ABSTRACT

Title of Thesis: ASSOCIATIONS BETWEEN CLASSICAL MUSIC, PHYSICAL ACTIVITY AND SYMPTOMS OF DEPRESSION IN OLDER ADULTS DURING THE COVID-19 PANDEMIC

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Master of Arts, Kinesiology, 2023

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Background: The initial lockdown in March 2020 due to COVID-19 rattled the residents of North America as normalcy came to a standstill, freedom was stripped away, and people were forced to adapt to new restrictions and regulations, simply to survive. The elderly population was greatly affected by the lockdown as it prohibited those living in assisted living facilities to physically interact with family and friends highlighting the need to identify protective behaviors against mental health and depression. The neurological benefits of listening to classical music is an emerging area of research. A few studies suggest the positive outcomes of listening to classical music in reducing symptoms of depression. Additionally, while the cardiovascular benefits of exercise are well known, the impact of exercise on affect continues to be an emerging area of research. **Purpose:** The purpose of this study is to understand the efficacy of listening to classical music in attenuating symptoms of depression in older adults (50 – 90+) utilizing data collected from 3 separate time points during the COVID-19 pandemic, and to determine if physical

activity is associated with providing additional benefit to lowering symptoms of depression. **Methods:** A survey including the Geriatric Depression Scale (GDS), the Physical Activity Scale for the Elderly (PASE), and questions about listening to music (classical, Broadway, Christian music), and the frequency of listening to music was generated and distributed to people living in the United States and Canada immediately following the initial COVID-19 lockdown in April 2020. Informed consent was obtained prior to completing the survey, and participants who were interested in receiving a follow-up survey were asked to provide their email addresses. The follow-up surveys were generated 4-months (August 2020) and one year (April 2021) after the initial survey. **Results:** At the initial onset of the COVID-19 lockdown in April 2020, significant associations were observed between classical music listening (CML) and lower symptoms of depression, physical activity (PA) and lower symptoms of depression, music listening frequency, and lower symptoms of depression. In August 2020 and April 2021, significant associations were found between physical activity and lower symptoms of depression. However, no associations were observed between classical music listening and lower symptoms of depression, and music listening frequency and lower symptoms Additionally, significant associations were observed between age and lower symptoms of depression, sex, and lower symptoms of depression at all three time points.

Conclusion: The results from our study suggest that there is an association between classical music listening and symptoms of depression, physical activity and symptoms of depression, music listening frequency and symptoms of depression in older adults (50+) during the early stages of the COVID-19 pandemic (April 2020). Additionally, the

association between physical activity and symptoms of depression was maintained throughout the first year of the pandemic as supported by the data collected in August 2020 (4 months) and April 2021 (12-months).

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by

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Thesis submitted to the Faculty of the Graduate School of the
University of Maryland, College Park, in partial fulfillment
of the requirements for the degree of
Master of Arts
2023

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Dedication

This thesis is dedicated to my Heavenly Father, Jesus Christ. I am who I am, because of Him.

To my parents (Stanley and Beatrice Arnold) for instilling in me the value of learning and equipping me with the tools to reach my goals.

To my husband (Antonio), my sons (Brandon and Matthew), for their unconditional love, encouragement, and support.

To my sister (Liz), and my friends, for their encouragement and support.

Acknowledgements

I would like to extend my deepest appreciation to my advisor Dr. J. Carson Smith for his mentorship, and guidance.

I would like to extend my deepest gratitude to Dr. Daniel Callow for his invaluable guidance, mentorship, and encouragement.

I’m extremely grateful to my advisory committee, fellow graduate students, and members of the Exercise for Brain Health Laboratory for their encouragement.

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4M- Four Month Follow-up

12M- Twelve Month Follow-up

BDI- Beck Depression Inventory

BDNF- Brain Derived Neurotrophic Factor

BL- Baseline

CM – Classical Music

CML – Classical Music Listening

COVID-19 – Coronavirus 2019

DSM-V – Diagnostic and Statistical Manual of Mental Disorders-V

GDS – Geriatric Depression Scale

GAS – Geriatric Anxiety scale

LIST-FREQ -Music Listening Frequency

LD- Lock Down

MDD- Major Depressive Disorder

MM – Mask Mandate

MM – Music Medicine

MT – Music Therapy

No-CML – No Classical Music Listening

PA – Physical Activity

P – P-Value

Q – Quarantine

QOL- Quality of Life

SARS-CoV-2 - Severe Acute Respiratory Syndrome Coronavirus 2

SD – Social Distancing

SD- Standard Deviation

SO- Social Isolation

WHO – World Health Organization

CHAPTER I: REVIEW OF LITERATURE

Overview

The elusive Coronavirus of 2019 brought the entire world to a standstill. Unfamiliar to the likes of quarantines, social distancing, mask wearing, isolation from family and loved ones due to stay at home orders, North Americans had to adjust to a myriad of unfamiliar changes implemented on a daily basis. People received conflicting information, challenging guidelines, and an uncertain future. Additionally, due to lockdowns, many people were prevented from gathering with families and friends. In addition to the stress imposed by the Coronavirus illness, Americans were further burdened by quarantines, social isolation and stay-at-home directives, and this raised concerns about how individuals would react to these changes (Pfefferbaum & North, 2020). Fear about the consequences of infection, symptoms of the infection, adverse effects of the experimental treatment, along with boredom, loneliness, and anger as a result of isolation led to worsening anxiety and mental distress (Pfefferbaum & North, 2020). The elderly are a vulnerable population, and because of age-related co-morbidities, they were at an increased risk of contracting the coronavirus.

When researchers compared COVID-19 induced pneumonia in young and elderly patients, they found that the elderly patients (age 60+) were at a greater risk of disease progression and death (Banerjee, 2020). During this public health crisis, seeking health care was nearly impossible and may have been a contributing factor to increased levels of depression especially among the elderly (Amal Dev, 2015). Additionally, healthcare professionals who worked in hospitals treating infected patients did not receive any

training to work with patients experiencing mental health issues, and reported experiencing depression, anxiety, fear, and frustration themselves (Xiang et al., 2020). There is an urgency to develop mental health treatments that can be utilized to help both patients and healthcare workers (Xiang et al., 2020). Emerging studies suggest that listening to classical music consistently and/or exercising regularly can contribute to mental health benefits by lowering symptoms of depression, especially in older adults (Ribeiro et al., 2021). These behavioral outcomes can be beneficial in treating and managing mental illnesses such as depression, especially in emergency situations such as the recent COVID-19 pandemic where access to mental health treatments were limited.

COVID-19

A pneumonia outbreak that originated in December 2019 in the Wuhan, Hubei Province in China steered the discovery of the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), known as the novel coronavirus (Ciotti et al., 2020). Infected patients presented symptoms ranging from mild to severe, while some were asymptomatic (Ciotti et al., 2020). Dry cough, malaise, fever, and dyspnea were the most common symptoms associated with the initial stages of the illness (Wang et al., 2020). Other symptoms such as headache, dizziness, abdominal pain, diarrhea, nausea, and vomiting (Wang et al., 2020). In a preliminary study conducted in February 2020 in China, noted that approximately a third of the patients required treatment in the intensive care unit, and were significantly older in age (median age 66) (Wang et al., 2020). The illness spread rapidly across the globe, resulting in significant casualties and this propelled the

World Health Organization (WHO) to declare a global pandemic on March 12, 2020 (Ciotti et al., 2020). Nations across the globe implemented measures such as social distancing (SD), lockdowns (LD), mask mandates (MM), quarantines (Q), and social isolation (SO). People all over the world suffered immensely as a result of the loss of loved ones, loss of income, limited food supply, and fear (Ciotti et al., 2020).

Depression

Depression can be characterized as a medical illness that affects the emotional and physical well-being of an individual (Altar, 1999). It can manifest at any age (Altar, 1999), and symptoms include feelings of sadness, lethargy, insomnia, and changes in mood (Cui, 2015). Depression can inhibit an individual's ability to enjoy life (Cui, 2015), by diminishing hope and ambition (Altar, 1999). It can be life-threatening as increasing feelings of hopelessness can lead to suicide ideation (Altar, 1999). It is quite debilitating for the elderly as it can lower their quality of life (Amal Dev, 2015). Depression is not a natural part of aging and is reversible with prompt and appropriate treatment (Kurlowicz & Greenberg, 2007). In a 2001-2002 study, an estimated 6.6% of the US adult population had experienced a major depressive disorder within the previous year (Altar, 1999). Major depressive disorder or clinical depression is characterized by the manifestation of symptoms for a duration of 2-weeks with changes in neurovegetative functions, cognition, and affect (American Psychiatric Association, 2013). Although common, it is a serious mood disorder and a diagnosis requires the presence of five of nine symptoms (Table 1), along with either the loss of interest/pleasure or a depressive mood (American Psychiatric

Association, 2013). Depressive symptoms, minor depression, and MDD represent a continuum of depressive symptom severity associated with psychosocial disability (as cited by Ayuso-Mateos et al., 2010). Cardiovascular disease, diabetes, obesity, cancer, asthma, and arthritis have a higher probability of experiencing depression (Altar, 1999). Additionally, depression is prevalent in smokers and binge drinkers. The chronic nature of the disease can exert a tremendous cost upon society (Altar, 1999). The psychosocial impact of COVID-19 on the elderly was particularly significant as age related cognitive decline contributed to increased levels of anxiety, stress, lack of sleep, and loneliness (Banerjee, 2020). COVID-19 wreaked havoc in the emotional state of people. Public health measures such as social distancing, isolation, and quarantine, guidelines implemented to contain the spread of the virus gave rise to confusion, and emotional distress due to conflicting messages from authorities, the loss of personal freedom, and financial losses (Pfefferbaum & North, 2020). Although the emotional impact was ubiquities across all age groups, the elderly population was particularly vulnerable and was impacted by the public health guidelines. Social distancing was a major strategy utilized to lower the spread of the virus, but it was a major cause in loneliness particularly among the elderly in nursing homes, and assisted living facilities (Banerjee, 2020). Depression in elderly people is prevalent amongst those with chronic illnesses & cognitive impairment (Alexopoulos, 2005). It severely impacts their quality of life (QOL) as it impacts their cognition and functionality, and family disruption, psychosocial adversity such as isolation, and bereavement can increase susceptibility to depressive symptoms (Table 1) (Alexopoulos, 2005). Loneliness is a major risk factor for depression, anxiety, and suicide (Banerjee, 2020). Additionally, people diagnosed with mental illnesses are

particularly vulnerable to experiencing an increase in symptoms during a public health crisis (Banerjee, 2020).

Therapeutic Interventions In Depression

Treatments for depression are diverse and unique to the severity of the condition. Commonly used forms of treatments for depression are: Psychotherapy, Pharmacotherapy, Electroconvulsive Therapy (ECT), and Repetitive transcranial stimulation (rTMS) (NIH, 2022). Electroconvulsive therapy (ECT) is used to treat those who do not respond to conventional drug therapy (DT) (Altar, 1999). Psychotherapy is effective in treating depression, but the benefits are not sustained (Chikahisa et al., 2006). Irrespective of the nature of the therapy, several weeks of treatment is required for a positive outcome (Altar, 1999). The aforementioned treatments are effective, but costly, and require long-term treatment for recovery.

Pharmaceutical treatment of depression has advanced in recent years with the advent of drugs that block the inactivation of the brain neurotransmitters serotonin (5-HT) and noradrenaline (NA) (Altar, 1999). Monoamine oxidase inhibitors (MAOI) is a class of drugs that slows the normal enzymatic degradation of these neurotransmitters (Altar, 1999). Monoamine reuptake blockers is another class of drugs that prevents the normal recapture of 5- HT and noradrenaline by their transport back into the presynaptic nerve-terminal (Altar, 1999). Fluoxetine (Prozac) or desipramine, known as Selective reuptake inhibitors, enhance levels of 5-HT or noradrenaline, respectively, in the nerve-terminal synapse (Altar, 1999).

Music

Music can be characterized as the art of thinking in sounds (Andrade & Bhattacharya, 2003). It is a universal language with a plethora of genres and musical preferences that are unique to each listener. Music is an important part of daily life and can be characterized as a cultural resource within the social construct of the regulation of emotions (Slobada, 2001), given its ability to increase emotional awareness and trigger autobiographical memories (Saarikallio, 2012). Based on previously observed results of music listening, Saarikallio (2012) outlines three psychological aspects of music listening: The use of music to express, experience, and/or regulate emotions; the use of music as a form of reflection, self-development, relaxation, and mental work, and the use of music to enhance socialization, relationship building, and identity development. Moreover, studies suggest that people listen to music for a plethora of additional reasons such as mood improvement, self-esteem, interpersonal relationships, overcoming boredom, and staying informed of current events (Ribeiro et al., 2021).

Music is a stimulus that elicits some form of response and has certain patterns and regularities which help form the basis of musical perception and lead to a variety of conscious or unconscious actions of directly observable changes in behavior or mental state (Watt & Ash, 1998). The limbic system is the neurophysiological location of feelings, emotional states, and sensations (Hanser & Thompson, 1994). Since the perception of music leads to stirring emotional reactions, these psychophysiological responses that

music evokes can be attributed to the influence of music on the limbic system (Hanser & Thompson, 1994). Additionally, “Music acts as an exercise for exciting and priming the common repertoire and sequential flow of the cortical firing patterns responsible for higher brain functions (Leng & Shaw, 1991)”.

Amongst the older population, music provides a means of exploring new creative direction and a way of reliving the past (Hanser, 1990). Music interventions have been shown to be a potential alternative to pharmaceuticals and /or electroconvulsive therapy (Reybrouck et al., 2017), and have been effectively used to treat mental illness, but very few studies have evaluated the benefits of music in treating depression (Castillo-Pérez et al., 2010). Music is known to have the ability to activate several processes which in turn can contribute to brain development and/or plasticity (Castillo-Pérez et al., 2010). Additionally, Fukui & Toyoshima (2008) suggest that there is sufficient research to support pathways involved in signaling can regulate cell survival and cell death as a result of musical action (Castillo-Pérez et al., 2010).

Music Therapy/Music Medicine

Music therapy and music medicine are used interchangeably. Music therapy can be characterized as the planned use of music to achieve therapeutic outcomes (Castillo-Pérez et al., 2010). It can be described as a professional music intervention based on research, utilized to treat individual needs, and is administered by a certified professional (Reybrouck et al., 2017). Music Medicine (MM) is the therapeutic use of music in medicine, administered by professionals such as scientists, and physicians (Reybrouck

et al., 2017). Listening to 10-minutes of Mozart's sonata for two pianos in D Major (K.448) is known as the "Mozart Effect" (Rauscher & Shaw, 1998) and has been known to enhance spatial-temporal reasoning (Rauscher & Shaw, 1998) by activating several signal pathways (Castillo-Pérez et al., 2010). Music can be a powerful weapon to fight mental illness. Additionally, music as a therapeutic measure is inexpensive and can be self-administered with guidance. Music listening can contribute to an increase in cerebral synaptic plasticity (Kim et al., 2006). The underlying mechanisms of music and depression are different, but work in a specific area of the brain that can lead to changes (Rauschecker, 2001). Impoverished neurons are associated with mood disorders, including depression (as cited by Verrusio et al., 2014). Sound exposure, such as music, is known to increase neurogenesis in the hippocampus, thus creating a relationship between depression and music (as cited by Verrusio et al., 2014). . This link between depression and music is encouraging as music can potentially be a viable form of treatment to reduce symptoms of depression. Moreover, no adverse effects have been reported thus far (Edwards, 2006), making it a sustainable long-term treatment that is enjoyable, economical, and tremendously beneficial.

