1%]
Presence of Chronic Health Condition (Those who answered YES)	160	70% [64% to 76%]
Bone, Muscle & Joint Problems	72	32% [26% to 38%]
Allergies	88	39% [32% to 45%]
Breathing Problems	31	14% [9.7% to 19%]
Blood Pressure	5	2.2% [1.0% to 5.2%]
Cardiovascular Disease	7	3.1% [1.5 % to 6.4%]
Digestion	16	7.0% [4.3% to 11%]
Diabetes	1	0.4% [0.01% to 3.1%]
Urogenital Problems	4	1.8% [1.0% to 4.6%]
Neurological Problems	3	1.3% [0.4% to 4.0%]
Headaches	92	40% [34% to 47%]
Cancer	0	--

Participants and Demographics:

Of the 240 self-identified musicians, 42 of these individuals indicated that they considered themselves to be "professional" musicians. The mean number of years playing was eleven years (sd= 6.1). On average, the sample of musicians practiced for approximately three hours per week (sd= 5.4). Twenty-five percent of the musicians were classified as "improvisers", after indicating that they were "Good" or "Excellent" improvisers. The majority of individuals (28%), when asked to rate their improvisational abilities, rated them as "Poor". Approximately 40% of the participants claimed to suffer from performance anxiety (Table 2).

Table 2. *Prevalence of subclinical mental health disorders in musicians*

Clinical Outcome	Number of Students N= 240	Proportion of students (95% Confidence Interval)
CES-D Score		
No clinical significance	124	52% [45% to 58%]
Possible Subclinical Depression	116	48% [42% to 55%]
Mental Health Disorders		
No	189	83% [78% to 88%]
Yes	38	17% [12% to 22%]
Missing	13	--
GAD-7 Anxiety Score		
No clinical significance	165	72% [66% to 77%]
Possible anxiety	65	28% [23% to 34%]
Missing	10	--
CAGE-AID Score		
No clinical significance	197	88% [83% to 91%]
Clinically significant	28	12% [8.7% to 17%]
Missing	15	--
Chronic Health Disorder		
No	68	30% [24% to 36%]
Yes	160	70% [64% to 76%]
Missing	12	--

Improvisation and serious mental health disorders

Bivariate associations were explored between improvisational ability and serious MHD, as well as between improvisation and other potential confounding variables (Table 3). By performing the forward variable selection strategy as outlined by Greenland *et al.* (2016), nearly all potential variables were retained in the model (Table 4).[68] Potential interaction terms were assessed by individually adding each to the model, and assessing if a significant difference upon each addition occurred (p<0.05). None of the interaction terms warranted inclusion in the final model. Individuals with self-reported creative musical capabilities were not more likely to suffer from subclinical depression than non-improvisers (OR=1.89, 95% CI [0.93, 3.88]).

Table 3. *Bivariate associations treating improvisation as an exposure for a variety of outcomes (where improvisation is binary: 0= non-improvisers; 1= improvisers)*

Characteristic	Odds Ratio	95% CI for OR
Mental Health Condition		
No	1.00	--
Yes	1.07	0.48, 2.38
Depression		
CES-D<16	1.00	--
CES-D >=16	1.24	0.69, 2.23
Anxiety		
No anxiety	1.00	--
GAD-7 Possible Anxiety	0.87	0.44, 1.72
CAGE-AID Substance Abuse		
No abuse	1.00	--
Possible Abuse	1.41	0.60, 3.33
Chronic Health Conditions		
No	1.00	--
Yes	0.78	0.41, 1.49
Muscle/Bone/Joint Problems		
No	1.00	--
Yes	0.77	0.40, 1.49
Sex		
Male	1.00	--
Female	0.61	0.47, 0.78
Hours Playing/Practicing ±	5.30	1.52, 18.48

Performance Anxiety		
No	1.00	--
Yes	0.77	0.61, 0.98

± Represents a continuous variable. Improvisers have a statistically significantly (OR=5.3) greater chance of spending an additional hour practicing than non-improvisers.

Table 4. *Variable selection strategy to determine adjusted odds ratio's for associations between improvisation and serious mental health disorders and depressive symptomatology. Logistic Modelling, Greenland et al. model selection strategy (MHD)*

Model	Model Variables	SE for coefficient	OR	95% CI for OR
1(a). Basic (MHD)	Improvisation Ability	0.16	1.03	0.76, 1.38
1(b). Forward RMSE	Improvisation Ability Hours Practicing	0.26	1.15	0.74, 1.81
1(c). Forward RMSE	Improvisation Ability Hours Practicing Age	0.35	1.41	0.87, 2.30
1(d). Forward RMSE	Improvisation Ability Hours Practicing Age Sex	0.43	1.55	0.91, 2.66
1(e). Forward RMSE	Improvisation Ability Hours Practicing Age Sex Anxiety	0.49	1.70	0.96, 3.00
1(f). Forward RMSE	Improvisation Ability Hours Practicing Age Sex Anxiety Performance Anxiety	0.57	1.85	1.01, 3.39
1(g). Forward RMSE	Improvisation Ability Hours Practicing Age Sex Anxiety Performance Anxiety SAPS Standard	0.63	1.95	1.03, 3.68
1(h). Forward RMSE	Improvisation Ability Hours Practicing Age Sex Anxiety Performance Anxiety SAPS Standard Chronic Health Condition	0.70	2.04	1.05, 3.98
1(i). Forward RMSE	Improvisation Ability Hours Practicing Age Sex Anxiety Performance Anxiety SAPS Standard Chronic Health Condition Professionalism	0.68	1.93	0.97, 3.84

1(j). Forward RMSE	Improvisation Ability Hours Practicing Age Sex Anxiety Performance Anxiety SAPS Standard Chronic Health Condition Professionalism CAGE-AID Substance Abuse	0.71	1.97	0.97, 3.98
1(k). Forward RMSE	Improvisation Ability Hours Practicing Age Sex Anxiety Performance Anxiety SAPS Standard Chronic Health Condition Professionalism CAGE-AID Substance Abuse SAPS Discrepancy	0.69	1.90	0.93, 3.87
1(l). Forward RMSE	Improvisation Ability Hours Practicing Age Sex Anxiety Performance Anxiety SAPS Standard Chronic Health Condition Professionalism CAGE-AID Substance Abuse SAPS Discrepancy Depression	0.69	1.89	0.93, 3.88

Table 5. *Variable selection strategy to determine adjusted odds ratio's for associations between improvisation and depression.*
Logistic Modelling, Greenland et al. model selection strategy (CES-D)

Model	Model Variables	SE for coefficient	OR	95% CI for OR
2(a). Basic (CESD split)	Improvisation Ability	0.12	1.07	0.86, 1.34
2(b). Forward RMSE	Improvisation Ability Anxiety	0.17	1.23	0.93, 1.62
2(c). Forward RMSE	Improvisation Ability Anxiety Hours Practicing	0.25	1.24	0.84, 1.83
2(d). Forward RMSE	Improvisation Ability Anxiety Hours Practicing Performance Anxiety	0.28	1.32	0.87, 2.01
2(e). Forward RMSE	Improvisation Ability Anxiety Hours Practicing Performance Anxiety Sex	0.31	1.39	0.90, 2.14
2(f). Forward RMSE	Improvisation Ability Anxiety Hours Practicing Performance Anxiety Sex SAPS Standard	0.35	1.48	0.94, 2.36
2(g). Forward RMSE	Improvisation Ability Anxiety Hours Practicing Performance Anxiety Sex SAPS Standard Professionalism	0.39	1.60	0.98, 2.59
2(h). Forward RMSE	Improvisation Ability Anxiety Hours Practicing Performance Anxiety Sex SAPS Standard Professionalism Presence of chronic illness	0.42	1.66	1.00, 2.73
2(i). Forward RMSE	Improvisation Ability Anxiety Hours Practicing Performance Anxiety Sex SAPS Standard Professionalism Presence of chronic illness SAPS Discrepancy	0.43	1.62	0.96, 2.73

2(j). Forward RMSE	Improvisation Ability Anxiety Hours Practicing Performance Anxiety Sex SAPS Standard Professionalism Presence of chronic illness SAPS Discrepancy Age	0.43	1.57	0.92, 2.68
2(k). Forward RMSE	Improvisation Ability Anxiety Hours Practicing Performance Anxiety Sex SAPS Standard Professionalism Presence of chronic illness SAPS Discrepancy Age Mental Health Condition	0.47	1.76	1.04, 2.97
2(l). Forward RMSE	Improvisation Ability Anxiety Hours Practicing Performance Anxiety Sex SAPS Standard Professionalism Presence of chronic illness SAPS Discrepancy Age Mental Health Condition CAGE-AID Substance Abuse	0.51	1.80	1.04, 3.14
2(m). Forward RMSE	Improvisation Ability Anxiety Hours Practicing Performance Anxiety Sex SAPS Standard Professionalism Presence of chronic illness SAPS Discrepancy Age Mental Health Condition CAGE-AID Substance Abuse Musculoskeletal Problem	0.53	1.87	1.07, 3.26

Improvisation and depressive symptoms

Similar to the approach outlined above, a forward variable selection strategy was used.[68] The model for the association between improvisational ability and depressive symptomatology was assessed for significant change upon the addition of potential interaction terms. It was found that the interaction between improvisational ability and perfectionist "standards" significantly contributed to the association ($p<0.05$), but was not included in the final model due to redundancy in other variables resulting in multicollinearity. The final model was assessed using fit classification tables, and it was concluded that the model adequately represents the association. _Further information on this is found in APPENDIX V._ The odds ratio for the model-adjusted association between improvisational ability and CES-D scores demonstrated a statistically significant, increased odds in those with higher reported improvisational ability (OR= 1.87, 95% CI [1.07, 3.26]) (Table 6). Correlation matrices were run between all model variables, and a moderate correlation was found between GAD-7 and CES-D scores ($r=0.58$).

Table 6: *Model-adjusted associations of MHD, subclinical depression, and improvisational ability.*

Model	OR	95% CI for OR
1. Model 1(l) MHD binary; Improvisation categorical	1.89	0.93, 3.88
2. Model 2(m) CES-D binary; Improvisation categorical	1.87	1.07, 3.26

5.5 Discussion

According to our knowledge, this is the first cross-sectional epidemiological study to investigate the association between improvisational capabilities and mental health outcomes. The association between improvisational abilities and mental health outcomes demonstrated no association (OR= 1.89, 95% CI [0.93, 3.88]). For our second research question, we found that improvisers were significantly more likely to suffer from subclinical depression than non-improvisers (OR= 1.87, 95% CI (1.07, 3.26]).

Previous literature has reported that professional musicians suffer from a disproportionate burden of serious MHD.[26-28, 69-70] While our sample was based on university student musicians (both professional and amateur), we did not find this to be the case. Overall, the burden of serious MHD across our musician sample (n=240) was approximately 17%. This is actually quite close to the estimated burden of MHD in the general Canadian population, which is estimated to be about 13%.[1, 17] We did not find any statistically significant evidence to suggest that highly creative musicians are more prone to suffer from serious MHD. Our results did not confirm our hypothesis that improvisers would suffer from a significantly higher burden of MHD, as no statistically significant increase in the OR was seen. However, we believe that the positive trend we did observe is likely due to creative expression of individuals struggling with various mental illnesses. While this cross-sectional survey cannot determine directionality between associations, we find it biologically implausible that spending time improvising music would lead to the development of a serious MHD. Rather, it is likely that individuals struggling with mood or anxiety disorders may find creating music to be a viable emotional outlet. Further study could longitudinally investigate the potential application of musical improvisation as an intervention for musicians struggling with MHD.

In regards to our second research question, we found that individuals with subclinical depression were significantly more likely to be musicians of higher self-reported improvisational capability. Overall, the burden of subclinical depression in our study sample was high (48%). However, this finding is similar to other studies focused on studying university music majors.[19, 29-30] Previous studies of depressive symptoms in university students have focused solely on music majors.[29-30] Our study was unique, in that we considered students of all departments who play music to be considered "musicians". By doing so, we captured amateur and self-taught musicians who may not specifically take music classes in university. In general, university students tend to display high levels of depression, anxiety and stress symptoms.[19, 29-30, 71] As illustrated through our multivariable model, it is likely that there are many correlates that play a role in the high prevalence of depressive symptoms seen in student musicians.

There are several plausible explanations for increased depressive symptomatology in highly creative individuals. To begin, it is quite likely that students struggling with feelings of depression and loneliness may turn to music as a means to express themselves. It is therefore possible that the actual burden of depressive symptoms could in fact be much higher if these individuals could not play music at all. University is filled with stressors for students, and less time for other recreational activities may be partially responsible for increased depressive symptoms. In this sample, we detected a moderate correlation between hours spent practicing music and improvisational ability ($r=0.37$). While we did not collect detailed information regarding practice habits, it is possible that increased time spent practicing an instrument may be isolating students from other social interactions. Students already spend a significant amount of time preoccupied with schoolwork. In this sample, we found that on average, students spend 17 hours in class and 18 hours studying outside of class. It is possible that students struggling to

balance the demands of university life may be reducing their time spent exercising, going outdoors and visiting friends- all activities associated with improved mood outcomes.[1, 17] It is our recommendation that students who enjoy creating music should actively seek opportunities to do so in group settings, such as in an informal band or jam session.

Previous studies have suggested that increased prevalence of anxiety and stress in musicians could be partially attributable to performance anxiety.[27, 30, 70, 72] In our sample, approximately 40% of musicians sampled claimed to suffer from "detrimental performance anxiety". Interestingly, when a correlation matrix was completed between improvisational ability and performance anxiety, a negative correlation was found (r= -0.15). This finding is actually plausible, as strong improvisers must treat every practice session and rehearsal as a performance, since they are spontaneously creating music. It is plausible that individuals who spend more time becoming familiar with actively making errors in their musical performance are less anxious during live performances. A recommendation to be made here is that musicians who find themselves highly anxious before performances could potentially benefit from improvising music during practice time. Overall, despite the findings presented here, we do not feel it is warranted to implicate improvisational ability as being a risk factor for depression or other MHD. Rather, we implore students who enjoy creating music to ensure that they maintain a healthy life balance and to seek professional help for serious mental health concerns.

Strengths and Limitations

This study has several limitations. First, is the issue of using a cross-sectional design and temporality. With a cross-sectional design, it is impossible to determine whether the exposure of interest (improvisation) is indeed causal for the outcome (depressive symptomatology). In fact, it

is plausible that, in this study, more depressed people are more likely to be creative. Second, this study also had a very low response rate. While we predicted that the response rate to our survey would be low, we ended up with a response rate of approximately 6.3%. While the worry for selection bias exists for such a low participation rate, we do not believe that there was a systematic reason for participants choosing to participate. The observed prevalence rates for the MHD of interest were similar to those reported as national averages. Third, potential misclassification may have occurred when ascertaining exposure status. As no previous study has attempted to assess the association between musical creativity and depression, there were no validated scales or questionnaires for us to use. However, we do believe that the questions we designed were comprehensive, and that they were created based on the best available evidence following our literature review.

This study also has several strengths. As far as we know, this is the first study of its kind to assess the association between improvisational ability and depressive symptomatology. Great care was taken to include and consider all potential confounding variables in our logistic models. We are confident that the validated instruments used to assess outcome status gave us an accurate representation on the burden of subclinical symptoms of mental health disorders.

5.6 Conclusion

Musicians with subclinical depression are significantly more likely to be strong improvisers. Evidence presented here suggests that highly creative musicians may suffer from a disproportionately higher amount of depressive symptomatology than less creative musicians.

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Chapter 6: Discussion

6.1 Overview of Findings

This thesis had two objectives: 1) to determine the association between playing music and depressive symptomatology, and; 2) to explore the association between improvisation and mental health outcomes.

To our knowledge, this is the first study that determined the association between practicing music as a hobby and depressive symptomatology in a sample of university students of multiple academic departments. No association was detected between being a musician and subclinical depression. When considering the association between number of years playing music and subclinical depression, no significant association was observed. When anxiety was removed from both of these models, the protective effect was enhanced and statistically significant.

In our second analysis, we explored the association between musicians' improvisational abilities and 1) presence of serious mental health disorders; and, 2) subclinical depression. We found that the odds of having a serious mental health disorder were not any greater in individuals with higher improvisational abilities than in individuals with lesser abilities. We also found that greater improvisational ability was associated with greater depressive symptomatology, and that this association was statistically significant.

6.2 Main Findings

6.2.1 Exposure to Music and Subclinical Depression

The results we found when examining the relationship between total number of years playing music and subclinical depression were surprising. The model-adjusted odds ratio suggested that there is no significant association between the two variables (OR=1.00, 95% CI [0.96, 1.04]). We had expected that we would see a statistically significant protective effect as the number of years playing an instrument increased. When we ran our model considering musical exposure as a dichotomous "musicianship" variable, there was still no effect, but a protective effect was slightly more pronounced (OR= 0.74, 95% CI [0.41, 1.33]). While we believe that our findings are valid, there are many considerations that may explain our results.

One of the surprises of our study was the high prevalence of self-reported depressive symptoms in the university students sampled. Previous estimates in Saskatchewan had suggested that subclinical depression (as measured by the CES-D) may be as high as 22%.[1] To our alarm, more than half of our sample screened positive for subclinical depression. Our estimates of the burden of possible anxiety in the students were also higher than anticipated. We detected an anxiety prevalence estimate of 32%, compared to our predicted estimate of 12%.[2-4] There have been studies conducted in populations of music undergraduate students that have reported similar figures.[5-7] In a study conducted in Turkish undergraduate musicians, it was found that 52% of the sample was depressed and 62% of the sample had anxiety.[7] Despite its 92% participation rate, there were some methodological issues with this study which had originally led us to question their findings. In particular, the instrument the researchers used to assess depression and anxiety combined several different conditions together, potentially confusing the interpretation. However, it is interesting to note that we detected the same subclinical depression prevalence of 52%. Demirbatir *et al.* report music students as being particularly at risk of psychological distress, but we extend this notion to include all university students.[7]

An important difference between our study and that of Demirbatir's was that we were interested in assessing depressive symptomatology.[7] While it is obvious that prevalence estimates of subclinical depression will exceed that of clinically diagnosed depression, the overall state of mood in our sample of students was bleak. The average CES-D score in our sample was 19, which is well over the 16 point cut-off used to gauge subclinical depression. Based on the results we have found here, it is clear that university students represent a significantly high-risk cohort in the Canadian population (and likely worldwide). It is our recommendation that more efforts be directed into identifying stress reducing and management techniques for these students.

Other factors to consider in terms of evaluating the results from our multivariable logistic models are related to the confounding variables. Many studies that have examined depression, depressive symptoms and anxiety often collect these conditions together.[5-7] In an attempt to address a gap in the literature, we included separate instruments to evaluate depression and anxiety, with a more comprehensive instrument to be used for depression.[8-9] CES-D scores and GAD-7 scores were highly correlated in our sample ($r = 0.71$). When we re-ran our models with the anxiety term removed, the protective effect of music became much more pronounced in both models. In fact, when music exposure was analyzed dichotomously, this protective effect was statistically significant (OR= 0.602, 95% CI [0.369, 0.982]). While we did run tests for multicollinearity, it is possible that by including the highly correlated (with depression) anxiety term in our models, we may have over-corrected for the association between music and subclinical depression. Our bivariate analyses suggest that the association between being a musician and possible anxiety is on the borderline of being statistically significant (OR= 0.68,

95% CI [0.45, 1.02]). Interestingly, of the 230 students who had possible subclinical depression, 122 of them also had possible anxiety.