Music and Depression

In a randomized controlled study, Chan et al., (2009), aimed to understand the effect of music on depression levels and physiological responses in community-based older adults in Hong Kong. Fifty eligible male and female participants (age 60+) were randomly assigned to an experimental (music) and a control group (weekly time of rest for 30 minutes). The experimental group was asked to choose from four music selections:

Western Jazz (April in Paris, Dreamville), Western classical (Beethoven's Symphony No. 5), Chinese classical (TAO, Lord of the Wind), and Asian classical (Everlasting Road). The study controlled for demographic variables: age, sex, religion, marital status, education level, medical history, and previous music-listening experience. The only psychological parameter used was the Geriatric Depression Scale (GDS). The experimental group was asked to listen to 30 minutes of music prior to their bedtime each night and were instructed to report the frequency and duration of their music listening (at home) weekly (Chan et al., 2009). There were no differences between the GDS scores of the two groups at baseline (P = 0.783) and week 1 (P = 0.061). However, statistically significant differences were found at weeks 3 & 4. The experimental group showed a statistically significant reduction in the GDS score at week 4 when compared to their baseline score (P=0.001), and the control group showed a statistically significant increase in the GDS score at week 4 when compared to their baseline score (P=0.007). The outcome of this study supports the idea that music interventions are an effective way to lower symptoms of depression in older adults. However, there were some limitations as the sample size was rather small, and the lack of monitoring of the self-administered music therapy may have led to inaccurate reporting.

In a randomized controlled trial designed to understand the impact of music versus psychotherapy on depression, Castillo-Pérez et al., (2010) recruited 79 participants (male=14, female=65) with moderate levels of depression, but with no other neurological pathology, and not participating in drug therapy from a clinic/hospital in Oaxaca, Mexico. Participants' ages ranged from 25-60 and were randomly assigned to one of two

conditions: music therapy (MT) (n=41, m=8, f=33), and psychotherapy (PT) (n=38, m=6, f=32). The initial evaluation was conducted using the Zung Self-rated Depression Scale. Weekly assessments were done using the Beck Depression Inventory (BDI), and the Hamilton Depression Scale was used during the final evaluation. Higher scores on the depression scales indicate greater symptoms of depression. The cohort in the MT were exposed to 8-weeks of baroque (Bach's Italian Concerto in F Major, BWV 780; Arcangelo Corelli's Concerto Grosso in D Major, Op.6) and classical music (Wolfgang Amadeus Mozart's Sonata for two pianos in D Major, K448) in 50-minutes of daily sessions (self-administered) at home, and a weekly session at the hospital. The PT group had weekly 30-minutes of individual psychotherapy. Positive changes in the MT group were observed during the 4th group session. Overall, 29 subjects from the MT group showed improvement, while only 12 subjects from the PT group showed improvement. Their results were statistically significant in favor of the music intervention (Castillo-Pérez et al., 2010). The lack of medical history associated with the depressive symptoms such as the onset, frequency and duration of episodes was a limitation in this study. Additionally, the music listening was self-administered and reported, and may have not been accurately reported.

A study assessing the effect of music therapy on depressive symptoms among elderly from two geriatric homes in Calicut, India, used a one-group pre-test and post-test design and included 40 participants (60 years+) with depressive symptoms (Dev, 2015). The Mini-Mental Status Examination (MMSE) was used to evaluate cognitive decline, the GDS to screen the participants for depressive symptoms, and Beck's Depression

Inventory (BDI-short form) to assess the level of depression. Additionally, socio-demographic data was also collected from each of the participants. Music therapy was administered for 30 minutes over the course of 21 days and included Indian music familiar to the participants. Most of the participants were male, and the majority (72.5%) had moderate symptoms of depression, and the rest (27.5%) had severe symptoms at baseline. Post-test was done one week following the intervention using the BDI. The results showed a significant reduction in depression in those who had moderate symptoms of depression at baseline. However, there was no change in those who had severe depression (Dev, 2015). The study supports the theory that listening to music can improve symptoms of mild to moderate symptoms in the elderly (Dev, 2015).

In a systematic review and meta-analyses of music therapy for older adults with depression, Zhao et al., (2016), used electronic databases to find articles that met their inclusion criteria. They included men and women (60+ years or older) with a clinical diagnosis of depression with treatment plans that included the following: music therapy and/or standard therapy and a control group that did not include any form of therapy. Standard therapy included drug therapy, health education, psychotherapy, and other clinical practices. Their search yielded 19 articles that met their inclusion criteria. They found when music was added to standard therapies (drug therapy, psychotherapy, health education), the treatment groups showed significant decrease in symptoms of depression compared to those who only had standard therapy. This supports the theory that music has a positive effect in lowering symptoms of depression in the elderly (Zhao et al., 2016).

The variability in music listening (genre, frequency, duration) can be considered a limitation in this meta-analysis.

Exercise and Depression

The benefits of regular exercise in improving high blood pressure, coronary artery disease, type-2 diabetes, atherosclerosis, and other cardiovascular diseases are well-established in literature (as cited by Mota-Pereira et al., 2011). Additionally, research supports the associations between the therapeutic benefits of exercise and the psychological well-being of older adults (Mota-Pereira et al., 2011) and symptoms of mild to moderate depression (Martinsen, 2009). Moreover, in addition to being is linked with reducing the risk of developing depression (Martinsen, 2009) regular exercise is also associated with increasing neurogenesis and neural plasticity through BDNF- dependent mechanisms and attenuating the inflammatory process by inducing a more resilient stress response (C. Phillips, 2017). Regular exercise can be an effective way to mitigate symptoms of depression.

In a 16-week intervention to study the effects of exercise training (ET) in older patients with major depression disorder, Blumenthal et al., (1999) randomly assigned 156 men and women (age $\geq$ 50 years) to one of three conditions: aerobic exercise, medication, or combined exercise and medication. The qualified participants met the MDD criteria stipulated in the DSM-IV. The Beck Depression Inventory (BDI) and the 17-item Hamilton Rating Scale for depression (HAM-D) were used at baseline and following the intervention. The HAM-D and BDI are tested, and validated instruments used to measure

symptoms of depression. Higher scores in both instruments indicate greater depression. The HAM-D and BDI scores in all three conditions were significantly lower after the intervention. The medication group had the fastest response to the treatment, while those who presented with lower symptoms of depression at baseline exhibited a faster response to the combination of treatments. The outcome of the study supports the effectiveness of exercise in treating depression as an alternative to traditional medical treatment. The lack of a non-treatment placebo group was a limitation in the study. Additionally, given that the exercise classes were conducted in a group setting, social interaction may have contributed to the positive outcome, as social interactions are known to potentially reduce symptoms of depression.

In a similar study, Babyak et al., (2000) explored the long-term benefits of exercise in treating MDD. One hundred and fifty-six adult volunteers with clinical depression were randomized to three conditions: aerobic exercise, sertraline therapy (Serotonin Reuptake Inhibitor (SSRI), and sertraline and exercise. The participants' depression scores were evaluated using the Hamilton Depression Rating Scale (HAM-D) and Beck Depression Inventory (BDI) at baseline, following the 4-month intervention, and 6 months after the intervention. All three groups exhibited significantly lower symptoms of depression immediately following the 4-month intervention. Participants were educated about MDD and advised to continue with a form of therapeutic activity such as medication, exercise, or psychotherapy. At the 10-month assessment (6 months following the 4-month intervention), the aerobic exercise group exhibited lower rates of depression compared to those in the other two conditions. In fact, those who had been assessed as being in

remission in the aerobic condition at the end of the 4-month intervention, were less likely to relapse.

In a study aimed to understand the therapeutic effects of moderate intensity exercise as an adjuvant to pharmacotherapy in treatment resistant MDD patients Mota-Pereira et al., (2011), included 33 individuals with treatment resistant MDD, and randomized them to the pharmacotherapy and exercise (experimental) group (n=22) and the pharmacotherapy (control) group (n=11). The experimental group participated in a daily walk of 30-45 minutes, 5 days a week for 12 weeks. All the participants wore ActiGraph GT1M LLC two-dimensional accelerometer permanently over the course of the 12 weeks, except when they were sleeping. The experimental group and the control group were prescribed non-sedating antidepressants. The control group did not engage in any exercise. Participants were evaluated for symptoms of depression, functional assessment, hemodynamic and anthropometric parameters at baseline, 4, 8, and 12 weeks. The depression scores were assessed using the Beck Depression Inventory (BDI-II) and the Hamilton Depression Rating Scale (HAMD17) (Hamilton, 1960) (Jackson-Koku, 2016). The experimental group improved in all of the studied parameters of depression and functioning (Mota-Pereira et al., 2011). Additionally, the patients in the experimental group exhibited a remission rate of 26% while the control group had no improvement (Mota-Pereira et al., 2011). This study suggests that exercise is an effective adjuvant therapy for treatment-resistant MDD patients (Mota-Pereira et al., 2011).

Callow et al. (2020), conducted a 136-question online survey in April 2020 when many states and provinces in North America instituted social distancing, isolation and lock down measures in an effort to contain the rapid spread of the Coronavirus. The survey included questions about demographics, current health status, and social distancing guidelines and included validated instruments such as the Geriatric Depression Scale (GDS) and the Physical Activity Scale for the Elderly (PASE). The survey was distributed primarily through social media to residents in the United States and Canada ages 18 and over. Complete responses were received from 1,369 individuals of which 1,046 were older adults (ages ≥50) and included in the analyses. GDS scores were received from n=848, and were categorized as follows: mild depression, 25.5%, moderately depressed, 63.1%, and severely depressed, 11.4% (Callow et al., 2020). When controlled for age, sex, and education, a greater total amount of physical activity was associated with lower symptoms of depression (Callow et al., 2020). Moreover, they found that light and vigorous activity also played a significant role in lowering symptoms of depression. This study supports the positive relationship between light and vigorous exercise in reducing symptoms of depression in older adults particularly during the recent pandemic (Callow et al., 2020).

A review by W. T. Phillips et al., (2003) explored the outcomes of cross-sectional, longitudinal, and randomized trials that investigated the role of physical activity in alleviating symptoms of depression. A random sample of 3403 males and females in a cross-sectional study the BDI and six-levels of self-reported exercise frequency ranging from daily exercise to few times per year were used to assess the outcomes. The results

reported a significant inverse association between exercise and symptoms of depression Moreover, those who exercised at least twice a week had lower symptoms of depression than those who exercised less (W. T. Phillips et al., 2003). In a Finnish longitudinal study older men and women were found to be at a greater risk of developing depressive symptoms as a result of age-related decrease in the intensity of physical exercise (Lampinen et al., 2000). In a randomized trial, McCann & Holmes (1984) randomly assigned 41 undergraduate females to 10 weeks of aerobic exercise progressive relaxation or a control group. The exercises were conducted three times a week and the BDI was used to measure symptoms of depression (Lampinen et al., 2000). The exercise group had a significant reduction in depression (Lampinen et al., 2000). Scientific literature supports the inverse relationship between physical activity and symptoms of depression, but further research needs to be done to develop a greater understanding of the causal relationships between aerobic exercise and symptoms of depression (W. T. Phillips et al., 2003).

A cross-sectional study in Japan examined the association between recommended levels of physical activity with levels of depression (Ishii et al., 2011). The internet-based survey was randomly distributed 12,435 respondents who had voluntarily registered in a research service organization. Data were collected from at least 750 participants from each of the stratified age groups (20s, 30s, 40s, 50+) and gender, and included sociodemographic information such as age, gender, education, employment status, marital status, living conditions & household income level. The Japanese version of the International Physical Activity Questionnaire (IPAQ) was used to obtained

information about physical activity, and the Japanese version of the Center for Epidemiologic Studies Depression (CES-D) scale was used to assess depressive symptoms. The CES-D is a 20-item scale (score range: 0-60), and a score of ≥ 16 is defined as “depressive” (Ishii et al., 2011). The outcome of the study suggested an association between physical activity and lower symptoms of depression, where those who engaged in the recommended physical activity had lower depression scores, and those who did not participate in the minimum required physical activity had higher scores of depression. The online platform and the lower response rate from people with higher symptoms of depression are limitations in the study. Additionally, those engaged in physical activity are more likely to participate in online surveys related to physical activity than those who are sedentary (Ishii et al., 2011).

In a follow-up to a cross-sectional study exploring the relationship between physical activity and depressive symptoms, FARMER et al. (1988), utilized data from 1900 healthy subjects between the ages of 25-77 who had participated in the first National Health and Nutrition Examination Survey (NHANES I). To assess depressive symptoms, they used the Center for Epidemiologic Studies Depression Scales (CES-D) and collected data on recreational physical activity and physical activity apart from recreation. The findings suggested a positive relationship between physical inactivity and higher depression scores (FARMER et al., 1988).

Physical activity data and psychological status were assessed in four population

samples in the United States and Canada over the span of 10-years. The analysis examined the association between physical activity and various aspects of mental health such as depression. The findings suggest a strong positive association between physical activity and lower levels of depression (Stephens, 1988).

A cross-sectional study that aimed to explore the relationship between moderate physical activity and depression symptoms, data from the Survey of Health, Aging and Retirement in Europe (SHARE) was utilized to analyze the data of 32,392 middle aged to older participants (Marques et al., 2020). The data was collected over a period of 4-years from 14 European countries (Marques et al., 2020). Data from the fourth (2011) and sixth (2015) waves were used for the analysis (Marques et al., 2020). SHARE is a multicultural database that includes information on health, microdata, socio-economic status, social and family networks, and was created as a result of a growing need to understand and address issues associated with the older population (Marques et al., 2020). Share implemented its data collection process in 2000, and has continued to collect data bi-annually (Marques et al., 2020). Physical activity data were collected based on duration, frequency, and intensity. Depression symptoms were evaluated using the EURO-D 12-item scale – a validated scale used to assess depression in Europe. The outcomes suggested that moderate and vigorous physical activity were inversely associated with symptoms of depression in both females and males, Additionally, moderate and vigorous physical activity once or twice a week were inversely associated with depression scores 4-years later, suggesting long-term benefits of physical activity in lowering symptoms of depression (Marques et al., 2020).