Other confounding variables may have also posed issues. In following our model selection strategy outlined by Greenland *et al.* (2016), none of our variables of interest warranted exclusion.[10] There are numerous reasons why this may have occurred, including good foresight into potential confounding variables. Particular interest may be paid to the variables that had significant bivariate associations with both musical exposure and depressive symptomatology. Specifically, these included perfectionism, substance abuse, exercise, and presence of other serious mental health disorders. In the future, more comprehensive instruments could be used to evaluate these factors. In the interest of keeping our questionnaire short, we often chose the shortest, validated instrument to assess confounding variables. At the very least, our findings suggest that many variables are associated with the development of subclinical depression.

Due to the overwhelming burden of symptoms of both anxiety and depression in university students, it is possible that any health benefit of music may have been lost due to the influence of so many other mental health issues and confounding factors. It is also possible that acute academic stress experienced by university students may be able to partially explain this concerning figure. Several reports have cited concern at growing anxiety and hopelessness observed in university students as they struggle to cope with academic demands.[7, 11-13] We believe that it is likely that playing music is beneficial for students struggling with symptoms of depression. However, our findings were non-significant, and this claim is not supported by the findings here. To build on this study, future work could use structural equation modelling in a longitudinal study design to determine how anxiety plays a role in the causal pathway of depression. Further study should be conducted before sound recommendations can be made.

6.2.2 Years Playing and Subclinical Depression (linear)

While not discussed in Paper 1 of this report (due to the manuscript style of this thesis), we also ran two linear models to answer our primary objective, so that the CES-D scores could be analyzed as a continuous variable. The main reason for us choosing to do this was to be thorough and comprehensive in our analysis. Elsewhere in the literature, it has been suggested not to analyze the CES-D as a continuous variable.[9, 14] Therefore, we advise interpreting the following findings with caution.

The distribution of CES-D scores ranging from 0-60 was positively skewed (Skew= 0.802, Kurtosis= 3.20). This distribution was considered to roughly approximate the normal distribution, and two linear models were run using this distribution as the outcome of interest. The first measured music as number of years playing while the second used musicianship status. We approached our linear models using the same strategy as outlined by Greenland *et al.*[10] This is outlined in Appendix III & IV. However, after performing several regression diagnostics and tests for multicollinearity, we determined that our models likely contained excessive variables. Instead, a Stata user-created forward-selection linear model selection strategy was used to generate multiple linear model iterations. After running multiple models with different combinations of variables, final models were generated through the **vselect** command in Stata.[15] The final, model-adjusted estimates are reported in Appendix III & IV.

Similar to the logistic regression results, all associations determined between musical exposure and depressive symptoms were null. Due to the high correlation between CES-D summed scores and GAD-7 summed scores, the final models were also re-run with the anxiety terms removed. Interestingly, the model that considered both music and CES-D as continuous

variables showed a statistically significant protective effect, once the anxiety term was removed (β=-0.21, 95% CI [-0.36, -0.06]). We do not believe that the interpretation of these models warrant any additional discussion than that already discussed for the logistic models above.

6.2.3 Improvisational Ability and Mental Health Disease

To our knowledge, this is the first study to explore the association between improvisational ability and mental health outcomes. As such, we recognize that our exposure measure has not been tested elsewhere and may be susceptible to misclassification. Our method of ascertaining improvisational ability was discussed in Paper 2. We chose to use the question related to assessing improvisational ability as "Excellent/Good/Satisfactory/Poor". This was done as it was the question that had the fewest missing values. We recognize that since the question has not been validated, misclassification bias may be a concern. However, we felt that due to the exploratory nature of the study, this question was the best solution we had to answering our research question. We also may have had some misclassification in our mental health outcome assessment. Several CCHS questions asking about specific MHD were posed to survey participants. To create a dichotomized variable, individuals who had indicated YES to any of the CCHS MHD were considered to have a mental health disorder. Everyone else was considered to be free of serious MHD. This was done as individual prevalences of the various disorders covered in the CCHS in our sample were very low.

It has already been widely reported that musicians suffer from a disproportionate amount of MHD when compared to non-musicians.[16-20] Estimates of serious MHD in the general Canadian population suggest a prevalence of 12%.[2-4] In our musician cohort, we detected a prevalence of 17%, roughly approximating the national value. Contrary to our hypothesis, those

with MHD were no more likely to have better improvisational abilities than those without MHD (OR= 1.89, 95% CI [0.93, 3.88]). However, our study may have been underpowered to detect the potentially positive effect demonstrated by our data. While we did predict this positive OR, we believe that this is because individuals struggling with MHD are more likely to turn to creative outlets in an attempt at emotional release.

Although this study uses a cross-sectional design and cannot determine temporality, we do not find it biologically plausible that more creative musicians become more mentally ill. Rather, we find it likely that individuals struggling with feelings of isolation, sadness, guilt or anxiety may find themselves turning to various forms of artistic expression in an effort to deal with their mood. We therefore challenge future researchers in this matter to explore this hypothesis in a longitudinal study. Serious MHD are often the result of a complex array of biological, environmental and psychological factors.[1-3] For example, someone born to a parent with schizophrenia is biologically pre-disposed to developing that disease him/herself. If that individual took up music as a hobby in their childhood, it would not be correct to deduce that the music caused the schizophrenia when it presented itself in the individual's early adult years. It is well-established that playing music is associated with positive mood-related outcomes.[21-32] Therefore, because of the null association between improvisation and MHD detected here, we would not recommend against improvisation, as there is no way to determine temporality in this association. Future studies interested in answering this question will likely be faced with considerable challenges in this respect, due to the difficultly in tracking MHD progression.

6.2.4 Improvisational Ability and Subclinical Depression

We found those with subclinical depression to be almost twice as likely to have stronger improvisational abilities than those without subclinical depression (OR= 1.87, 95% CI (1.07, 3.26]). However, we do not feel that the increased odds of improvisational abilities in those with subclinical depression warrants a dissuasion from the practice at this time. This was the first study to explore the association between musical improvisation and depressive symptomatology. Future longitudinal studies will need to be conducted before we can discuss tangible implications. However, we do believe that other factors related to improvisation and subclinical depression are worth noting. We found a considerable correlation between time spent practicing, time spent improvising, and improvisational ability. Our study did not collect detailed information regarding specific practicing habits, but long hours spent practicing have been shown in other studies to lead to feelings of loneliness and frustration.[5, 7, 33] It is plausible that it may be important for musicians to break up practice time, and to seek opportunities to practice music in group settings.

Previous studies have suggested that increased prevalence of anxiety and stress in musicians is largely attributable to performance anxiety.[5, 18, 20, 34] Forty percent of the musicians in our study reported suffering from detrimental performance anxiety prior to a musical performance. Performance anxiety could explain the increased anxiety and depression symptoms observed in our sample population. Both the CES-D and GAD-7 instruments deal with symptoms experienced in a short time frame- the last two weeks. As half of our sample was comprised of musicians, individuals performing regularly could be frequently exposing themselves to high levels of stress.

Interestingly, when a correlation matrix was completed between improvisational ability and performance anxiety, a negative correlation was found (r= -0.15). This finding is logical, as

strong improvisers must treat every practice session and rehearsal as a performance, since they are spontaneously creating music. It is possible that musicians who find themselves highly anxious before performances could potentially benefit from improvising music during practice time. Overall, despite the findings presented here, we do not feel it is warranted to implicate improvisational ability as being a risk factor for depression or other MHD. Rather, we suggest that students who enjoy creating music to ensure that they maintain a healthy life balance and to seek professional help for serious mental health concerns.

6.3 Epidemiological Implications

6.3.1 Internal Validity

Internal validity refers to the "validity of the comparisons made within the study".[35] In other words, internal validity speaks to the truth within the study sample. Internal validity increases as the level of confounding, measurement error, and other biases decrease. In this study, the primary concern for internal validity comes from potential selection bias.

Selection bias is defined as "the way in which exposed and non-exposed individuals, are selected is such that an apparent observation is observed- even if, in reality, exposure and disease are not associated".[35] At first glance, it appears that this study is of ample concern for selection bias. For starters, we had a very low response rate. Only 6.3% of the students we contacted participated in our survey. With a response rate this low, we have to be concerned about the possibility that the students who *did* choose to participate may have done so for a systematic reason. For example, in a study proclaiming to elucidate the healing nature of music, it may be that musicians are systematically more likely to participate in the study, due to their vested interest in the study matter. However, we do not feel that such a problem existed in our study.

We were keenly aware of the language to use in our study description, such that it would not deceive potential participants, but was kept purposely vague so that one particular group would not more strongly identify with the study's purpose. In doing so, we do not believe that any one particular group of students had a systemically different reason for choosing to participate, although we recognize that this may still have occurred. The purpose of the study was said to "investigate the association between playing music as a hobby and a variety of health outcomes". Before beginning the study, a previous report had estimated that approximately 66% of the Canadian population has played some sort of musical instrument.[36] With this figure in mind, it is unlikely that a particular group of musicians were more likely to complete the survey. Finally, the results we reported here were very similar to the Demirbatir *et al.* study of depression and anxiety in music students. That study reported a response rate of 92%.[7]

As displayed in Table 1 (Chapter 4), we are able to see a diverse distribution of programs of study. The participating departments were contacted at random, and the ones that chose to participate represent a variety of different disciplines. We believe that our sample, although not completely random, is not unduly biased. We recognize that we have no way of comparing our respondents to students who chose not to participate. However, due to the electronic nature of survey delivery, we think it is likely that most students "choosing" not to participate likely did so by not even opening their email. There was no fiscal incentive or compensation provided to students for participating in this study. It is quite likely that a vast majority of students felt too busy to bother with our survey. This was evidenced even through the difficulty we had in contacting departments to agree to participate to send out the invitation materials. We estimate that of all the departments we invited to participate, only 10% actually returned our initial email. Therefore, we do believe that our sample is representative of university students in terms of

music exposure and depressive symptomatology. We believe that our low response rate is related to the mode of delivery, rather than being specifically related to the exposure or the outcome.