Brain Derived Neurotrophic Factor (BDNF)

Neurotrophins are a family of proteins in the brain that contribute to the growth, maintenance, and survival of neurons (C. Phillips, 2017). Brain Derived Neurotrophic Factor (BDNF) is a neurotrophin that is highly regulated and involved in neuroplastic changes associated with learning and memory (Miranda et al., 2019). Changes in BDNF expression are inversely associated with psychiatric diseases and normal aging process (Miranda et al., 2019). BDNF controls the growth of new neurons from neural stem cells and supports the differentiation, maturation, and survival of neurons in the nervous system (Bathina & Das, 2015). Stress is known to suppress BDNF synthesis in the hippocampus, and reduced volumes in the hippocampus and prefrontal cortex are associated with major depression (Castren et al., 2007). Additionally, lower levels of dopamine in the brain along with a low number of dopamine receptors are two of the contributing factors that result in depression (as cited by Castillo-Pérez et al., 2010). Sustaining BDNF synthesis and improving dopamine production can contribute to maintaining a healthy mental state.

Music, Exercise, & Depression

BDNF levels are found to be low in those suffering from major depression, and has been associated with suicidal behavior, and Yeh et al. (2015), aimed to compare the improvement of depression and BDNF levels in women (n=106) through a 12-week trial with (n=47) and without (n=59) music aerobic exercise (MAE) in Taiwan. The Beck Depression Inventory-II (BDI-II) was used to screen participants (age 40+) for depression.

The Short Portable Mental Status Questionnaire (SPMSQ) was used to determine cognitive status. Blood draws were done at baseline and at the follow-up to measure BDNF levels through Luminex assay. The experimental group participated in three 50-minute sessions of music and exercise on a weekly basis, while the control group watched 50-minutes of television three times a week. The exercise intensity of the MAE sessions was designed to achieve moderate level of exercise with a maximal heart rate of 64%. Heart rates were measured using pulse oximeters. The music used varied in rhythm and tempo. From the experimental group, n=41 completed the trial, and n=26 from the control group also completed the trial. The depression levels (mild-moderate) and BDNF levels between the two groups were similar prior to the trial. Following the intervention, the experimental group had a significant reduction in the BDI-II scores while the control group did not have any changes in their scores from baseline. Likewise, the BDNF levels in the experimental groups increased significantly, and the control group had no changes in in the levels between baseline and follow-up. These findings suggest music and exercise were efficacious in increasing BDNF levels, which contributed to the reduction in depressive symptoms in the experimental group (Yeh et al., 2015).

Doubt associated with the efficacy of pharmacotherapy on people with light to moderate depression led Verrusio et al. (2014) to conduct a 6-month randomized control trial examining the benefits of pharmacotherapy versus exercise/music therapy in 24 older adults (mean age=75.5, M=11, F=13) with mild to moderate depression. Participants were randomized two groups: pharmacotherapy n=12, and exercise/music therapy n=12. All the participants met the DSM-IV criteria for major depression with mild to moderate

symptoms. The main outcome measures used in the study were the Hamilton Anxiety Scale (HAS) and the Geriatric Depression Scale (GDS). The control group (pharmacotherapy) received antidepressants while the experimental group engaged in exercise and music. The results at the end of the third month and the sixth month, showed a twofold positive effect in the exercise/music therapy group, reducing symptoms of depression and anxiety (Verrusio et al., 2014b).

Summary

The COVID-19 pandemic and all the guidelines placed to reduce the spread of the virus have given rise to an increase in the rate of depression in all ages, but especially among the elderly. Older adults in active adult/retired communities and nursing homes were greatly impacted over the last two years. The isolation and separation from families as a result of county and provincial guidelines, have led to increased depression and anxiety. Research suggests that music along with regular exercise can be effective in reducing symptoms of depression. As noted earlier, stress reduces BDNF, and lower levels of BDNF is associated with depression. Although traditional therapies such as pharmacotherapy, psychotherapy, ECT, and rTMS though effective are not sustainable as they can be cost-prohibitive and are not as convenient. Classical music, in particular, can be very effective in attenuating symptoms of depression as it enhances neurotrophins such as BDNF. Much like music, studies suggest physical activity also can increase BDNF, and is effective in reducing symptoms of depression. Implementing affordable and simple therapeutic measures such as exercise programs and classical music listening can be effective in lowering the incidence of depression among older adults.

CHAPTER II: SIGNIFICANCE AND RESEARCH QUESTIONS

Significance of Research Proposed

Although understanding the impact of listening to music on depression is an emerging area of research around the globe, there are only a limited number of studies in the United States that have explored the benefits of listening to classical music in treating depression and/or attenuating symptoms of depression. Most studies in this niche area of interest have focused on a "non-genre specific" association between music and depression. However, there is a need to understand the association between "genre specific" music listening, such as classical music, and depression. There is a significant amount of research demonstrating the efficacy of physical activity in preventing and managing depression (Stubbs et al., 2016). Furthermore, a number of studies support the long-term effects of physical activity interventions compared to traditional modes of therapy in preventing and managing depressive symptoms and depression (Babyak et al., 2000). Although studies have evaluated the effects of music and physical activity in attenuating symptoms of depression in older adults (Verrusio et al., 2014), there is limited research focused on the interactive effects of music listening and physical activity in attenuating symptoms of depression. As such, the proposed thesis will address the question of whether or not there is an additional benefit to reduced symptoms of depression when physical activity participation is combined with listening to classical music.

Depression is the major cause of mental disorders in the United States and other developed nations (Phillips et al., 2003). The anxiety, fear, restrictions, loss of job/income, death, and rise in the cost of living as a result of the COVID-19 pandemic have contributed significantly to the increase in depression and symptoms of depression all over the globe. Loss of jobs have led to loss of medical insurance, which in turn has prohibited people from having access to proper medical care and related treatments. Listening to classical music and physical exercise are affordable forms of therapy that can be utilized to reduce and manage symptoms of depression, and depression, and can be a valuable contribution to the physical and emotional well-being of all ages, especially the elderly.

Research Questions and Hypotheses

1) Was listening to classical music during the initial lockdown phase of COVID-19 associated with lower symptoms of depression in older adults (50+)? Additionally, given that greater physical activity was associated with lower symptoms of depression (Callow et al., 2021), did physical activity provide added benefit to symptoms of depression when combined with listening to classical music?

2) Do the associations between listening to classical music during the initial lockdown phase (wave 1) of COVID-19 and symptoms of depression in older adults (50+), change after 4 months (wave 2) and 12 months (wave 3) following the initial lockdown? Additionally, did physical activity provide added benefit to symptoms

of depression when combined with listening to classical music at 4 months and 12 months following the initial lockdown?

Specific Aims

Specific Aim #1: To determine if listening to classical music was associated with lower symptoms of depression in older adults (50+) during the initial lockdown phase of COVID-19, and if concurrent participation in PA was associated with additional benefit to symptoms of depression.

Hypothesis #1a: We hypothesize that older adults (50+) who listened to classical music during the initial lockdown phase of COVID-19 will have lower symptoms of depression compared to those who did not.

Hypothesis#1b: Greater levels of physical activity in combination with greater classical music will result in greater associations with symptoms of depression compared to listening to classical music alone.

Specific Aim #2: To determine if lower symptoms of depression in older adults (50+) were maintained at 4 months (wave 2) and 12 months (wave 3) following the initial COVID-19 lockdown phase (wave 1) in those who listened to classical music during the initial lockdown and if additional benefits to managing symptoms of depression in those who also exercised were also preserved at 4m and 12m.

Hypothesis #2a: We hypothesize that older adults (50+) who listened to classical music during the initial lockdown will continue to have lower symptoms of depression at 4m and 12m compared to those who did not.

Hypothesis #2b: Greater levels of physical activity in combination with greater classical music will result in greater associations with symptoms of depression compared to listening to classical music alone will be preserved at 4m and 12m.

CHAPTER III: METHODS

Survey

Data were collected using an online Qualtrics survey. The initial survey consisted of 136 questions and was estimated to take approximately 15 minutes to complete. The 4-month and 12-month follow-up surveys consisted of 162 questions. The survey was approved by the University of Maryland Institutional Review Board, and written informed consent was obtained from all participants prior to proceeding with the survey. The surveys were advertised through social media to residents of the United States and Canada, and distributed to active adult communities, and other affiliates of the Exercise for Brain Health Laboratory. The initial survey included questions regarding demographic information, geographical location (zip code), current health status, questions related to music listening, and well-known and validated instruments such as the Physical Activity Scale for the Elderly (PASE), and the Geriatric Depression Scale (GDS). 1,409 individuals responded to the first survey in April 2020. At the end of the first survey, individuals had the option to provide their email address, if they were interested in participating in a follow-up survey. Five hundred and sixty individuals completed the 4-month follow-up survey, and a total of three hundred and sixty-six individuals completed the 12-month follow-up survey. The follow-up surveys were identical to the initial survey but had a few additional questions regarding music listening, faith, and additional questions related to covid-19.

Physical Activity Scale for the Elderly (PASE)

The Physical Activity Scale for the Elderly (PASE) is a widely used validated questionnaire used to assess physical activity over a 7-day period in older adults (Washburn et al., 1993). Participants are asked to provide information about the frequency (days/week) and duration (hours/day) of their participation in sedentary and active behavior. Originally designed to quantify and account for the intensity and type of active behaviors common in older adults, the survey includes activities such as walking outside, recreational aerobic (light, moderate, and vigorous) and strength exercise, yard work, gardening, house repairs, and caring for others. Each activity is scored based on the original Washburn et al scale in which the frequency and duration are used as anchors, the activity type is assigned an empirically derived weight (Washburn et al., 1993). Each activity type and their associated scores are then categorized into either leisure (walking outside and recreational exercise), or household (yard work, gardening, home repairs, and caring for others) physical activity, and the total PASE score represents the sum of these 2 categories.

Geriatric Depression Scale (GDS)

The Geriatric Depression Scale (GDS) is a well-established, tested, and validated measure used to assess depressive symptoms in older adults (Kurlowicz & Greenberg, 2007). The GDS represents a valid screening devise that is sensitive to depression among the elderly (Yesavage & Sheikh, 1986). The efficacy of GDS as an instrument

has been validated through research and clinical practice and was found to have a 92% sensitivity and an 89% specificity when evaluated against diagnostic criteria (Kurlowicz & Greenberg, 2007). The GDS is a 30-question scale using an objective "yes" or "no" response, focusing on psychiatric vs. somatic symptoms to assess levels of enjoyment, interests, and social interactions. Individuals respond to the questions based on how they have felt over the course of 7-days, prior to the day of testing. Of the 30-questions, 20 questions are given a point each, if answered positively. High cumulative scores indicate greater severity of depression. Scores are assessed for depression as follows: Normal (0-9), Mildly depressive (10-19), and Severe Depression (20-30).

Music Listening

Individuals were asked to respond to questions about music such as: "What genre of music do you listen to? (Choose from multiple genres)", and "Over the past month, I have listened to music (number of days)" on the initial survey. In the follow-up surveys, additional questions such as, "Have your music listening preferences changed during the pandemic", and "What genre of music have you listened to over the past month? (Choices of genres, and the ability to select all that apply)" were added.

Statistical Analyses

To test Aim 1, a mixed linear regression was conducted to determine the independent effects of classical music listening on GDS scores, while controlling for age, sex, and education (R^2_1). At the second step, the PASE score was added to this model

and regressed on GDS scores, while controlling for age, sex, and education, and classical music listening, to determine the independent effects of PA at baseline ($PASE_{BL}$) on depression symptoms (R^2_2) at baseline, beyond the variance explained by the covariates and classical music listening. A statistically significant ($p < .05$) change in R^2 at the second level of the regression will be used to determine if PA provided an independent benefit, with greater $PASE_{BL}$ hypothesized to be associated with lower depression scores at baseline.

To test Aim 2a, a mixed linear regression was first performed to determine whether classical music listening was significantly associated with changes in depression scores from **baseline to 4 months** (GDS_{4m}), while controlling for age, sex, and education, following the start of the COVID pandemic. In step 2, the PASE score at 4 months ($PASE_{4m}$) was added to the model and regressed on GDS change scores (GDS_{4m}), while controlling for age, sex, education, and classical music listening, to determine the independent effects of PA on depression symptoms (R^2_2), beyond the variance explained by the covariates and classical music listening. A statistically significant ($p < .05$) change in R^2 at the second level of the regression was used to determine if PA provided an independent benefit, with greater $PASE_{4m}$ hypothesized to be associated with less positive change in depression scores.

To test Aim 2b, a mixed linear regression was first performed to determine whether classical music listening was significantly associated with changes in depression scores from **baseline to 12 months** (GDS_{12m}), while controlling for age, sex, and education. At

step 2, the PASE score at 12 months ($PASE_{12m}$) was added to the model and regressed on GDS change score (GDS_{12m}), while controlling for age, sex, and education, and classical music listening, to determine the independent effects of PA on depression symptoms (R^2_2), beyond the variance explained by the covariates and classical music listening. A statistically significant ($p < .05$) change in R^2 at the second level of the regression was used to determine if PA provided an independent benefit, with greater $PASE_{12m}$ hypothesized to be associated with less positive change in depression scores.

Table 1: Sample size for all three time points

Time point	CML	No-CML	TOTAL
Wave 1 (baseline)	463	619	1082
Wave 2 (4m)	116	342	458
Wave 3 (12m)	89	230	319

Sensitivity analysis assuming the parameters of α =0.05 and a power of 0.95 produced the following outcomes:

Wave 1: Total sample(n=1082) effect size f^2 = 0.0143126 (small)

Wave 2: Total sample (n=458) effect size f^2 = 0.033942 (small)

Wave 3: Total sample (n=319) effect size f^2 = 0.0488738 (small)

F^2 effect size can be characterized as follows:

F^2 = 0.02 indicates a small effect

F^2 = 0.15 indicates a medium effect

F^2 = 0.35 indicates a large effect

Table 2: DSM Criteria for Major Depressive Disorder

Table 2- DSM 5 Criteria for major depressive disorder

	DSM-5		Changes from DSM-IV-TR
A	Five or more out of nine symptoms (including at least one of depressed mood and loss of interest or pleasure) in the same 2-week period. Each of these symptoms represents a change from previous functioning.		DSM-IV statement on not counting "mood-incongruent delusions and hallucinations" was removed from DSM-5.
		Frequency requirements:	
	1. Depressed mood (subjective or observed); can be irritable mood in children and adolescents	Most of the day, nearly every day	Subjective descriptors of depressed mood in DSM-IV included "sad or empty", in DSM-5 these include "sad, empty or hopeless".
	2. Loss of interest or pleasure	Most of the day, nearly every day	
	3. Change in weight or appetite	Appetite: Nearly every day Weight: 5% change over 1 month	
	4. Insomnia or hypersomnia	Nearly every day	
	5. Psychomotor retardation or agitation (observed)	Nearly every day	
	6. Loss of energy or fatigue	Nearly every day	
	7. Worthlessness or guilt	Nearly every day	
	8. Impaired concentration or indecisiveness	Nearly every day	
	9. Thoughts of death or suicidal ideation or attempt	Thoughts: recurrent Attempt: any	
B	Symptoms cause significant distress or impairment.		
C	Episode not attributable to a substance or medical condition.		
	Note 1: Criteria A–C represent a major depressive episode (MDE).		Criteria for an MDE and MDD were in separate tables of DSM-IV (with MDD referring to MDE), but are merged into a single list in DSM-5.
	Note 2: Clinical judgement is inevitably required to distinguish if MDE is present in addition to a normal response to a significant loss.		MDE criterion E of DSM-IV stating that "The symptoms are not better accounted for by bereavement" was removed from DSM-5 and replaced by Note 2.
D	Episode not better explained by a psychotic disorder.		
E	There has never been a manic or hypomanic episode.		
	Note 3: Exclusion E does not apply if (hypo)manic episode was substance induced or attributable to medical condition.		

*Diagnostic and Statistical Manual of Mental Disorders (DSM-5)

CHAPTER IV: RESULTS

Geriatric Depression Scale

Data were collected from adults (50+) who had responded to our online surveys generated in April 2020 (BL), August 2020 (4M), and April 2021 (12M) from the United States and Canada. The baseline data were collected from 1082 older adults, and of the participants with total GDS scores reported (n=875), 63% of the respondents (n=552) were categorized as being within the normal range, while 25% of the respondents (n=222) were categorized as being mildly depressed, and 12% (n=101), as being severely depressed. At the 4M timepoint, data were collected from 458 older adults, and of the total GDS scores reported (n=379), 66% of the respondents (n=249) were categorized as being within the normal range, while 25% (n=96) were categorized as experiencing mild depression, and 9% (n=34) were categorized as experiencing severe depression. The 12M data was collected from 319 respondents, and of total GDS scores reported (n=274), 68% (n=185) were categorized as being within the normal range, while 26% of respondents (n=72) were categorized as experiencing mild depression, and 6% (n=17) were categorized as experiencing severe depression (Table 3).

TABLE 3 – Geriatric Depression Scale

GDS	April 2020 (n=875)	Aug 2020 (n=379)	April 2021 (n=274)
Normal	63% (552)	66% (249)	68% (185)
Mild	25% (222)	25% (96)	26% (72)
Severe	12% (101)	9% (34)	6% (17)

Geriatric Depression Scale Categories: Normal (0-9), Mild (10-19), Severe (20-30).

Classical Music Listening

A Chi-squared goodness of fit test was conducted to observe the changes in the sample size between April 2020 and August 2020, and August 2020 and April 2021. Significant changes in the percentage of CML were observed between April 2020 and August 2020, X^2 (1, N=1540) =41.829, p<.001. No changes in the percentage of CML were observed between August 2020 and April 2021, X^2 (1, N=777) =0.641, p=0.424 (Table 4).

TABLE 4 - Demographics (age, sex, education), Geriatric Depression Scale (GDS), Classical Music Listening (CLM), Physical Activity Scale for the Elderly (PASE), and Music Listening Frequency (list-freq) at all three timepoints: April 2020, August 2020, and April 2021.

	APRIL 2020		AUGUST 2020		APRIL 2021	
	NO-CML	CML	NO-CML	CML	NO-CML	CML
TOTAL n(%)	619 (57.21%)	463 (42.79%)	342 (74.67%)	116 (25.33%)	230 (72.1%)	89 (27.9%)
AGE n (missing)	619 (0)	463 (0)	342(0)	116 (0)	230 (0)	89 (0)
4 (50-59)	211	104	76	32	40	15
5 (60-69)	260	175	135	46	93	34
6 (70-79)	118	140	105	29	78	33
7 (80-89)	28	41	25	9	17	7
8 (90+)	2	3	1	0	2	0
SEX MALE/FEMALE	M(126) F(492)	M(93) F(368)	M(78) F(263)	M(22) F(93)	M(53) F(177)	M(22) F(67)
n (missing)	618 (1)	461(2)	341 (1)	115 (1)	230 (0)	89 (0)
MEAN (SD)	0.796 (0.403)	0.798 (0.402)	0.771 (0.421)	0.809 (0.395)	0.770 (0.422)	0.753 (0.434)
EDU n (missing)	613 (6)	461(2)	341 (1)	115 (1)	230 (0)	89 (0)
MEAN (SD)	2.739 (1.213)	3.174(1.078)	3.100 (1.136)	3.148 (1.019)	3.204 (1.077)	3.258 (1.072)
0 -Some High School	9	3	4	0	0	1
1-High School Diploma	89	21	24	3	14	3
2 -Some College/AA Degree	178	103	72	31	46	17
3 -College Degree (BA/BS)	166	150	111	39	75	29
4-Graduate Degree	119	134	94	30	69	29
5 -Doctoral Degree	52	50	36	12	26	10
GDS n (missing)	452 (167)	423 (40)	276 (66)	103 (13)	197 (33)	77 (12)
MEAN (SD)	9.863 (7.667)	8.099 (6.517)	8.504 (6.979)	8.388 (6.234)	7.711 (6.160)	8.468 (6.555)
PASE n (missing)	619 (0)	463 (0)	342 (0)	116 (0)	230 (0)	89 (0)
MEAN (SD)	100.276 (67.948)	106.522 (58.658)	115.577 (65.720)	125.254 (63.958)	108.271 (59.793)	111.908 (53.091)
LIST-FREQ n (missing)	437 (182)	461 (2)	292 (50)	116 (0)	199 (31)	88 (1)
MEAN (SD)	2.492 (1.265)	2.662 (1.233)	2.428 (1.240)	2.914 (1.191)	2.503 (1.275)	2.545 (1.268)
1 (1-2 days)	144	118	97	21	67	27
2 (3-4 days)	84	100	64	24	34	18
3 (5-6 days)	59	63	40	15	29	11
4 (7 days)	150	180	91	56	69	32

Note: Significant changes in the percentage of CML observed between April 2020 and August 2020, X^2 (1, N=1540) =41.829, p<.001. No changes in the percentage of CML observed between August 2020 and April 2021, X^2 (1, N=777) =0.641, p=0.424.

April 2020 – COVID-19 Onset – Baseline (BL)

Geriatric Depression Scale and Classical Music Listening - April 2020 (Baseline)

We tested the association between classical music listening (CML) and symptoms of depression in older adults (50+) during the initial lockdown phase of COVID-19 in April 2020 (BL). We hypothesized that classical music listening will be associated with lower symptoms of depression. We used a linear regression model to determine the additional independent effect of CML on GDS scores at BL. A second model including the CML score along with all covariates (age, sex, and education), yielded a small, but statistically significant negative effect, and accounted for an additional 1.2% of the variance in the GDS scores when compared to a base model including only covariates (R^2_{change}=0.012, F_{change}=10.585, p=0.001) (Table 5, figure 1). Furthermore, when controlling for age, sex, and education, CML was negatively associated with GDS scores at BL (p=.001, β=-.112).

Figure 1: April 2020 (BL) Geriatric Depression Scale vs. Classical Music Listening

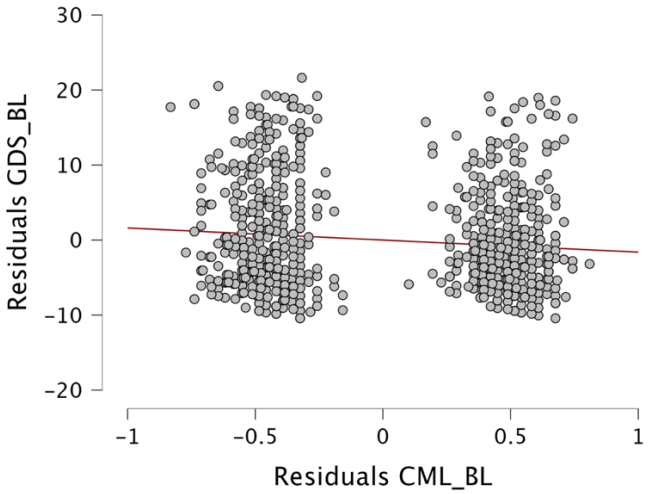


Table 5: Geriatric Depression Scale and Classical Music Listening- April 2020

Model Summary – Geriatric Depression Scale – April 2020

Model	R	R^2	Adjusted R^2	RMSE	R^2 Change	F Change	df1	df2	p
H_0	0.152	0.023	0.02	7.117	0.023	6.769	3	862	< .001
H_1	0.187	0.035	0.03	7.078	0.012	10.585	1	861	0.001

Note. Null model includes AGE_BL, SEX_BL, EDU_BL

Coefficients

							95% CI	
Model		Unstandardized	Standard Error	Standardized	t	p	Lower	Upper
H_0	(Intercept)	11.744	1.616		7.269	< .001	8.573	14.916
	AGE_BL	-0.596	0.265	-0.076	-2.25	0.025	-1.117	-0.076
	SEX_BL	1.827	0.6	0.103	3.043	0.002	0.649	3.005
	EDU_BL	-0.38	0.208	-0.062	-1.825	0.068	-0.789	0.029
H_1	(Intercept)	11.396	1.61		7.077	< .001	8.235	14.556
	AGE_BL	-0.446	0.268	-0.057	-1.666	0.096	-0.971	0.079
	SEX_BL	1.881	0.597	0.106	3.149	0.002	0.708	3.053
	EDU_BL	-0.273	0.21	-0.044	-1.3	0.194	-0.685	0.139
	CML_BL	-1.61	0.495	-0.112	-3.254	0.001	-2.581	-0.639

Geriatric Depression Scale, Classical Music Listening, and Physical Activity - April 2020 (Baseline)

Additionally, we tested the hypothesis that physical activity (reported using the Physical Activity Scale for the Elderly -PASE) explained additional variance above and beyond classical music listening in lowering symptoms of depression in April 2020 (BL). We hypothesized that physical activity would have a negative association with symptoms of depression. We used a linear regression model to determine the additional independent effect of PASE on GDS scores at BL. An additional model including PASE scores along with all covariates (age, sex, education, and CML), was statistically significant and accounted for additional variance (in GDS scores than the model with covariates and CML only) (R^2_{change}=0.045, F_{change}=41.805, $p<0.001$), accounting for an additional 4.5% of the variance in the GDS score (Table 6, Figure 2). Greater self-reported physical activity was negatively associated with GDS scores while controlling for CML, Age, Sex, and education ($p<.001$, β=-.112). Additionally, age and education were also negatively associated with GDS scores (see Table 6).

Table 6: Geriatric Depression Scale, Classical Music Listening, and Physical Activity Scale for the Elderly- April 2020

Model Summary - GDS_BL

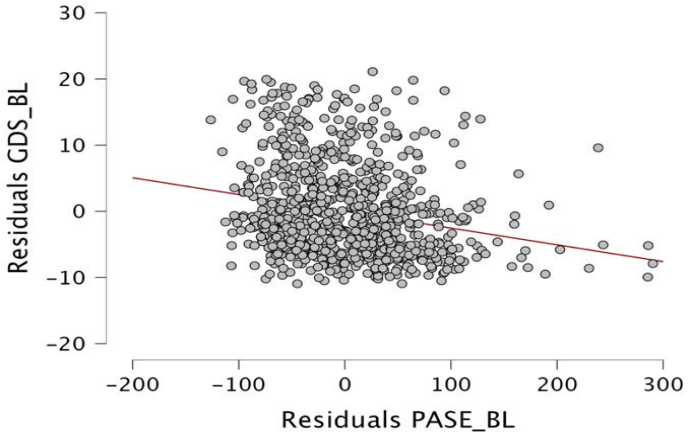
Model	R	R^2	Adjusted R^2	RMSE	R^2 Change	F Change	df1	df2	p
H_0	0.187	0.035	0.03	7.078	0.035	7.779	4	861	< .001
H_1	0.282	0.08	0.074	6.916	0.045	41.805	1	860	< .001

Note. Null model includes AGE_BL, SEX_BL, EDU_BL, CML_BL

Coefficients

							95% CI	
Model		Unstandardized	Standard Error	Standardized	t	p	Lower	Upper
H_0	(Intercept)	11.396	1.61		7.077	< .001	8.235	14.556
	AGE_BL	-0.446	0.268	-0.057	-1.666	0.096	-0.971	0.079
	SEX_BL	1.881	0.597	0.106	3.149	0.002	0.708	3.053
	EDU_BL	-0.273	0.21	-0.044	-1.3	0.194	-0.685	0.139
	CML_BL	-1.61	0.495	-0.112	-3.254	0.001	-2.581	-0.639
H_1	(Intercept)	16.168	1.738		9.303	< .001	12.757	19.58
	AGE_BL	-0.846	0.269	-0.108	-3.148	0.002	-1.373	-0.319
	SEX_BL	1.646	0.585	0.093	2.815	0.005	0.498	2.794
	EDU_BL	-0.206	0.205	-0.034	-1.004	0.316	-0.609	0.197
	CML_BL	-1.59	0.484	-0.111	-3.288	0.001	-2.539	-0.641
	PASE_BL	-0.025	0.004	-0.218	-6.466	< .001	-0.033	-0.018

Figure 2: Geriatric Depression Scale vs. Physical Activity Scale for the Elderly – April 2020



Geriatric Depression Scale, Classical Music Listening and Music Listening Frequency- April 2020 (Baseline)

An additional analysis was conducted to explore the association between music listening frequency (list-freq) and symptoms of depression in April 2020. Although this was not part of the initial hypothesis or aims of this study, the data accumulated led to the exploration of the additional analysis. A linear regression model was used to determine the independent effects of music listening frequency on GDS scores and was found to be statistically significant at BL (R^2_{change}=0.009, F_{change}=7.538, p=0.006), accounting for an additional 0.9% of variance in the GDS scores (Table 7, Figure 3). Music listening frequency was negatively associated with GDS scores at BL while controlling for CML, Age, Sex, and Education (p=.009, β=-.093).