Misclassification bias is defined as a systematic error in the means of ascertaining or determining outcome or exposure status.[35] Misclassification bias may have occurred in our study may be through the use of several un-validated questions in our survey. While we had completed a comprehensive review of existing literature, measuring musical exposure status proved to be difficult. Previous studies have posed questions regarding years playing a musical instrument and time spent practicing, and we are reasonably confident that any errors in the self-reporting of these questions would result in non-differential misclassification. We do not have any reason to believe that students with subclinical depression and students without subclinical depression are any more or less likely to mis-classify whether or not they have ever played a musical instrument. However, this issue may have been a more prominent issue in our second paper. The questions asking the study participants to self-rate their own improvisational ability may be more concerning in terms of potential bias. As the questions related to improvisational ability relied on each participant's own critique of his or her abilities, it is possible that students with subclinical depression may have ranked themselves more harshly (i.e. judging their improvisational abilities poorer than in reality). However, even if this were to be the case, this would have resulted in an underestimation of improvisational ability, and resulting in a differential misclassification towards the null. While concerning, a differential misclassification towards the null would yield more conservative effect sizes.

A final source of bias could have resulted from uncontrolled-for confounding variables. Confounding variables are defined as what occurs when "a third factor that is both a risk factor for the outcome of interest and is associated with the exposure in question".[35] While we

recognize that it is possible we may have entirely missed important confounding variables, we are very confident in the research we conducted before the survey's creation to determine all potentially relevant confounding variables that may be associated with playing music and depression. Further, following our data analysis, we completed multiple tests of goodness of model fit, including tests that can indicate whether important variables are missing. None of the results obtained from these tests showed sign for concern. We recommend that future studies interested in music and mental health outcomes to pay particular attention to confounder selection, as we were surprised at how strongly correlated many variables were to both our exposure and outcome.

6.3.2 External Validity

This study used a university student population to assess the relationship between lifelong exposure to music and mental health outcomes. While the results we found are interesting in the context of student well-being, it is clear that they are not generalizable to the wider, Canadian population. It is clear that mental health and stress differs substantially between average Canadians and Canadian university students.

While we do not recommend that our results be extrapolated to the wider Canadian population, we do believe that our results are likely generalizable to other Canadian university populations. Considerable care was taken to ensure that our sample was diverse and representative of an average, Canadian university campus. For example, the University of Toronto and Lakehead University were used as sample schools to account for differences between remote and urban populations. Great care was also taken to involve a wide variety of academic departments, and to allow for both graduate and undergraduate students to participate.

No significant differences were noted across these different groups of individuals. As such, we feel that our 469 person sample of university students likely serves as a good representation of Canadian university students in general. We do recognize that sampling only the University of Toronto and Lakehead University students does not likely reflect the same demographics as would sampling all Canadian universities. However, we do believe that our sample would be comparable to a broader sample in relation to our variables of interest.

6.3.3 Causation

This study utilized a cross-sectional study design. It is important to note that cross-sectional studies cannot determine causality in a relationship between variables. In the context of this study, this means that we have no way of knowing the direction of the association between musical exposure and depressive symptomatology. Cross-sectional results cannot discern whether the musical exposure is responsible for fewer depressive symptoms, or if people with less depressive symptoms are simply more likely to play music. Due to the widely reported health benefits of playing music, it is unlikely that the latter statement is true. However, this is less clear for our discussion surrounding the relationship between improvisatory ability and mental health outcomes. It is very difficult to determine the temporal relationship between musical creativity and mental health outcomes, as both of these likely involve some level of biological pre-dispositions. Here, we attempted to provide context for our findings based upon available literature. However future studies interested in evaluating the role of musical improvisation in mood outcomes could potentially examine this in an intervention study design.

6.3.4 Practical Applications

Based upon the findings presented here, we would not recommend any particular clinical "recommendation" in relation to music and depressive symptoms. Future studies interested in investigating the causal pathway between playing music and depression should focus on longitudinal study design. Our findings suggest that no association between playing music and depressive symptomatology exists. A safe recommendation would be to advise students to continue participating in hobbies and pastimes that they find relaxing. If a student currently feels that practicing guitar for a few hours a week is an enjoyable activity, we do not advise against it. This applies to recommendations based on improvisation as well. While we did observe a higher prevalence of depressive symptoms in improvisers compared to non-improvisers, we do not believe that this proves worthy of a clinical recommendation advising against it. Rather, we encourage musicians to continue partaking in enjoyable pastimes. It is unlikely that the association between musical improvisation and subclinical depression is causal, although future longitudinal studies will need to be conducted to confirm this.

An important take-home message of the results from this study is that further help is needed to deal with the alarming burden of mental illness on university campuses. While it is possible that students already suffering from mental health disorders may have been more likely to participate in this survey, the need to address mental illness on university campuses remains of critical importance. University students experience stress from a variety of sources, and it is important that adequate resources and help are provided on campus. It is likely that a high level of social stigma surrounds MHD on campuses, and it is up to administration and faculty to attempt to open a dialogue. We believe that our findings here re-iterate the importance of mental health initiatives on university campuses.

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Chapter 7: Ethical Considerations

Prior to the commencement of this study, appropriate ethical approval was obtained through the Lakehead University Research Ethics Board (REB) and the University of Toronto REB [Appendix VI]. While this study did not expose participants to any serious harm, all survey participants were made aware of potential risks prior to their participation in the study. It is possible that some mental or emotional harm may have been experienced by the participants in the survey due to the upsetting nature of some of the survey questions. This survey did not claim to diagnose cases of depression, but did recommend individuals seek medical help if the questions upset them. Participants were free to exit out of the survey at any time if they no longer wished to participate, with no consequence.

The purpose of the CES-D was explained in full prior to the start of the survey. School-specific crisis centre numbers were provided, as well as links to several online mental health resources. Due to the anonymous nature of the survey, individual feedback involving CES-D scoring could not be provided, although links to the CESD-R public domain survey were provided. Interested individuals were easily able to calculate their own score and interpret it, based on the conventional cut-point.

REDCap is a secure, web-based data collection instrument. Various methods are in place by the creators of the application to protect against potential hackers and malicious users trying to access users' survey tools and databases. However, this particular questionnaire did not ask for any identifying information. While participants interested in obtaining the overall results of the study were required to provide their e-mail address in the survey, this was collected through a

separate survey, so that the email address provided could not be linked to any of the other data collected.

Chapter 8: Limitations, Strengths and Relevance

8.1 Limitations

This study has several limitations that are worth discussing here. First and foremost is the possibility of potential selection bias. While we predicted that the response rate to our survey would be low, we ended up with a response rate of approximately 6.3%. It is possible that individuals who chose to participate may have had a particular reason for doing so, and that this may have affected the study results. Musicians may have felt more inclined to participate in the survey, although our prevalence of having ever played was similar to that found in the Canadian population.[2] Individuals already suffering from MHD may been more likely to participate in the study, and could possibly help to explain the high observed prevalence of subclinical depression. However, we did create our initial survey invitation to be somewhat vague, in an effort to reduce this type of selection bias. Further, for reasons already discussed, we strongly believe that our low participation rate was likely due to the electronic format of the survey, rather than a systematic reason for choosing not to participate. We were also encouraged to note that our results echoed findings from a similar study of students with a 92% response rate.[1] The small sample size may have also affected the power of our statistical analysis. Originally, we had calculated that we would need 500 student responses to answer our research question with a power of 80% and an alpha of 0.05. However, once missing variables were removed and nested models were created, we were left with substantially smaller sample sizes. This is apparent with the fairly large confidence intervals, especially in the second paper.

Potential misclassification bias may have occurred when ascertaining exposure status. Many of our exposure-related questions were created by the research team. We do believe that

the questions that we used in our survey were created based off of the best available evidence. However, it is likely that misclassification did occur. If this misclassification did indeed occur, it likely would have resulted differential misclassification biased towards the null, for reasons outlined in Chapter 6. This is of concern more so in our second manuscript, where it is possible that students with poor self-esteem and other depressive symptoms may have more critically evaluated their musical skill. If this was the case, more subclinically depressed students may have systematically ranked their improvisational skills lower. While this would have made detecting a significant difference more difficult, we can be re-assured that our effect estimates are conservative.

Another potential weakness is in regards to the use of two (slightly) different CES-D questionnaires over the course of the study. The CESD-R was used for 50 participants, while the remaining 529 used questions derived from the CES-D. While this unplanned change did result in slightly different questionnaires, it is likely that the effect of this oversight would be non-differential misclassification towards the null, making any observed effect more likely. This is because the CESD-R poses more intrusive and serious questions than does the CES-D, and those classified as having potential subclinical depression would have been less likely to have been classified that way on the CESD-R. Our analysis of these two slightly different questionnaires was the same. Both versions are scored on the scale, with the goal of the revised version to provide comparable results to the original CES-D. The slight differences in questions between the two versions are likely to have little effect and, if any, to nullify the effect size.

Other weaknesses are in regards to the use of continuous vs. dichotomous variables. In several of the instruments used (CES-D, GAD-7, CAGE-AID), the possibility to treat scores as continuous scores exist. However, to keep the analysis simple, the dichotomous scores were used

in the logistic models. This may have created measurement error through data loss in our sample, although it is likely to be non-differential, with a bias towards the null. There has been debate in the literature over how to analyze CES-D scores. While the continuous scores yield higher power, the distribution is generally not normally distributed, which poses issues for statistical modelling.

8.2 Strengths

This study also has several strengths. This is the first study that we are aware of to assess the association between lifelong musical exposure and depressive symptomatology. This study uses a validated questionnaire to assess depressive symptomology, so it is unlikely that misclassification occurred in depression assessment. The questionnaire was relatively short, and as such, did not create an excessive burden on its participants. Great care was taken to include and consider all potential confounding variables. Conservative model selection strategies were employed to ensure that all relevant variables were retained in each model. Following the creation of the final models, tests of goodness of fit were conducted to ensure that no additional variables warranted inclusion. We also believe that we have created a compelling argument for the design of some of the improvisational questions we used. Future studies could attempt to validate these questions in a larger sample.