Table 7: Geriatric Depression Scale, Classical Music Listening and Music Listening Frequency- April 2020 (Baseline)

Model Summary - GDS_BL

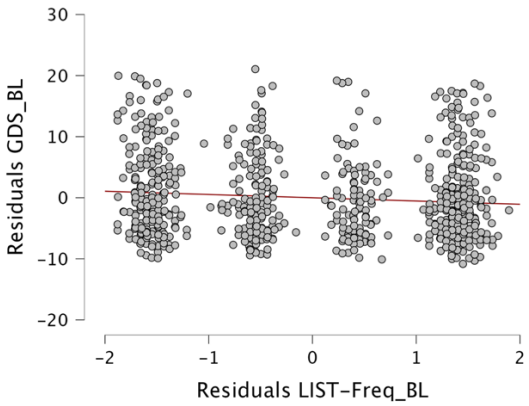
Model	R	R^2	Adjusted R^2	RMSE	R^2 Change	F Change	df1	df2	p
H_0	0.188	0.035	0.031	6.931	0.035	7.453	4	813	< .001
H_1	0.21	0.044	0.038	6.904	0.009	7.538	1	812	0.006

Note. Null model includes AGE_BL, SEX_BL, EDU_BL, CML_BL

Coefficients

							95% CI	
Model		Unstandardized	Standard Error	Standardized	t	p	Lower	Upper
H_0	(Intercept)	11.948	1.629		7.333	< .001	8.75	15.147
	AGE_BL	-0.522	0.273	-0.067	-1.91	0.056	-1.058	0.014
	SEX_BL	1.76	0.601	0.102	2.93	0.003	0.581	2.94
	EDU_BL	-0.399	0.212	-0.066	-1.878	0.061	-0.816	0.018
	CML_BL	-1.316	0.502	-0.093	-2.622	0.009	-2.301	-0.331
H_1	(Intercept)	13.582	1.729		7.857	< .001	10.189	16.975
	AGE_BL	-0.582	0.273	-0.075	-2.132	0.033	-1.117	-0.046
	SEX_BL	1.671	0.599	0.097	2.789	0.005	0.495	2.847
	EDU_BL	-0.371	0.212	-0.061	-1.751	0.08	-0.786	0.045
	CML_BL	-1.257	0.5	-0.089	-2.514	0.012	-2.239	-0.276
	LIST-Freq_BL	-0.534	0.194	-0.095	-2.745	0.006	-0.915	-0.152

Figure 3: Geriatric Depression Scale vs. Music Listening Frequency – April 2020



August 2020 – 4 Months After COVID-19 Onset (4M)

Geriatric Depression Scale and Classical Music Listening – August 2020 (4M)

In August 2020, approximately 4-months after the initial data collection, we collected data to determine if there was an inverse association between symptoms of depression and classical music listening. We hypothesized that greater classical music listening over the course of four months will contribute to an inverse association between classical music listening (CML) and symptoms of depression in older adults (50+). We used a linear regression model to determine the additional independent effect of CML on GDS scores at 4M. A second model including CML score along with all covariates (age, sex, and education), was not statistically significant at 4M (p=.664, β=-.022). (Table 8).

Table 8: Geriatric Depression Scale and Classical Music Listening – August 2020 (4M)

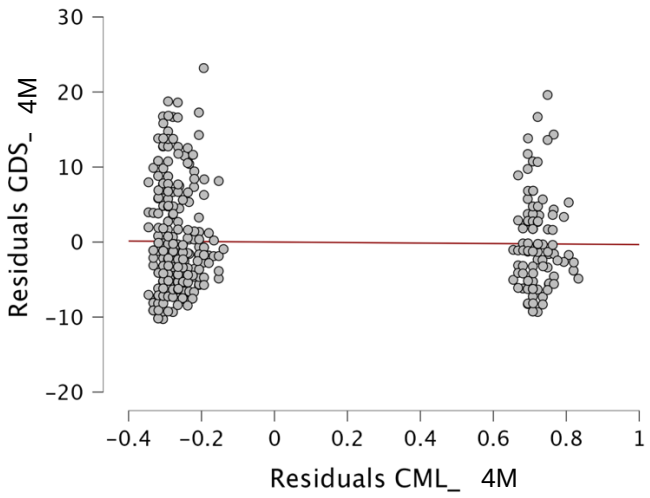
Model	R	R^2	Adjusted R^2	RMSE	R^2 Change	F Change	df1	df2	p
H_0	0.216	0.047	0.039	6.642	0.047	6.08	3	372	< .001
H_1	0.217	0.047	0.037	6.65	0	0.189	1	371	0.664

Note. Null model includes AGE_4M, SEX_6M, EDU_6M

Coefficients

							95% CI	
Model		Unstandardized	Standard Error	Standardized	t	p	Lower	Upper
H_0	(Intercept)	11.561	2.493		4.637	< .001	6.658	16.463
	AGE_4M	-0.935	0.398	-0.12	-2.35	0.019	-1.717	-0.153
	SEX_4M	2.591	0.832	0.16	3.113	0.002	0.955	4.227
	EDU_4M	-0.075	0.312	-0.012	-0.24	0.81	-0.688	0.538
H_1	(Intercept)	11.667	2.508		4.652	< .001	6.735	16.599
	AGE_4M	-0.944	0.399	-0.122	-2.367	0.018	-1.728	-0.16
	SEX_4M	2.615	0.835	0.162	3.132	0.002	0.973	4.256
	EDU_4M	-0.07	0.312	-0.011	-0.226	0.822	-0.684	0.543
	CML_4M	-0.337	0.775	-0.022	-0.434	0.664	-1.86	1.187

Figure 4: August 2020- Geriatric Depression Scale vs. Classical Music Listening



Geriatric Depression Scale, Classical Music Listening, and Physical Activity – August 2020 (4M)

Using the data collected in August 2020, we wanted to understand if there was a negative relationship between GDS scores and physical activity four months following the initial data collection. We hypothesized that greater classical music listening and greater physical activity over the course of four months will lead to a negative association between physical activity along with classical music listening (CML) and symptoms of depression in older adults (50+). We used a linear regression model to determine the additional independent effect of PASE & CML on GDS scores at 4M. An additional model including PASE scores along with all covariates (age, sex, education, and CML), was statistically significant and accounted for more variance (in GDS scores than the model with covariates and CML only) (R^2_{change}=0.072, F_{change}=30.261, $p<0.001$), accounting for an

additional 7.2% of the variance in the GDS score (Table 9, Figure 5). Greater self-reported physical activity was negatively associated with GDS scores while controlling for CML, age, sex, and education (p<.001, β=-.274). Additionally, age and sex were also negatively associated with lower GDS scores.

Figure 5: August 2020 - Geriatric Depression Scale vs. Physical Activity Scale for the Elderly

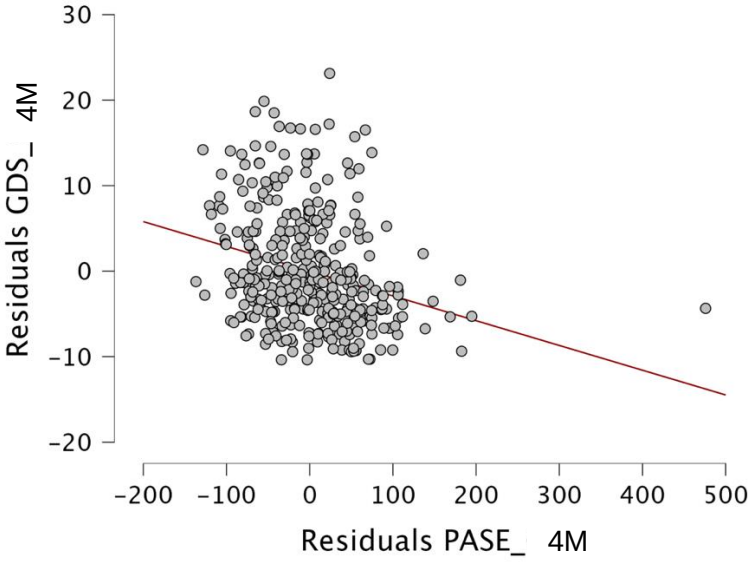


Table 9: Geriatric Depression Scale, Classical Music Listening, and Physical Activity - August 2020 (4M)

Model	R	R^2	Adjusted R^2	RMSE	R^2 Change	F Change	df1	df2	p
H_0	0.217	0.047	0.037	6.65	0.047	4.597	4	371	0.001
H_1	0.345	0.119	0.107	6.402	0.072	30.261	1	370	< .001

Note. Null model includes AGE_4M, SEX_4M, EDU_4M, CML_4M

Coefficients

							95% CI	
Model		Unstandardized	Standard Error	Standardized	t	p	Lower	Upper
H_0	(Intercept)	11.667	2.508		4.652	< .001	6.735	16.599
	AGE_4M	-0.944	0.399	-0.122	-2.367	0.018	-1.728	-0.16
	SEX_4M	2.615	0.835	0.162	3.132	0.002	0.973	4.256
	EDU_4M	-0.07	0.312	-0.011	-0.226	0.822	-0.684	0.543
	CML_4M	-0.337	0.775	-0.022	-0.434	0.664	-1.86	1.187
H_1	(Intercept)	17.481	2.636		6.632	< .001	12.298	22.664
	AGE_4M	-1.379	0.392	-0.178	-3.517	< .001	-2.149	-0.608
	SEX_4M	2.346	0.805	0.145	2.913	0.004	0.763	3.929
	EDU_4M	-0.032	0.301	-0.005	-0.107	0.915	-0.623	0.559
	CML_4M	-0.312	0.746	-0.02	-0.418	0.676	-1.779	1.155
	PASE_4M	-0.029	0.005	-0.274	-5.501	< .001	-0.039	-0.019

Geriatric Depression Scale, Classical Music Listening and Music Listening Frequency- August 2020 (4M)

The additional analysis conducted to explore the association between additional between music listening frequency (list-freq) and symptoms of depression in April 2020 was repeated in August 2020 to determine if there was a change in the direction of the association during the four-month period between April and August 2020. A linear regression model was used to understand the independent effects of music listening on GDS scores at 4M and no statistical significance was found (R^2_{change}=0, F_{change}=0.015, p=0.902), accounting for no additional variance in the GDS score, suggesting there was no association between music listening frequency and symptoms of depression (Table 10, Figure 6). Music listening frequency was negatively associated with GDS scores while controlling for CML, Age, Sex, and Education (p=.902, β=-.007).

Figure 6: 4M-Geriatric depression Scale vs. Listening Frequency

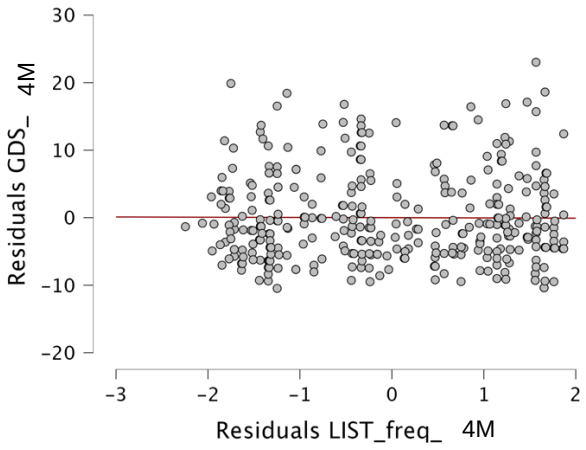


Table 10: Geriatric Depression Scale, Classical Music Listening and Music Listening Frequency- August 2020 (4M)

Model Summary - GDS_4M

Model	R	R^2	Adjusted R^2	RMSE	R^2 Change	F Change	df1	df2	p
H_0	0.22	0.049	0.038	6.642	0.049	4.507	4	353	0.001
H_1	0.221	0.049	0.035	6.651	0	0.015	1	352	0.902

Note. Null model includes AGE_4M, SEX_4M, EDU_4M, CML_4M

Coefficients

							95% CI	
Model		Unstandardized	Standard Error	Standardized	t	p	Lower	Upper
H_0	(Intercept)	12.009	2.533		4.742	< .001	7.028	16.99
	AGE_4M	-0.987	0.402	-0.129	-2.455	0.015	-1.777	-0.196
	SEX_4M	2.593	0.852	0.16	3.043	0.003	0.917	4.269
	EDU_4M	-0.094	0.316	-0.016	-0.298	0.766	-0.715	0.527
	CML_4M	-0.368	0.781	-0.025	-0.471	0.638	-1.905	1.169
H_1	(Intercept)	12.095	2.629		4.6	< .001	6.924	17.266
	AGE_4M	-0.987	0.402	-0.129	-2.453	0.015	-1.778	-0.196
	SEX_4M	2.582	0.858	0.16	3.011	0.003	0.896	4.269
	EDU_4M	-0.091	0.318	-0.015	-0.285	0.776	-0.715	0.534
	CML_4M	-0.349	0.797	-0.023	-0.438	0.662	-1.917	1.219
	LIST_freq_4M	-0.036	0.291	-0.007	-0.124	0.902	-0.609	0.537

April 2021 – 12 months After COVID-19 Onset (12M)

Geriatric Depression Scale and Classical Music Listening – April 2021 (12M)

Data were collected in April 2021, 12 months following the initial data collection, to determine if there were changes in the direction of the association between symptoms of depression and classical music listening from April 2020, and August 2020. We hypothesized that greater classical music listening over the course of twelve months may contribute to a negative association between classical music listening (CML) and symptoms of depression in older adults (50+) as seen in April 2020. We used a linear regression model to determine the additional independent effect of CML on GDS scores at 12M. A second model including the CML score along with all covariates (age, sex, and education), was not statistically significant, with a positive association with the GDS scores, and the additional variance was statistically insignificant when compared to a base model (Table 11, figure 7). Additionally, age and sex were also negatively associated with GDS scores.

Figure 7: 12M – Geriatric Depression Scale vs. Classical Music Listening

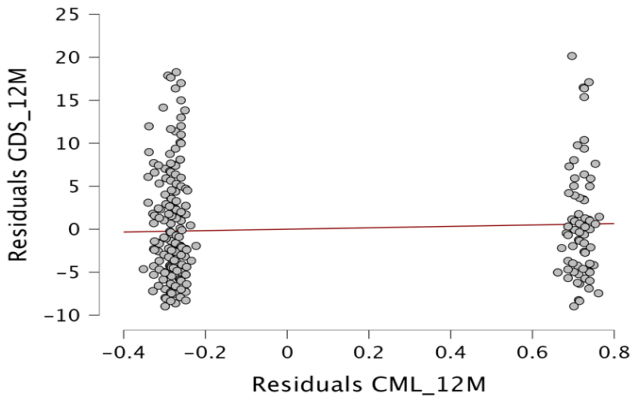


Table 11: Geriatric Depression Scale and Classical Music Listening -April 2021 (12M)

Model Summary - GDS_12M

Model	R	R^2	Adjusted R^2	RMSE	R^2 Change	F Change	df1	df2	p
H_0	0.179	0.032	0.021	6.204	0.032	2.962	3	270	0.033
H_1	0.188	0.035	0.021	6.205	0.003	0.971	1	269	0.325

Note. Null model includes AGE_12M, SEX_12M, EDU_12M

Coefficients

							95% CI	
Model		Unstandardized	Standard Error	Standardized	t	p	Lower	Upper
H_0	(Intercept)	10.492	2.816		3.726	< .001	4.948	16.036
	AGE_12M	-0.618	0.444	-0.084	-1.392	0.165	-1.492	0.256
	SEX_12M	2.048	0.911	0.136	2.248	0.025	0.254	3.842
	EDU_12M	-0.275	0.361	-0.046	-0.761	0.448	-0.986	0.436
H_1	(Intercept)	10.206	2.831		3.605	< .001	4.632	15.779
	AGE_12M	-0.607	0.444	-0.083	-1.366	0.173	-1.481	0.268
	SEX_12M	2.083	0.912	0.138	2.284	0.023	0.287	3.878
	EDU_12M	-0.284	0.361	-0.047	-0.787	0.432	-0.996	0.427
	CML_12M	0.823	0.835	0.059	0.985	0.325	-0.821	2.467

Geriatric Depression Scale, Classical Music Listening, and Physical Activity – April 2021 (12M)

Using the data collected in April 2021, we determined the relationship between GDS scores and physical activity 8 months following the August 2020 data collection and 12 months following the initial collection in April 2020. We hypothesized that greater classical music listening and greater physical activity over the course of 12 months would be associated with lower symptoms of depression in older adults (50+). We used a linear regression model to determine the independent effects of both PASE & CML on GDS scores at 12M. An additional model including PASE scores along with all covariates (age, sex, education, and CML), was statistically significant (in GDS scores than the model with covariates and CML only) (R^2_{change}=0.05, F_{change}=14.778, p<0.001), accounting for an additional 5% of variance in the GDS score (Table 12, figure 8). Similar to the August 2020 outcome, greater self-reported physical activity was negatively associated with GDS scores while controlling for CML, Age, Sex, and education (p<.001, β=-.231). Additionally, age and sex were also negatively associated with GDS scores.

Figure 8: April 2021 -Geriatric Depression Scale vs. Physical Activity Scale for the Elderly

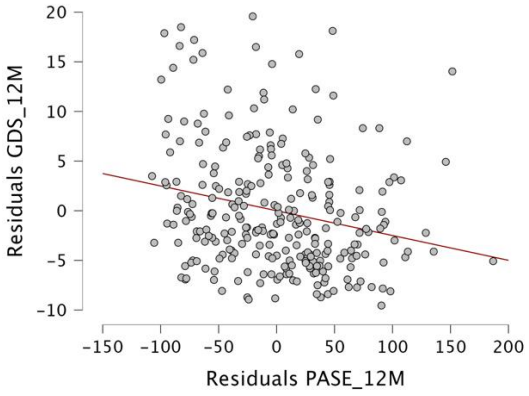


Table 12: Geriatric Depression Scale, Classical Music Listening, and Physical Activity – April 2021 (12M)

Model Summary - GDS_12M

Model	R	R^2	Adjusted R^2	RMSE	R^2 Change	F Change	df1	df2	p
H_0	0.188	0.035	0.021	6.205	0.035	2.464	4	269	0.045
H_1	0.293	0.086	0.069	6.052	0.05	14.778	1	268	< .001

Note. Null model includes AGE_12M, SEX_12M, EDU_12M, CML_12M

Coefficients

							95% CI	
Model		Unstandardized	Standard Error	Standardized	t	p	Lower	Upper
H_0	(Intercept)	10.206	2.831		3.605	< .001	4.632	15.779
	AGE_12M	-0.607	0.444	-0.083	-1.366	0.173	-1.481	0.268
	SEX_12M	2.083	0.912	0.138	2.284	0.023	0.287	3.878
	EDU_12M	-0.284	0.361	-0.047	-0.787	0.432	-0.996	0.427
	CML_12M	0.823	0.835	0.059	0.985	0.325	-0.821	2.467
H_1	(Intercept)	14.592	2.988		4.884	< .001	8.71	20.474
	AGE_12M	-0.966	0.443	-0.132	-2.181	0.03	-1.839	-0.094
	SEX_12M	1.969	0.89	0.131	2.213	0.028	0.217	3.721
	EDU_12M	-0.143	0.354	-0.024	-0.403	0.687	-0.841	0.555
	CML_12M	0.791	0.814	0.057	0.971	0.332	-0.812	2.395
	PASE_12M	-0.025	0.006	-0.231	-3.844	< .001	-0.038	-0.012

Geriatric Depression Scale, Classical Music Listening and Music Listening Frequency- April 2021 (12M)

Similar to April 2020 and August 2021 time points, a post hoc analysis was conducted to explore the direction of the association between additional music listening frequency (list-freq) and symptoms of depression. A linear regression model was used to understand the independent effects of music listening on GDS scores at 12M and no statistical significance was found (R^2_{change}=0.003, F_{change}=0.764, p=0.383), accounting for no additional variance in the GDS score (Table 13, Figure 9). There was no association with GDS scores while controlling for CML, Age, Sex, and Education (p=.383, β=-.054). However, the variables age and sex maintained a negative association with GDS scores when controlled for CML and music listening frequency.

Figure 9: April 2021- Geriatric Depression Scale vs. Music Listening Frequency

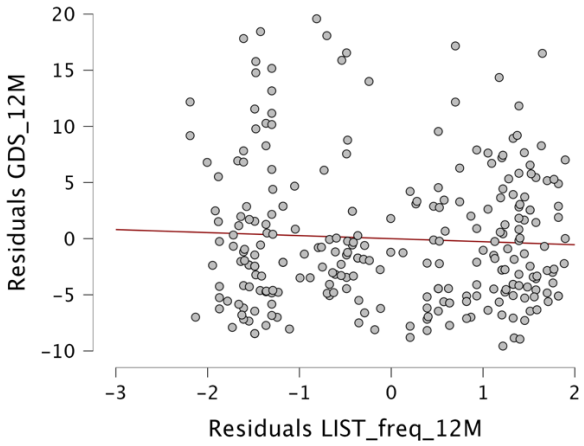


Table 13: Geriatric Depression Scale, Classical Music Listening and Music Listening Frequency- April 2021 (12M)

Model	R	R^2	Adjusted R^2	RMSE	R^2 Change	F Change	df1	df2	p
H_0	0.186	0.035	0.02	6.257	0.035	2.331	4	260	0.056
H_1	0.194	0.037	0.019	6.259	0.003	0.764	1	259	0.383

Note. Null model includes AGE_12M, SEX_12M, EDU_12M, CML_12M

Coefficients

							95% CI	
Model		Unstandardized	Standard Error	Standardized	t	p	Lower	Upper
H_0	(Intercept)	10.284	2.915		3.527	< .001	4.543	16.025
	AGE_12M	-0.617	0.46	-0.083	-1.342	0.181	-1.524	0.289
	SEX_12M	2.079	0.93	0.138	2.235	0.026	0.247	3.911
	EDU_12M	-0.274	0.372	-0.045	-0.737	0.462	-1.008	0.459
	CML_12M	0.771	0.847	0.055	0.91	0.364	-0.898	2.44
H_1	(Intercept)	11.23	3.111		3.61	< .001	5.104	17.357
	AGE_12M	-0.667	0.464	-0.089	-1.439	0.151	-1.581	0.246
	SEX_12M	1.955	0.941	0.13	2.076	0.039	0.101	3.809
	EDU_12M	-0.241	0.374	-0.04	-0.645	0.52	-0.979	0.496
	CML_12M	0.768	0.848	0.055	0.906	0.366	-0.901	2.437
	LIST_freq_12M	-0.27	0.309	-0.054	-0.874	0.383	-0.878	0.338

CHAPTER V: DISCUSSION

Our findings from the April 2020 data (BL) demonstrate that CLM was associated with lower symptoms of depression, independent of the effects of age and sex. Additionally, physical activity was also independently associated with lower symptoms of depression. Music listening frequency was also independently associated with lower symptoms of depression, and the associations were statistically significant. Additionally, the covariates age and sex also had a negative association with symptoms of depression. The data from August 2020 (4M) demonstrate that there was no association between CLM and symptoms of depression. Physical Activity retained its negative association with symptoms of depression with independent effects that were statistically significant at 4M. Music listening frequency did not have an association with symptoms of depression in August 2020 (4M). Age and sex retained a negative association with symptoms of depression. In April 2021 at the 12m timepoint, CLM was not associated with lower symptoms of depression. Greater levels of physical activity remained associated with lower symptoms of depression, and music listening frequency did not have an association with lower symptoms of depression. Age and sex continued to have a negative association with symptoms of depression.

Geriatric Depression Scale and Classical Music Listening

This may be one of the first cross-sectional studies to understand the impact of classical music listening on symptoms of depression during the initial stages of COVID-19. Music listening can be characterized as a form of self-regulation that can be

intentional or unintentional, adaptive or dysfunctional, allowing its listeners the unique ability to reach certain emotional goals (Randall et al., 2014). Given the powerful impact of music on emotion, the primary aim of this study was to understand if listening to classical music, specifically, could help mitigate the depressive symptoms associated with the COVID-19 pandemic restrictions and lock-down protocols in April 2020. Although literature supporting the efficacy of listening to classical music in attenuating symptoms of depression is very limited, existing research supports the positive impact music can have in alleviating symptoms related to psychological and mental disorders such as depression (Chan et al., 2011). A multi-national (USA, UK, India, and Italy) study explored the role of multi-genre music listening (including classical music, but not limited to) played in regulating mood and emotion during the COVID-19 pandemic (Hennessy et al., 2021). Between April 6 and 7, 2020, an online survey was generated and included questions that explored individual differences and the functions of music that can regulate symptoms of depression and anxiety, changes in music listening habits, and music and mood regulation based on the country of residence and the associated levels of the severity of the COVID-19 pandemic and restrictions. They used the Patient Health Questionnaire (PHQ; Kroenke et al., 2001): a brief instrument that measures 134 symptoms/severity of depression, and the Brief Music and Mood Questionnaire (a 21-item self-report instrument for assessing the use of seven music-related mood regulation strategies: entertainment, strong sensation, revival, diversion, mental work, discharge, and solace (Hennessy et al., 2021). To evaluate the changes in the habits related to music listening preferences during the pandemic, they utilized the data they had obtained to create digital playlists containing the songs respondents had reported listening to pre-

COVID and during COVID and utilized a Python Library to access auditory features from the songs, and extracted the following features from each song: The acoustic and rhythmical nature of the song, energy, valence, tempo, dynamics, mode. Additionally, they used the MacArthur Scale of Subjective Status to obtain information about socioeconomic status, and history of musical training experience. They incentivized their participants by offering some small monetary gifts, while others were entered in a draw to win gift cards (Hennessy et al., 2021). Similar to our findings, they found a correlation between music listening and lower symptoms of depression while controlling for age, sex and education at the initial onset of the pandemic in 2020 (Hennessy et al., 2021). They also found that individuals who were more depressed and didn't listen to music, reported feeling worse since the start of the pandemic compared to those who were depressed and reported listening to music (Hennessy et al., 2021). This may potentially explain why an association was not found between classical music listening and GDS scores in our analyses of the responses from the data collected in August 2020 and April 2021. As reported by Hennessy et al., (2021), those who sought out music listening during the initial survey in April 2020 may not have participated in the follow-up survey as a result of improved mood/lower symptoms of depression. Additionally, it should be noted that most literature looked at music listening as a whole, instead of separating independent effects by genre, while our study focused on the specific genre of classical music listening versus general music listening. The statistically significant association between classical music listening and lower symptoms of depression during the initial onset of the pandemic in April 2020 suggests that although music listening, in general, is associated with lowering symptoms of depression, classical music listening as a specific genre has greater

associations with lower symptoms of depression given the significant independent effects when compared to general music listening, and this significant relationship was also found when controlling for music listening frequency. It is important to note that although our 4M and 12M findings did not support our hypotheses that greater classical music listening over the course of 4 months and 12 months following the initial lockdown could lead to a positive association between CLM and lower scores of depression, no other study thus far has published any findings of a similar nature. Our goodness of fit test did suggest a significant reduction in the number of participants who completed the survey at the 4M and 12M time points. The lower numbers in participation may have been a result of lesser COVID-19 restrictions in the 4M and 12M time points in various parts of the United States and Canada. As restrictions were lifted, listening CML may not have been a priority as pre-lockdown activities slowly started to resume and time and schedule restrictions may have prohibited those who listened to CML during the initial lockdown in April 2020 from investing time in CML. As the rigidity of COVID-19 restrictions and protocols were lifted in August 2020 and April 2021 in the United States and Canada, people slowly adapted to their “new normal” lives. The acceptance of the “new normal” may have led to lower levels of concern, anxiety, and symptoms of depression as there was an increase in social interaction and family interaction. This may have impacted the quantity and quality of classical music listening and maybe a reason why our study did not find an association between classical music listening and lower symptoms of depression at the 4-month and 12-month time points. Moreover, it should be noted that our study did not collect data on previous music-listening experience to use as a baseline to measure the changes in CML.

Symptoms of Depression and Physical Activity

Our study found a strong association between self-reported physical activity and lower symptoms of depression at baseline, 4M and 12M, corroborating previous research about the benefits of physical activity and exercise on the mental and physical health of older adults. The statistically significant independent effects of physical activity in lowering symptoms of depression while controlling for age, education and CML across all three timepoints, supports our hypothesis that the strong associations between physical activity and lower symptoms of depression are retained throughout the 1-year period of data collection. This is perhaps one of the first studies to explore the long-term effects of physical activity during COVID-19 in participants aged 50+. A similar cross-sectional study during the initial onset of COVID-19 utilized the PASE and GDS and Geriatric Anxiety Scale (GAS) through an online survey to understand the effects of physical activity on mental health and found strong associations between physical activity and lower symptoms of depression in older adults (50+) (Callow et al., 2020). They found that greater physical activity was strongly associated with lower symptoms of depression (Callow et al., 2020). Another study during the pandemic explored the importance of physical activity related to mental health, and the difference in physical activity levels between the pre-pandemic and physical distancing and found that those who managed to maintain their physical activity levels reported lower depression and anxiety symptoms (Puccinelli et al., 2021). The role of physical activity and exercise in attenuating symptoms of depression is well established in literature. A survey by De Mello et al., (2013) aimed at studying the benefits of exercise mitigating symptoms of depression. The survey included the Beck Depression Inventory, a well-established and validated measure of

depression along with two questions designed to evaluate and classify physical activity and collected data from 1042+ adults. They found that participants who did not engage in physical activity were twice as likely to exhibit symptoms of depression than those who engaged in regular physical activity (De Mello et al., 2013). Much like the previous studies, our findings support the strong association in the literature between greater levels of physical activity and lower symptoms of depression.