8.3 Relevance

This study is the first to evaluate the association between lifelong music playing exposure, musical improvisation and mental health outcomes. While the results of this study were unable to demonstrate causality, the findings will be directly pertinent to future research. The findings here do not suggest any adverse health effect will result from musical training, or

from musical improvisation. Based off of our sample, our results highlight a high-risk student cohort and the need for adequate mental health awareness in this age group. We were alarmed to see such high rates of depressive symptomatology in our study sample, and recognize that music may be but a small factor in the prevention of a terrible illness. Our figures should serve as a solemn reminder to Canadian university campuses of the high burden of stress, anxiety, and pressure experienced by students over a short term period. The results obtained from this study will hopefully fuel more research investigating role music playing may have in depressive symptoms and mental health.

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Chapter 9: Conclusion

9.1 Summary of Thesis Findings

This was the first study to determine the association between playing music in self-taught, amateur, and professional musicians and depressive symptomatology in a sample of university students. This thesis had two objectives: 1) to determine the association between playing music and depressive symptomatology, and; 2) to explore the association between improvisation and mental health outcomes.

The results found in this study suggest that playing music as a hobby has no association with depressive symptomatology. This was true when music exposure was measured as a dichotomous variable, and when it was measured as total number of years playing. In our second analysis, we explored the association between musicians' improvisational abilities and presence of serious mental health disorders as well as subclinical depression (measured by the CES-D). We found that the odds of having a serious mental health disorder were not any greater in individuals with higher improvisational abilities than in individuals with lesser abilities. We found that musicians with subclinical depression are significantly more likely to have higher improvisational capabilities. The prevalence of potential subclinical depression in the university students sampled was high (52%). It is possible that low response rate and potential selection bias may have impacted our results.

9.2 Implications of Thesis Research

The primary objective of this thesis was to determine the association between lifelong exposure to music and depressive symptomatology. In light of conflicting evidence suggesting that musicians suffer from a disproportionately higher burden of mental health disorders, we

found no evidence of any association between years playing and depressive symptoms. Our findings suggest that concern of increased prevalence of depressive symptoms in student musicians is not warranted. Further, we do not feel any recommendations either for or against playing music with regards to depressive symptomatology are warranted. Due to the high reported burden of subclinical depression, we encourage university students to seek out pastimes that are enjoyable and relaxing. Our study confirmed the existence of several important covariates that were also associated with the relationship between music and subclinical depression. Future study investigating subclinical depression in students could use some of the covariates discussed in this study as a guide from which to base their own statistical inquiries.

This was the first report to explore the association between improvisation and mental health outcomes. No association was found between serious mental health disorders and improvisational capability. However, we did find that musicians with subclinical depression are significantly more likely to have higher improvisational capabilities. In the field of musical improvisation research, this finding has several implications. While our research question was exploratory in nature, our findings provide suggestive evidence that creative musicians may differ in some way from their non-creative counterparts in regards to specific mood-related outcomes. We anticipate that future research involving musicians will take these potential differences into account.

Our findings may also be of value to research surrounding music therapy. In recent years, there has been much debate over the potential supremacy of active music therapy over that of passive music therapy models. As our study was concerned with short-term depressive symptoms, there is now some evidence to suggest that these could be associated with varying levels of musical creativity.

9.3 Future Directions

We believe that the groundwork conducted here could be of interest to related studies in the future. This study was conducted using a cross-sectional design and as such, temporality in associations could not be determined. While our study was limited in several ways, we do think that our methodology could be of value to researchers within the field. Our diverse questionnaire allowed us to investigate associations between multiple covariates, and it was found that all of them are significantly associated with both playing music and depressive symptomatology. Researchers interested in similar study can refer to our review of these variables, and enhance their own explorations.

We also recommend that similar studies in the future learn from some of the shortcomings of our measurement tools. We recognize a need for validated and reliable instruments from which to ascertain musical exposure, and recommend future studies to pilot such instruments before their widespread implementation. It would be of interest to discuss with various musicians how best to go about measuring musical creativity. Musical improvisation yields a promising field for the study of human creativity, and developing valid ways to measure this would be of value.

We also recommend that studies interested in building on the work conducted here to incorporate a larger sampling frame. We believe it would be of interest to conduct this research in a sample from the general population, where academic related stressors would not likely be as present. We also recognize the need for longitudinal studies to assess the potential temporal relationship between the amount of time spent playing music and depression. In studies that are followed forward in time, there would likely be opportunity to collect more comprehensive

measurements of musical exposure. Studies such as these could help to provide a more reliable

picture of a potential association between playing music and depression.

Chapter 10: Reflections

Conducting the research necessary to complete this thesis has been an incredibly long and rewarding journey. I cannot thank my thesis committee and Dr. Vicki Kristman enough for their support in helping me to create an original research question, and designing a methodology that allowed me to answer that research question. Music has always been an enormous pastime of mine, and I have always felt that it offers a unique set of skills and experience. Being able to conduct research in an area in which I am so passionate was an opportunity that I am very grateful for.

Learning how to collect my own data and manipulate that data in the Stata statistical software seemed impossible last year. Now, I feel confident with the skills that I have learned through Dr. Kristman's help, my peers, and though self-directed learning. I believe that my Epidemiology Master's has awarded me with a unique set of skills that will be relevant to my medical career I will begin at McMaster University in September.

APPENDICES

Appendix 1: Survey

The following survey is being conducted for a master's thesis project. The purpose of the study is to determine the association between music exposure and a variety of health outcomes. The study will be conducted in accordance to Lakehead University rules and policies. Participation is entirely voluntary. None of the researchers, your department Chair, nor your professors will know whether you agree to fill out the survey. This study has been approved by the Lakehead University and the University of Toronto Research Ethics Boards. If you have any questions related to the ethics of the research, please contact Sue Wright at the Lakehead University Research Ethics Board at 807-343-8283 or Sasmita Rajaratnam at the University of Toronto Research Ethics Board at 416-978-6899. The data collected from this study (including your responses) will be stored in an online, secure REDCap platform. As per Lakehead University's policy, all collected data will be stored on a secure, password-protected computer for five years, after which, it will be destroyed. Please note that all of your survey responses are entirely anonymous, and cannot be linked to you in any way.

If you agree to participate in this study, please complete the survey below. The survey will take approximately ten minutes to complete. You are free to withdraw from the survey at any point if you feel uncomfortable, or no longer wish to complete. You are also free to skip any one question, or series of questions if you feel uncomfortable.

Thank you so much for your participation!

Do you agree to take part in this survey and read through the information page? By choosing YES, you consent and agree for the answers you provide to be utilized in this project.

Yes

No

Which department are you studying in?

_____

What school are you currently attending?

Lakehead University

University of Toronto

Other (Please Specify)

The following questions will be used to assess your levels of depressive symptomatology over the past week. You will be presented with twenty statements related to your experience of common symptoms of depression. For each statement you are presented with, please select the response that most accurately describes your experience in the last week. The CSE-D does not attempt to diagnose clinical depression, and further information regarding the CSE-D public domain may be found at http://cesd-r.com/.

I was bothered by things that don't usually bother me (Choose the option you most agree with).

- o Rarely or none of the time (Less than 1 day)
- o Some or a little of the time (1-2 days)
- o Occasionally or a moderate amount of time (3-4 days)
- o Most or all of the time (5-7 days)

I did not feel like eating; my appetite was poor (Choose the option you most agree with).

- o Rarely or none of the time (Less than 1 day)
- o Some or a little of the time (1-2 days)
- o Occasionally or a moderate amount of time (3-4 days)
- o Most or all of the time (5-7 days)

I felt like I could not shake off the blues even with help from my family and friends (Choose the option you most agree with).

- o Rarely or none of the time (Less than 1 day)
- o Some or a little of the time (1-2 days)
- o Occasionally or a moderate amount of time (3-4 days)
- o Most or all of the time (5-7 days)

I felt that I was just as good as other people (Choose the option you most agree with).

- o Rarely or none of the time (Less than 1 day)
- o Some or a little of the time (1-2 days)
- o Occasionally or a moderate amount of time (3-4 days)
- o Most or all of the time (5-7 days)

I had trouble keeping my mind on what I was doing (Choose the option you most agree with).

- o Rarely or none of the time (Less than 1 day)
- o Some or a little of the time (1-2 days)
- o Occasionally or a moderate amount of time (3-4 days)
- o Most or all of the time (5-7 days)

I felt depressed (Choose the option you most agree with).

- o Rarely or none of the time (Less than 1 day)
- o Some or a little of the time (1-2 days)

- o Occasionally or a moderate amount of time (3-4 days)
- o Most or all of the time (5-7 days)

I felt that everything I did was an effort (Choose the option you most agree with).

- o Rarely or none of the time (Less than 1 day)
- o Some or a little of the time (1-2 days)
- o Occasionally or a moderate amount of time (3-4 days)
- o Most or all of the time (5-7 days)

I felt hopeful about the future (Choose the option you most agree with).

- o Rarely or none of the time (Less than 1 day)
- o Some or a little of the time (1-2 days)
- o Occasionally or a moderate amount of time (3-4 days)
- o Most or all of the time (5-7 days)

I thought my life had been a failure (Choose the option you most agree with).

- o Rarely or none of the time (Less than 1 day)
- o Some or a little of the time (1-2 days)
- o Occasionally or a moderate amount of time (3-4 days)
- o Most or all of the time (5-7 days)

I felt fearful (Choose the option you most agree with).

- o Rarely or none of the time (Less than 1 day)
- o Some or a little of the time (1-2 days)
- o Occasionally or a moderate amount of time (3-4 days)
- o Most or all of the time (5-7 days)

My sleep was restless (Choose the option you most agree with).