Symptoms of Depression and Music Listening Frequency

Although looking at the association between music listening frequency and lower symptoms of depression was not part of the original aims of this study, we wanted to ascertain the existence of a potential relationship as literature in this area is limited. It is important to note that listening frequency was not measured based on specific genres but more generally, inclusive of all types of music. Our analysis found a significant association between music listening frequency and symptoms of depression in the April 2020 data. A systematic review that included 17 studies looking at the effectiveness of music listening in reducing depressive symptoms in adults, utilized the Geriatric Depression Scale and the Beck Depression Inventory to assess symptoms of depression and found no statistical significance between daily and weekly music listening (Chan et al., 2010). They found that music listening frequency was not linked to the efficacy of music listening in reducing symptoms of depression, but music listening was effective in reducing symptoms of depression (Chan et al., 2010). Although this does not support our findings from April

2020 that music listening frequency did have a significant relationship with lower symptoms of depression, it does support our subsequent findings from August 2020 and April 2021 that music listening frequency did not have a statistically significant effect in ameliorating symptoms of depression. We did not collect any data on previous music listening frequency and therefore did not have a baseline model with which to compare our results. Additionally, there may have been an error in reporting music listening frequency as people don't always accurately quantify music listening; some may have reported active music listening while others may have approximated music they heard in the background. It is important to note that Physical activity maintained its statistically significant association with lower symptoms of depression at all three timepoints, and age and sex also retained a negative association with symptoms of depression at all three timepoints.

Age and Depression

A study that explored the association between age and depression, found that middle-aged adults (30-59) had the lowest depression scores and there was an upward trajectory in the depression scores of older adults 60+. Additionally, they found that the scores were twice as high in those ages 70+ (Mirowsky & Ross, 1992). It is suggested that the increase in the prevalence of depression in the elderly may be attributed to changes in economic status, widowhood, decline in physical abilities, and decreased quality of life (Mirowsky & Ross, 1992). We found a significant association between age and lower symptoms of depression during the initial onset of the pandemic in April 2020, August 2020, and April 2021. Older adults in our study had lower symptoms of

depression. In a study looking at depression in older adults ages 60+ during the COVID-19 pandemic, Das et al., (2021) found that depression levels were lower in older adults in spite of the increased risk of contracting COVID-19 given the presence of diabetes and hypertension among the participants. Socio economic status and family care and support may have been contributing factors to lower symptoms of depression (Das et al., 2021). In a longitudinal study looking at the emotional distress and long-term psychological impact of older adults in Spain, López et al., (2022) used a stress process model developed by Lazarus and Folkman that looked at inter-related conditions that can lead to stress. Coping styles along with available resources typically shape stress experienced by older adults, particularly in difficult situations like the COVID-19 pandemic (López et al., 2022). This model, known as the FRAG model, and looks at Family functioning, Resilience, Acceptance, and Gratitude as variables that can help manage stress (López et al., 2022). Their survey was digitally distributed in April 2020, and at two subsequent time points 3 and 9 months following the initial survey. They used the Hospital Anxiety and Depression Scale to measure anxiety and depression and found that older adults did not experience higher emotional distress during all three time points and their depression remained stable through the duration of the study (López et al., 2022). Their findings are in line with our findings in relation to depression in older adults, as age was inversely associated with symptoms of depression. Although their sample size was smaller than ours (n=192), yet similar with regard to sex as the majority of their participants were female. Our findings didn’t support previous studies but are in line with the findings of Das et al., (2021) and López et al., (2022) that during the COVID-19 pandemic, older people experienced lower symptoms of depression.

Sex and Depression

Our data found a significant association between women and symptoms of depression at all three time points during the CODID-19 pandemic. Depression affects women twice as much as it does men(Kuehner, 2017). Although the reason behind this is not well established, sex hormones, increased levels of body shame, low self-esteem, and childhood trauma such as sexual abuse may be linked with a higher prevalence of depression in women compared to men (Riecher-Rössler, 2017). Additionally, socioeconomic status and inequality in the workplace may also be contributing factors to higher incidence of depression in women (Nolen-Hoeksema & Keita, 2003). Given the multi-faceted links between women and depression, multi-focal treatment plans may need to be established to treat depression. Incorporating non-traditional treatments such as physical activity and classical music listening can help manage symptoms and potentially help lower the severity of the illness.

Strengths and Limitations

Although numerous studies have looked at the impact of physical activity and/or music listening in attenuating symptoms of depression during the COVID-19 pandemic, this may be the first, and perhaps the only study to explore *classical* music listening, physical activity, and music listening frequency over the course of 12 months during the pandemic. The independent effects of classical music listening during the initial onset of

the pandemic in 2020, the independent effects of physical activity in lowering symptoms of depression at three-time points, and the independent effects of music listening frequency in lowering symptoms of depression in April 2020 can be considered strengths of this cross-sectional study. Additionally, this is one of the few studies that collected data over the span of the first year of the COVID-19 pandemic. Also, the associations between the covariates, age and sex, with depression can also be characterized as a strength of this study. We do need to acknowledge some weaknesses of this study as well. Firstly, this study did not use a validated instrument to collect data pertaining to music listening. Using a validated instrument could have provided more accurate results. Secondly, we did not collect any data on our participants' music listening history and therefore were unaware of the changes in music listening that may have taken place during the initial stages of the COVID-19 lockdown. The same is true for physical activity as we did not have the history of our participants' physical activity habits prior to April 2020 in order to determine if the levels of physical activity were curtailed because of the lockdown measures that were in place at the onset of the pandemic. The initial survey was completed within a few weeks of the global pandemic lockdown. As such, the response rate was high compared to the follow-up response rates. The GDS assesses symptoms of depression and is not a diagnostic tool for a clinical diagnosis of depression. Since data was not collected on past diagnoses of depression, an existing diagnosis of depression (at baseline) may have potentially impacted the outcome of the analysis. Also, there can be variability associated with the self-reported responses about listening to classical music, engaging in physical activity, and music listening frequency. Our study did not explore the socialization aspects of our respondents at any of the time points. Given that

our study collected data from all over the United States, and Canada, there was a considerable amount of variability with COVID-19 restrictions within counties and states in the United States, boroughs, and provinces in Canada. As such, there was a marked difference in the amount of isolation and social interaction experienced by older adults who participated in this study. Increased social interactions may have potentially impacted music listening in general, including classical music listening and music listening frequency. We did not control for symptoms of depression based on social interaction at each of the time points and peoples' changes in social interactions may have been a contributing factor to the outcome of the data we collected at the 4M and 12M time points. Most importantly, our findings at the initial time point did have a statistically significant effect in mitigating symptoms of depression as a result of listening to classical music. Also, at all three-time points, age, and sex were associated with lower symptoms of depression. Interestingly, education which is often used as a proxy to measure important outcomes did not have an association with classical music listening, physical activity, or music listening frequency in all three-time points of our study. Older adults were more adept at dealing with the emotional distress of Covid-19 (López et al., 2022), and this may have been the reason why education did not play a pivotal role in impacting the outcome of classical music listening, physical activity, and music listening frequency during the COVID-19 pandemic.

Conclusions

The results from this cross-sectional study support the well-established associations between physical activity and lower symptoms of depression over a 12-

month period. Although there was a correlation between classical music listening and lower symptoms of depression, and music listening frequency and lower symptoms of depression at the initial time point in April 2020, the subsequent time points did not have a statistically significant association between classical music listening and lower symptoms of depression, and music listening frequency and lower symptoms of depression. Our study was successful in identifying the independent effects of classical music listening in lowering symptoms of depression, especially during the initial onset of the pandemic. This suggests that listening to classical music and/or engaging in physical activity can potentially to be a simple, cost-effective way to help manage feelings of despair, fear, and other symptoms of depression, associated with stressful events much like the COVID-19 pandemic. Incorporating either classical music listening or physical activity, or both into daily lifestyle can help regulate mood and affect, particularly in older adults, and reduce the need for medications which are often costly and can have severe side effects. Additionally, it can equip people with a coping strategy to combat unanticipated life events without having to depend on medications.

Future Directions

The effects of COVID-19 pandemic are likely to reverberate in our thoughts for years to come and have hopefully prepared global citizens to anticipate similar unexpected situations. The outcome from studies such as ours can help people learn to incorporate healthy habits into their lifestyles to manage symptoms of depression. Follow-up studies with validated measures looking at the associations between specific genres of music listening and physical activity in ameliorating symptoms of depression can

provide insights into pre-emptive measures that can be incorporated into the daily lifestyles of older adults to help cope with triggers that can lead to depression. This can help reduce the dependency on pharmacotherapy, which can reduce financial burdens associated with costly medical treatments and help maintain emotional balance and well-being in older adults.

Appendices

Appendix 1

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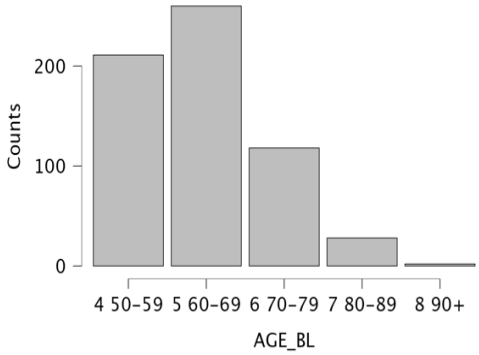

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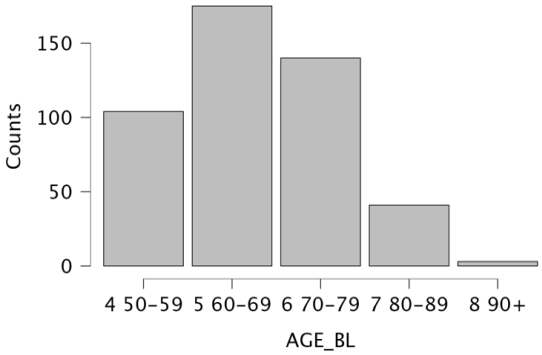

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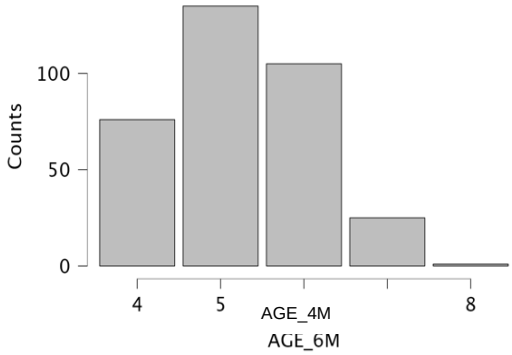

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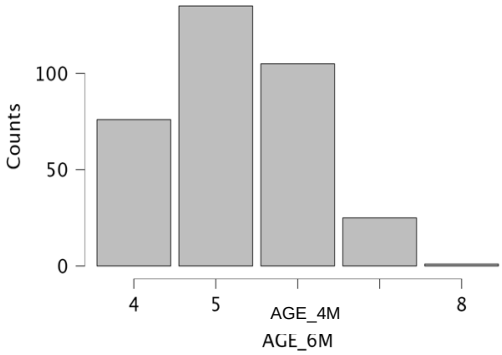

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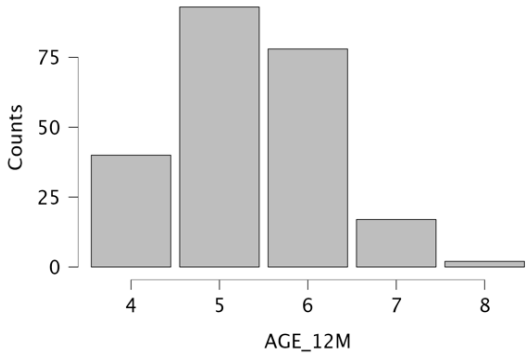

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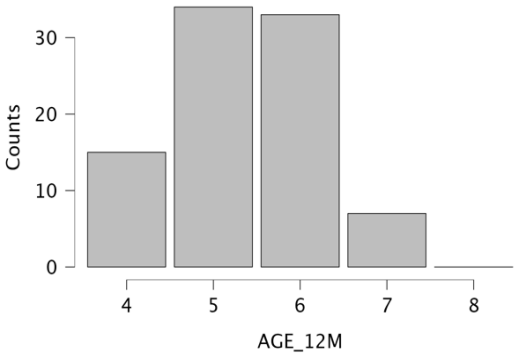

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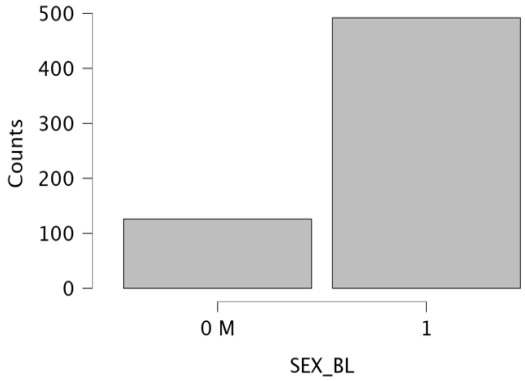

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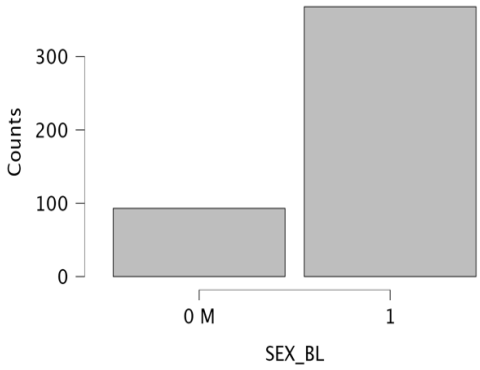

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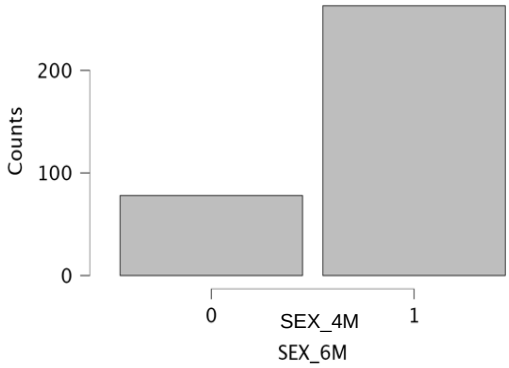

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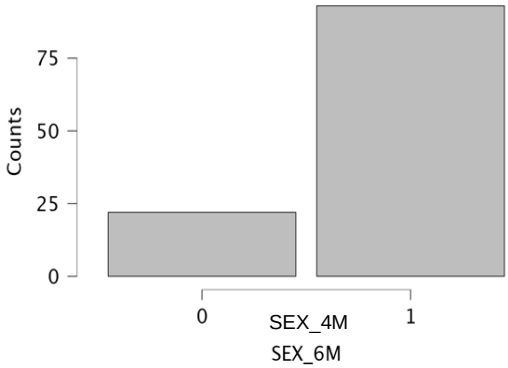

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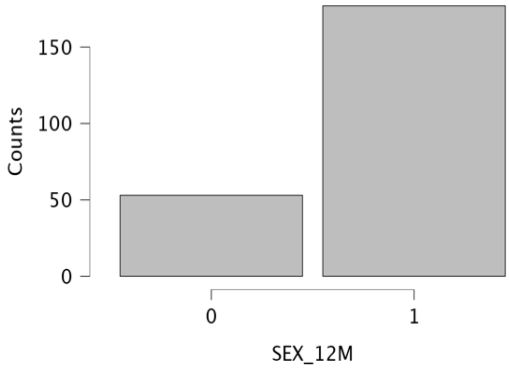