- o Rarely or none of the time (Less than 1 day)
- o Some or a little of the time (1-2 days)
- o Occasionally or a moderate amount of time (3-4 days)
- o Most or all of the time (5-7 days)

I was happy (Choose the option you most agree with).

- o Rarely or none of the time (Less than 1 day)
- o Some or a little of the time (1-2 days)
- o Occasionally or a moderate amount of time (3-4 days)
- o Most or all of the time (5-7 days)

I talked less than usual (Choose the option you most agree with).

- o Rarely or none of the time (Less than 1 day)
- o Some or a little of the time (1-2 days)
- o Occasionally or a moderate amount of time (3-4 days)

      o   Most or all of the time (5-7 days)

I felt lonely (Choose the option you most agree with).

- o   Rarely or none of the time (Less than 1 day)
- o   Some or a little of the time (1-2 days)
- o   Occasionally or a moderate amount of time (3-4 days)
- o   Most or all of the time (5-7 days)

People were unfriendly (Choose the option you most agree with).

- o   Rarely or none of the time (Less than 1 day)
- o   Some or a little of the time (1-2 days)
- o   Occasionally or a moderate amount of time (3-4 days)
- o   Most or all of the time (5-7 days)

I enjoyed life (Choose the option you most agree with).

- o   Rarely or none of the time (Less than 1 day)
- o   Some or a little of the time (1-2 days)
- o   Occasionally or a moderate amount of time (3-4 days)
- o   Most or all of the time (5-7 days)

I had crying spells (Choose the option you most agree with).

- o   Rarely or none of the time (Less than 1 day)
- o   Some or a little of the time (1-2 days)
- o   Occasionally or a moderate amount of time (3-4 days)
- o   Most or all of the time (5-7 days)

I felt sad (Choose the option you most agree with).

- o   Rarely or none of the time (Less than 1 day)
- o   Some or a little of the time (1-2 days)
- o   Occasionally or a moderate amount of time (3-4 days)
- o   Most or all of the time (5-7 days)

I felt that people dislike me (Choose the option you most agree with).

- o   Rarely or none of the time (Less than 1 day)
- o   Some or a little of the time (1-2 days)
- o   Occasionally or a moderate amount of time (3-4 days)
- o   Most or all of the time (5-7 days)

I could not get going (Choose the option you most agree with).

- o   Rarely or none of the time (Less than 1 day)
- o   Some or a little of the time (1-2 days)
- o   Occasionally or a moderate amount of time (3-4 days)
- o   Most or all of the time (5-7 days)

While the CES-D does not serve as a clinical diagnostic tool for depression, if any of the previous questions made you feel uncomfortable, some numbers are provided below for professional help at your institution. Further, if you indicated that more than half of the above symptoms bother you at least some or more of the time, it is our team's recommendation that you follow up with your family doctor or a medical professional.

University of Toronto Health and Wellness Centre

416-978-8030

Lakehead University Student Health and Counselling Centre

(807) 343-8361

Connex Ontario 1-866-531-2600 (Phone and live web chat available)

http://www.mentalhealthhelpline.ca/

The following questions are related to your experience and abilities with playing a musical instrument. Please answer each question to the best of your ability.

Do you play or practice a musical instrument?

- o Yes
- o No

Do you sing? (Please select YES only if you receive vocal coaching or lessons, or are part of a band/choir/singing group)

- o Yes
- o No

How many years have you been playing? (If you play more than one instrument, please indicate the total number of years you have been playing any instrument).

_____

In the last six months, how many hours per week on average would you say you spend practicing or playing a musical instrument?

_____

Do you play more than one musical instrument (singing included)?

o Yes
o No

Do you identify as a professional or an amateur musician? (If you are in a music program and plan to pursue a career as a professional musician, please select "Professional")

o Professional
o Amateur

How would you rate your ability to improvise (spontaneously create music) when you play/sing your chosen instrument?

o Excellent
o Good
o Satisfactory
o Poor
o I do not improvise
o I don't know

When you practice or play music, how much of your time spent playing would you say you spend actively improvising?

o 75-100%
o 50-75%
o 25-50%
o 0-25%

Do you consider yourself a jazz musician?

o Yes
o No

On average, how many hours do you spend in class per week?

____

On average, how many hours outside of class do you spend studying per week?

_____

Do you tend to feel anxious to the point of being detrimental to your presentation prior to a musical performance?

o Yes
o No

The following questions are used to assess your experience with symptoms commonly associated with anxiety in the past two weeks. For each statement, please respond to the questions based on your experiences over the past two weeks.

Over the past two weeks, how often have you been feeling nervous, anxious, or on edge?

- o Not at all
- o Several days
- o More than half the days
- o Nearly every day

Over the past two weeks, how often have you not been able to stop or control worrying?

- o Not at all
- o Several days
- o More than half the days
- o Nearly every day

Over the past two weeks, how often have you felt that you are worrying too much about different things?

- o Not at all
- o Several days
- o More than half the days
- o Nearly every day

Over the past two weeks, how often have you had trouble relaxing?

- o Not at all
- o Several days
- o More than half the days
- o Nearly every day

Over the past two weeks, how often have you been so restless that it is hard to sit still?

- o Not at all
- o Several days
- o More than half the days
- o Nearly every day

Over the past two weeks, how often did you find yourself becoming easily annoyed or irritable?

- o Not at all
- o Several days
- o More than half the days
- o Nearly every day

Over the past two weeks, how often have you felt afraid that something awful might happen?

- o Not at all
- o Several days
- o More than half the days
- o Nearly every day

For each statement, please indicate if you have had or been diagnosed in the past six months with any of the following.

In the last six months, have you had or been diagnosed by a medical professional, with schizophrenia or other psychosis?

- o Yes
- o No
- o I do not know
- o I choose not to answer

In the last six months, have you had or been diagnosed by a medical professional, with a mood disorder? Examples include: major depression, bipolar disorder, mania, dysthymia

- o Yes
- o No
- o I do not know
- o I choose not to answer

In the last six months, have you had or been diagnosed by a medical professional, with an anxiety disorder such as a phobia, obsessive-compulsive disorder, or a panic disorder?

- o Yes
- o No
- o I do not know
- o I choose not to answer

In the last six months, have you had or been diagnosed by a medical professional, with a substance use disorder?

- o Yes
- o No
- o I do not know
- o I choose not to answer

In the last six months, have you had or been diagnosed by a medical professional, with a post-traumatic stress disorder?

- o Yes
- o No
- o I do not know
- o I choose not to answer

In the last six months, have you had or been diagnosed by a medical professional, with a learning disability?

- o Yes
- o No
- o I do not know

    o I choose not to answer

In the last six months, have you had or been diagnosed by a medical professional, with attention deficit disorder?

    o Yes
    o No
    o I do not know
    o I choose not to answer

In the last six months, have you had or been diagnosed by a medical professional, with an eating disorder such as anorexia or bulimia?

    o Yes
    o No
    o I do not know
    o I choose not to answer

For each statement following, please indicate whether you agree with each statement based on the past three months.

Do you drink alcohol?

    o Yes
    o No

Have you ever experimented with drugs?

    o Yes
    o No

In the past three months, have you felt that you should cut down or stop drinking or doing drugs?

    o Yes
    o No

In the past three months, has anyone annoyed you or gotten on your nerves by telling you to cut down or stop drinking or doing drugs?

    o Yes
    o No

In the past three months, have you felt guilty by how much you drink or do drugs?

    o Yes
    o No

In the past three months, have you been waking up or wanting to have an alcoholic drink or use drugs?

    o Yes

o No

For each group of co-morbidities listed, please indicate whether or not the group affects you, and how much it affects your health. If you do not wish to answer any of the questions, or feel uncomfortable, please skip.

Do you currently have any muscle, bone or joint probelems? (such as rehumatoid arthritis, osteoarthritis, back or neck pain, fibromyalgia, thin bones or osteoprosis, fracture, infection, others)

- o Yes
- o No

How much does it affect your health?

- o Not at all
- o Mild
- o Moderate
- o Severe

Do you currently have any allergies? (such as hay fever, dermatitis, eczema, allergies to medication, fool allergy, others)

- o Yes
- o No

How much does it affect your health?

- o Not at all
- o Mild
- o Moderate
- o Severe

Do you currently have any breathing problems? (such as asthma, emphysema, bronchitis, fibrosis, lung scarring, TB, pneumonia, infection, common cold, others)

- o Yes
- o No

How much does it affect your health?

- o Not at all
- o Mild
- o Moderate
- o Severe

Do you currently have hypertension? (high blood pressure)

- o Yes

o No

How much does it affect your health?

- o Not at all
- o Mild
- o Moderate
- o Severe

Do you currently have any heart or circulation problems? (such as angina, heart attack, heart failure, heart valve problem, hardening of arteries, varicose veins, claudication, foot or leg ulcers, others)

- o Yes
- o No

How much does it affect your health?

- o Not at all
- o Mild
- o Moderate
- o Severe

Do you currently have any digestive problems? (such as ulcer, gastritis, infammatory or irritable bowel disease, colitis, Crohn's disease, hiatus hernia, gall stones, pancreatitis, others)

- o Yes
- o No

How much does it affect your health?

- o Not at all
- o Mild
- o Moderate
- o Severe

Do you currently have diabetes?

- o Yes
- o No

How much does it affect your health?

- o Not at all
- o Mild
- o Moderate
- o Severe

Do you currently have any kidney or genitourinary problems? (such as kidney failure, nephritis, kidney stones, gynecological or prostate problmes, endometriosis, dysmenorrhea or menstrual problems, fibroids, urinary tract infection, prostate problems, bladder control problems, others)

       o Yes

       o No

How much does it affect your health?

       o Not at all

       o Mild

       o Moderate

       o Severe

Do you currently have any neurological problems? (such as stroke, seizures, multiple sclerosis, Parkinson's, paraplegia, quadriplegia, paralysis, Alzheimer's, dizziness, others)

       o Yes

       o No

How much does it affect your health?

       o Not at all

       o Mild

       o Moderate

       o Severe

Do you currently have headaches? (such as migraine, tension, stress, sinus, others)

       o Yes

       o No

How much does it affect your health?

       o Not at all

       o Mild

       o Moderate

       o Severe

Do you currently have cancer? (such as breast, lung, prostate, cervix, stomach, colon, kidney, bone, metastasis or spread, lymphoma, leukemia, others)

       o Yes

       o No

How much does it affect your health?

       o Not at all

       o Mild

       o Moderate

       o Severe

The following questions will assess common emotions and feelings associated with perfectionism. Please indicate your agreement with each statement.

I have high expectations for myself.

- o Strongly disagree
- o Disagree
- o Slightly disagree
- o Neutral
- o Alightly agree
- o Agree
- o Strongly agree

Doing my best never seems to be enough.

- o Strongly disagree
- o Disagree
- o Slightly disagree
- o Neutral
- o Alightly agree
- o Agree
- o Strongly agree

I set very high standards for myself.

- o Strongly disagree
- o Disagree
- o Slightly disagree
- o Neutral
- o Alightly agree
- o Agree
- o Strongly agree

I often feel disappointed after completing a task because I know I could have done better.

- o Strongly disagree
- o Disagree
- o Slightly disagree
- o Neutral
- o Alightly agree
- o Agree
- o Strongly agree

I have a strong need to strive for excellence.

- o Strongly disagree
- o Disagree
- o Slightly disagree
- o Neutral
- o Alightly agree

- o Agree
- o Strongly agree

My performance rarely measures up to my expectations.

- o Strongly disagree
- o Disagree
- o Slightly disagree
- o Neutral
- o Alightly agree
- o Agree
- o Strongly agree

I expect the best from myself

- o Strongly disagree
- o Disagree
- o Slightly disagree
- o Neutral
- o Alightly agree
- o Agree
- o Strongly agree

I am hardly ever satisfied with my performace.

- o Strongly disagree
- o Disagree
- o Slightly disagree
- o Neutral
- o Alightly agree
- o Agree
- o Strongly agree

Demographic Information

What is your age?

_____

What was your biological sex at birth?

- o Male
- o Female
- o Intersex
- o I choose not to answer

What is your gender?

- Man
- Woman
- Trans Man, Trans Woman, or Two Spirit
- Gender Neutral or Gender Free
- Another Gender Identity not listed here
- I choose not to answer

Here is a list of terms to describe sexuality or sexual orientation. Check all terms with which you identify:

- Heterosexual/ Straight
- Bisexual
- Gay
- Lesbian
- Queer
- Questioning
- Another sexual orientation not listed here
- I choose not to answer

What is the highest level of education you have completed?

- High school
- College/Diploma Program
- University Degree
- Master's Degree
- PhD
- Professional school (i.e. medical school, law school, etc.)

How would you describe your means of paying for your education? (Please check all that apply)

- My parents pay my tuition for me
- My parents and I pay my tuition
- I pay my tuition
- Scholarships, bursaries, and other awards
- Student loans (i.e. OSAP)
- I receive funding to pay for my education

Are you an international student?

- Yes
- No

In the past six months, how often did you smoke?

- Never
- Occasionally
- Daily

Appendix II: Study Information Page

Information Sheet to Participate in a Research Study

Title: Depressive symptomatology and lifelong music experience: a cross-sectional study

Investigator: Jennifer Asselstine

Thesis Supervisor: Dr. Vicki Kristman

Thesis Committee Members: Dr. Michel Bedard

Dr. Rebecca Schiff

Dear Potential Participant,

You have been asked to participate in this research initiative because you have been identified as a current student completing studies in a Canadian university. The following research is being conducted for a master's thesis. The purpose of the study is to determine the association between music exposure and a variety of health outcomes. The study will be conducted in accordance to Lakehead University rules and policies. Please read through the following information before choosing to start the survey. Participation is entirely voluntary. Additionally, none of the researchers, your department Chair, nor your professors will know whether you agree to fill out the survey.

Study Procedures

If you are interested in participating in the survey once reading this information page, the first question on the survey will ask you if you will provide your informed consent to participate. The remainder of the survey will take approximately ten minutes to complete. The questionnaire will ask you a variety of questions related to various health outcomes, as well as any information regarding the role of music in your life. A few baseline characteristic factors will also be addressed.

Risks and Benefits

There are no direct benefits to being in this study. However, knowledge gained through the findings of this study will be imperative to informing future research in the field. If you are interested in receiving the results of the study, after you have completed the survey, you will be re-directed to a new page where you will be able to enter your contact information. There are no risks of physical harm as the result of participating in this study. The questionnaire utilized in the survey will ask you questions regarding chronic health conditions and mental health conditions. While the choice to answer these questions is entirely up to you, it is possible that the nature of the questions may prove to be distressing or upsetting to some. As a reminder, you are free to stop completing the survey at any time, without

consequence. Further, you are free to skip specific questions if you do not wish to answer them. As your answers are collected completely anonymously, if you decide after you have submitted the survey that you no longer wish to participate, it is important to note that at this stage, it would be impossible to remove your individual survey, as the research team will have no way of knowing your survey from other participants'.

Confidentiality

As this survey will pose a variety of questions related to certain health outcomes, confidentiality is our top priority. All data will be collected and stored using REDCap software, which is a secure, web-based survey platform. Data will be downloaded from the REDCap server onto a secure, password-protected computer that is in the research team's lab. Most importantly, no identifying data will be collected at any point in the survey. Therefore, it will be impossible to link any answers you provide to yourself. Only the primary investigator and the master's student will have access to the data collected from the survey. If you are interested in receiving the results of this study, a separate link will be provided following the submission of the survey, where you any provide your email address, unaffiliated with any of your responses.

This study has been approved by the Lakehead University Research Ethics Board. If you have any questions related to the ethics of the research and would like to speak to someone outside of the research team please contact Sue Wright at the Research Ethics Board at 807-343-8283 or research@lakeheadu.ca.

If you have any questions regarding this study, please feel free to direct your inquiries to myself at jasselst@lakeheadu.ca, or the supervisor of this project, Dr. Vicki Kristman, at vkristman@lakeheadu.ca.

Thank you for your interest,

Jennifer Asselstine

Appendix III: CES-D Linear Models

Model Selection Strategy

Linear Modelling (Greenland Method)

Model	Model Variables	SE for coefficient	β	95% CI for β
1 (a). Basic (Total CES-D)	Years Playing Music	0.080	-0.172	-0.329, -0.015
1(b). Forward RMSE	Years Playing Music Anxiety	0.058	-0.023	-0.137, 0.090
1(c). Forward RMSE	Years Playing Music Anxiety SAPS Discrepancy	0.056	-0.059	-0.170, 0.051
1(d). Forward RMSE	Years Playing Music Anxiety SAPS Discrepancy Hours Studying	0.054	-0.030	-0.137, 0.076
1(e). Forward RMSE	Years Playing Music Anxiety SAPS Discrepancy Hours Studying SAPS Standard	0.053	-0.005	-0.109, 0.099
1(f). Forward RMSE	Years Playing Music Anxiety SAPS Discrepancy Hours Studying SAPS Standard Age	0.055	-0.004	-0.112, 0.104
1(g). Forward RMSE	Years Playing Music Anxiety SAPS Discrepancy Hours Studying SAPS Standard Age CAGE-AID Abuse	0.056	-0.012	-0.121, 0.097
1(h). Forward RMSE	Years Playing Music Anxiety SAPS Discrepancy Hours Studying SAPS Standard Age CAGE-AID Abuse Sex	0.056	-0.013	-0.123, 0.097
1(i). Forward RMSE	Years Playing Music Anxiety SAPS Discrepancy Hours Studying SAPS Standard	0.056	-0.013	-0.124, 0.098

	Age CAGE-AID Abuse Sex Hours in Class			
1(j). Forward RMSE	Years Playing Music Anxiety SAPS Discrepancy Hours Studying SAPS Standard Age CAGE-AID Abuse Sex Hours in Class Muscle/Bone/Joint Problem	0.056	-0.010	-0.121, 0.101
1(k). Forward RMSE	Years Playing Music Anxiety SAPS Discrepancy Hours Studying SAPS Standard Age CAGE-AID Abuse Sex Hours in Class Muscle/Bone/Joint Problem Mental Health Disorder	0.055	0.001	-0.108, 0.110
1(l). Forward RMSE	Years Playing Music Anxiety SAPS Discrepancy Hours Studying SAPS Standard Age CAGE-AID Abuse Sex Hours in Class Muscle/Bone/Joint Problem Mental Health Disorder Chronic Health Condition	0.055	0.002	-0.107, 0.111

Linear Modelling (Greenland Method)

Model	Model Variables	SE for coefficient	β	95% CI for β
2 (a). Basic (Total CES-D)	Musicianship	1.126	-1.80	-4.01, 0.416
2(b). Forward RMSE	Musicianship Anxiety	0.819	-0.176	-1.79, 1.43
2(c). Forward RMSE	Musicianship Anxiety SAPS Discrepancy	0.800	-0.768	-2.34, 0.805
2(d). Forward RMSE	Musicianship Anxiety SAPS Discrepancy Mental Health Disorder	0.757	-0.268	-1.76, 1.22
2(e). Forward RMSE	Musicianship Anxiety SAPS Discrepancy Mental Health Disorder Age	0.800	-0.160	-1.73, 1.41
2(f). Forward RMSE	Musicianship Anxiety SAPS Discrepancy Mental Health Disorder Age CAGE-AID Abuse	0.812	-0.193	-1.79, 1.40
2(g). Forward RMSE	Musicianship Anxiety SAPS Discrepancy Mental Health Disorder Age CAGE-AID Abuse Hours in Class	0.818	-0.292	-1.90, 1.32
2(h). Forward RMSE	Musicianship Anxiety SAPS Discrepancy Mental Health Disorder Age CAGE-AID Abuse Hours in Class Sex	0.827	-0.313	-1.94, 1.31
2(i). Forward RMSE	Musicianship Anxiety SAPS Discrepancy Mental Health Disorder Age CAGE-AID Abuse Hours in Class Sex Muscle/Bone/Joint Problem	0.826	-0.217	-1.84, 1.41
2(j). Forward RMSE	Musicianship Anxiety	0.827	-0.139	-1.77, 1.49

	SAPS Discrepancy Mental Health Disorder Age CAGE-AID Abuse Hours in Class Sex Muscle/Bone/Joint Problem Hours Studying			
2(k). Forward RMSE	Musicianship Anxiety SAPS Discrepancy Mental Health Disorder Age CAGE-AID Abuse Hours in Class Sex Muscle/Bone/Joint Problem Hours Studying Chronic Health Condition	0.828	-0.145	-1.77, 1.48
2(l). Forward RMSE	Musicianship Anxiety SAPS Discrepancy Mental Health Disorder Age CAGE-AID Abuse Hours in Class Sex Muscle/Bone/Joint Problem Hours Studying Chronic Health Condition Hours Exercising	0.827	-0.177	-1.80, 1.45

Appendix IV: Beta Coefficients for Linear Regression

Model-Adjusted beta coefficients for models where CES-D scores are continuous

Model	Beta Coefficient	95% Confidence Interval
(vselect)		
Linear Model #1 (CESD cont, music-years)	-0.068	-0.184, 0.047
Linear Model #1, **no anx.** (CESD cont, music-years)	-0.206**	-0.356, -0.055
Linear Model #2 (CESD cont, music_spl)	-0.128	-1.608 to 1.352
Linear Model #2, **no anx.** (CESD cont, music_spl)	-1.67	-3.60, 0.266

Appendix V: Model Fit for Logistic Regression

Testing Fit Strategy

Once the models were created, several tests were conducted to ensure that the fit of the models were satisfactory. Interaction terms were included in the final models, and those with significant interaction effects ($p < 0.05$) were included in the models. Interaction terms assessed for the primary objective included the interaction between anxiety and music, standard perfectionism score and music, discrepancy perfectionism score and music, and presence of MBJ conditions and music. Each model was also tested for correlations between variables and for multicollinearity issues. In each model, anxiety was found to be highly correlated ($r > 0.70$) with depression. Multicollinearity tests were conducted, and variance inflation factors (VIF) greater than 5 were considered to be worrisome [Lindsey and Sheather]. In cases where each variable's VIF was <5 but the condition number was >20, multicollinearity checks were re-performed, removing the intercept term. In all cases, the removal of this term resulted in satisfactory results for multicollinearity. To test for goodness of model fit in the logistic models, the estat command in Stata was used.

Appendix VI: Ethics Approvals

Lakehead
UNIVERSITY

October 26, 2016

Principal Investigator: Dr. Vicki Kristman
Student: J. Asselstine
Health and Behavioural Sciences
Department of Health Sciences
Lakehead University
955 Oliver Road
Thunder Bay, ON P7B 5E1

Dear Dr. Vicki Kristman and Jennifer Asselstine:

Re: REB Project #: 079 16-17 / Romeo File No: 1465418
Granting Agency: N/A
Agency Reference #: N/A

On behalf of the Research Ethics Board, I am pleased to grant ethical approval to your research project titled, "Depressive symptomatology and lifelong music experience: a cross-sectional study".

Ethics approval is valid until October 26, 2017. Please submit a Request for Renewal to the Office of Research Services via the Romeo Research Portal by September 26, 2017 if your research involving human participants will continue for longer than one year. A Final Report must be submitted promptly upon completion of the project. Access the Romeo Research Portal by logging into myInfo at:

https://erpwp2.lakeheadu.ca/

During the course of the study, any modifications to the protocol or forms must not be initiated without prior written approval from the REB. You must promptly notify the REB of any adverse events that may occur.

Best wishes for a successful research project.

Sincerely,

Dr. Lori Chambers
Chair, Research Ethics Board

/tm

PROTOCOL REFERENCE # 33703

November 28, 2016
Dr. Vicki Kristman
NCIC EPIDEMIOLOGY UNIT
FACULTY OF MEDICINE
Ms. Jennifer Asselstine
NCIC EPIDEMIOLOGY UNIT
FACULTY OF MEDICINE
Dear Dr. Kristman and Ms. Jennifer Asselstine,
Re: Your research protocol entitled, "Depressive symptomatology and lifelong music exposure: A cross-sectional study"
ETHICS APPROVAL Original Approval Date: November 25, 2016
Expiry Date: November 24, 2017
Continuing Review Level: 1
We are writing to advise you that the Health Sciences Research Ethics Board (REB) has granted approval to the above-named research protocol under the REB's delegated review process. Your protocol has been approved for a period of **one year** and ongoing research under this protocol must be renewed prior to the expiry date.
Any changes to the approved protocol or consent materials must be reviewed and approved through the amendment process prior to its implementation. Any adverse or unanticipated events in the research should be reported to the Research Oversight and Compliance Office - Human Research Ethics Program as soon as possible.
Please ensure that you submit an Ethics Renewal Form or a Study Completion/Closure Report 15 to 30 days prior to the expiry date of your current ethics approval. Note that ethics renewals for studies cannot be accepted more than 30 days prior to the date of expiry.
If your research is funded by a third party, please contact the assigned Research Funding Officer in Research Services to ensure that your funds are released.
Please note, all approved research studies are eligible for a routine Post-Approval Review (PAR) site visit. If chosen, you will receive a notification letter from our office. For information on PAR, please see
http://www.research.utoronto.ca/wp-content/uploads/documents/2014/09/PAR-Program-Description-1.pdf.
Best wishes for the successful completion of your research.
Yours sincerely,
Elizabeth Peter, Ph.D.
REB Chair
Research Oversight and Compliance Office - Human Research Ethics Program
McMurrich Building, 12 Queen's Park Crescent West, 2nd Floor, Toronto, ON M5S 1S8 Canada
Tel: +1 416 946-3273 Fax: +1 416 946-5763 ethics.review@utoronto.ca http://www.research.utoronto.ca/for-researchers-administrators/ethics/

<u>**Appendix VII: Curriculum Vitae**</u>

Jennifer Asselstine

2260 Vista Oak Road   Cell: 905-484-2316

Oakville, ON, Canada   Email: jasselst@lakeheadu.ca

L6M 3L8

Education

<u>Master of Health Sciences</u> *with Specialization in Epidemiology*

Lakehead University, Thunder Bay, ON, September 2015- Present

Supervisor: Dr. Vicki L. Kristman

Advisors: Dr. Michel Bedard, Dr. Rebecca Schiff

Thesis: Depressive symptomatology and lifelong music exposure: a cross-sectional study

<u>B.Sc. Honours Biomedical Science,</u> Minor in Music

University of Guelph, Guelph, ON, September 2011- June 2015

Academic Honours

Ontario Graduate Scholarship Recipient, Lakehead University (May 2016- April 2017)

Epidemiology Faculty Award, Lakehead University (September 2015)

VCM Undergraduate Scholarship (September 2011-April 2015)

Dean's Honor List, University of Guelph (September 2011- April 2015)

Research Experience

Research Assistant, Lakehead University, Thunder Bay, ON, September 2015- April 2017

Research Assistant, Sunnybrook Hospital, Toronto, ON, May 2013-April 2014

Medical Consultant, Sunnybrook Hospital, Toronto, ON, June 2012-Spetemeber 2012

Academic Publications

Asselstine, J, Brison, R, Kristman VL. The Rivermead Post-Concussion Questionnaire Predicts Social, Mental, and Overall Self-Reported Recovery Six Months After Mild Traumatic Brain Injury In Older Adults. (Jun 2017). Submitted for publication to PLOS ONE.

Asselstine J, Kristman VL. Music therapy for Alzheimer's patients. Maladies Chroniques et Blessures au Canada. 2016 Nov 1;36(11).

Conference Presentations

Canadian Society of Epidemiology & Biostatistics (CSEB) Biennial Conference, Banff, AB, May 2017

- Asselstine J, Kristman VL. The Rivermead Post-Concussion Questionnaire Predicts Social, Mental, and Overall Self-Reported Recovery Six Months After Mild Traumatic Brain Injury In Older Adults. (Poster Presentation)).

- Asselstine J, Kristman VL, Bedard, M, Schiff, R. Depressive symptomatology and lifelong musical exposure: a cross-sectional study. (Poster Presentation).

Canadian Society of Epidemiology & Biostatistics (CSEB) Lakehead Student Chapter Research Showcase, Thunder Bay, ON, April 2017

- Asselstine J, Kristman VL. The Rivermead Post-Concussion Questionnaire Predicts Social, Mental, and Overall Self-Reported Recovery Six Months After Mild Traumatic Brain Injury In Older Adults. (Poster Presentation)).

- Asselstine J, Kristman VL, Bedard, M, Schiff, R. Depressive symptomatology and lifelong musical exposure: a cross-sectional study. (Rapid Fire Oral Presentation).

St. Joseph's Care Group Research Showcase, Thunder Bay, ON, January 2017

- Asselstine J, Kristman VL. The Rivermead Post-Concussion Questionnaire Predicts Social, Mental, and Overall Self-Reported Recovery Six Months After Mild Traumatic Brain Injury In Older Adults. (Poster Presentation)).

Canadian Society of Epidemiology & Biostatistics (CSEB) Student Conference 2016, Winnipeg, MB, June 2016

- Asselstine J, Kristman VL. Music therapy for Alzheimer's patients. (Oral Presentation)

Trauma Annual Conference (TAC) 2015, Calgary, AB, April 2015

- Asselstine J, Tien H, Nasciemento, B, Tremblay, L. Factors Associated with Primary Fascial Closure Rate in Patients Undergoing Damage Control Laparotomy. (Oral Presentation).

Academic Services

CSEB Lakehead Student Chapter Student Co-President, August 2016- Present

CSEB Newsletter Editorial Team, March 2017- Present