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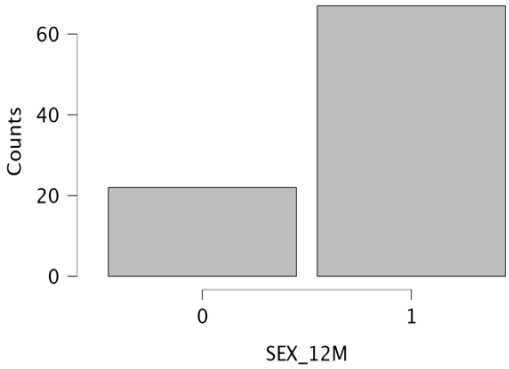

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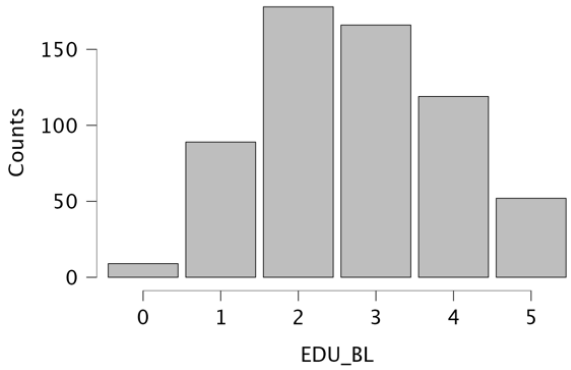

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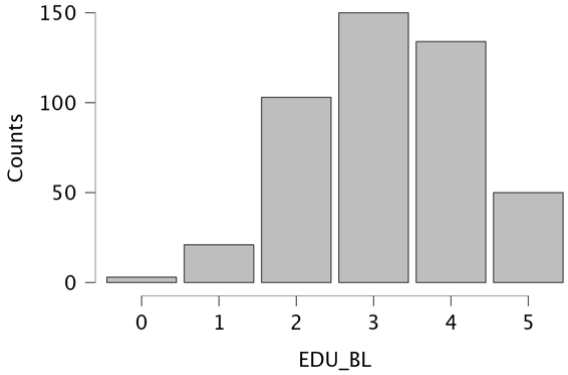

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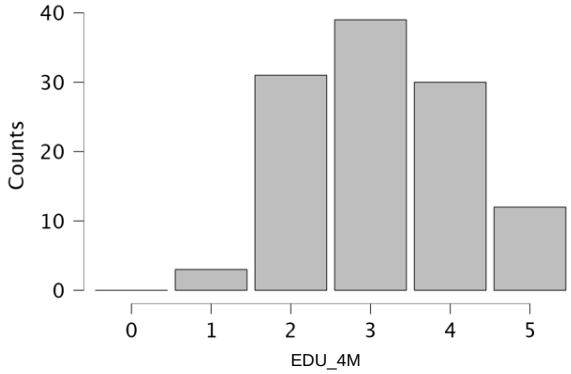

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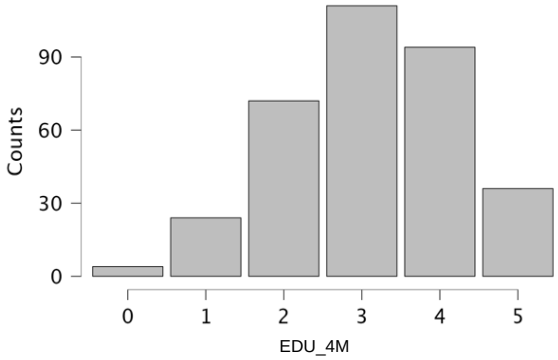

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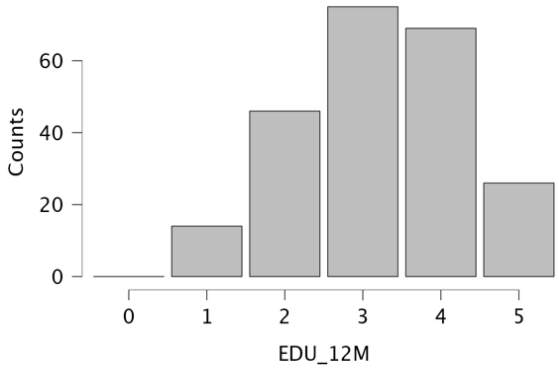

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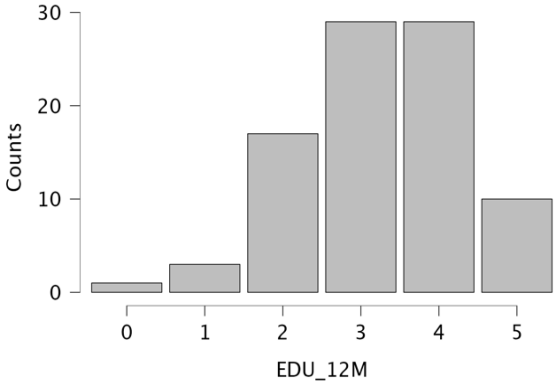

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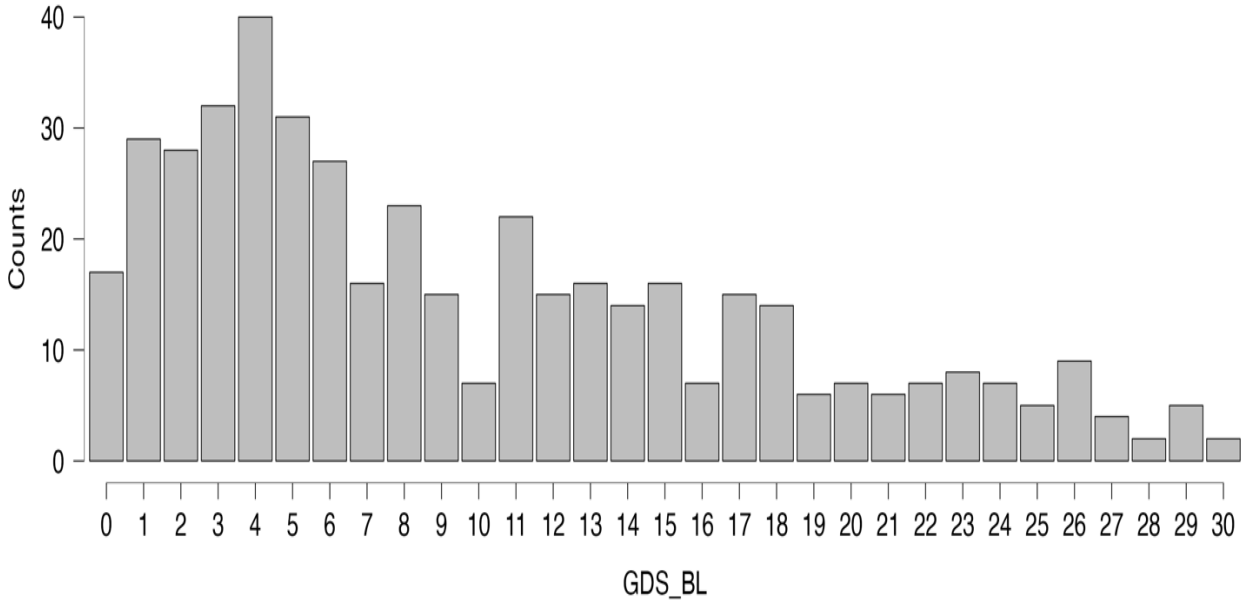

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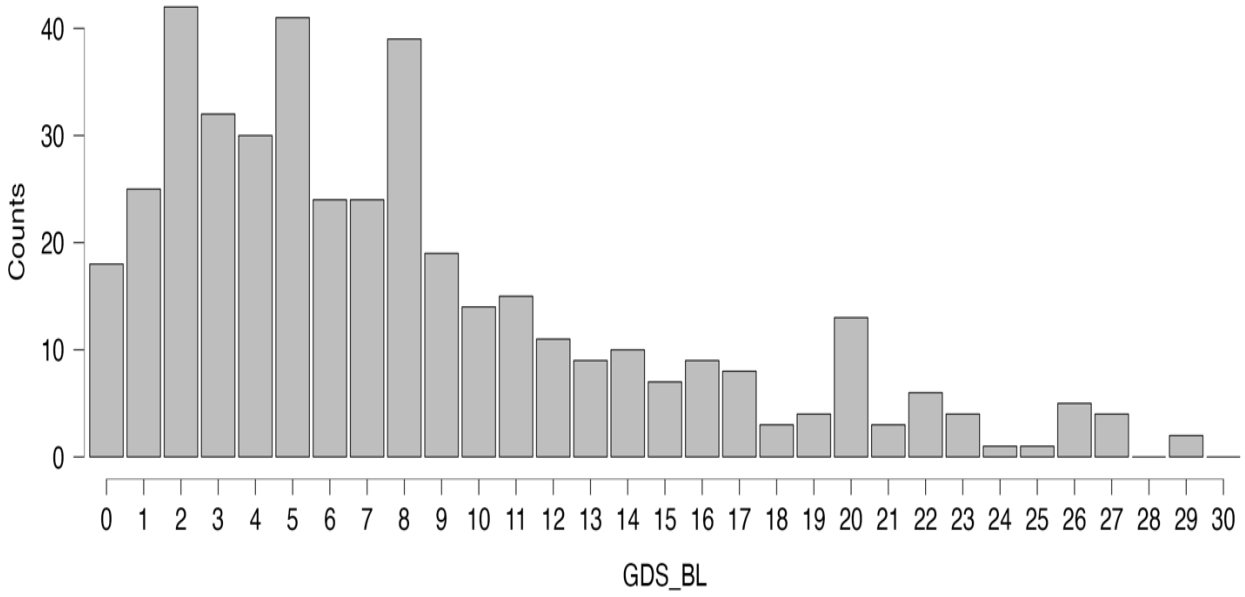

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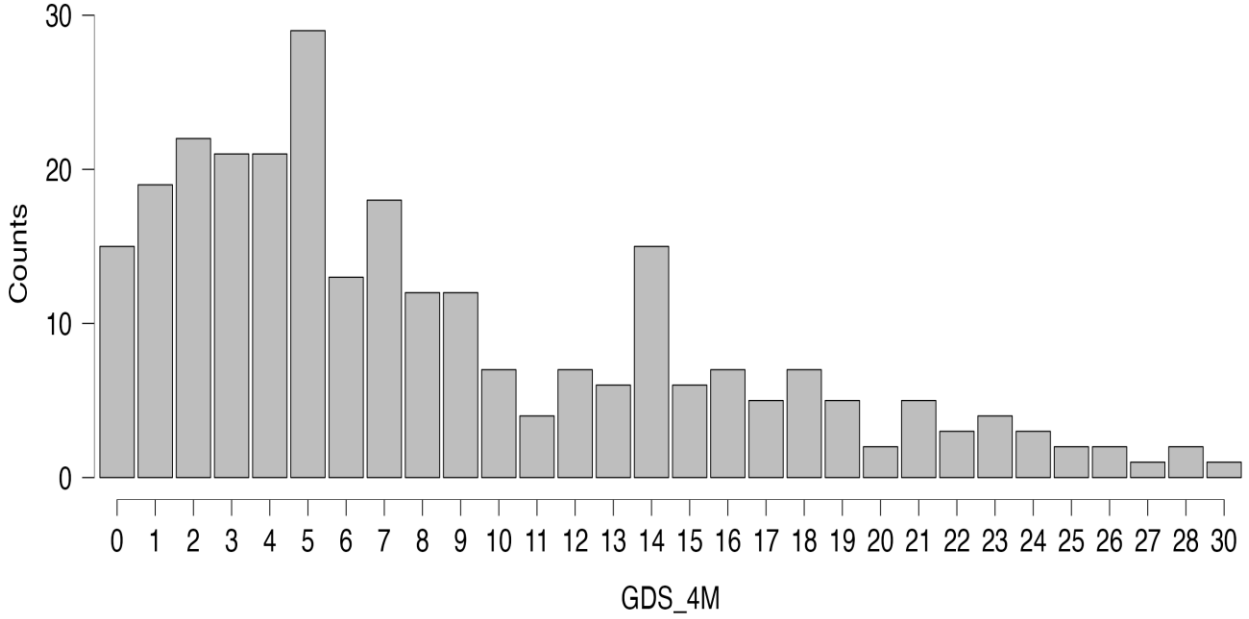

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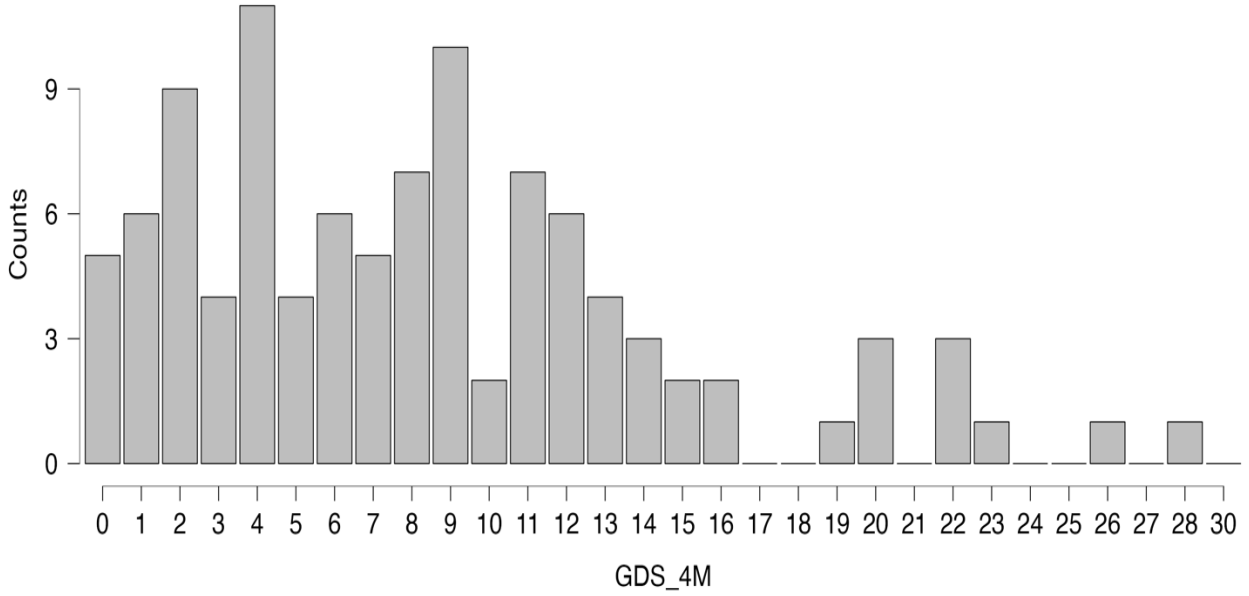

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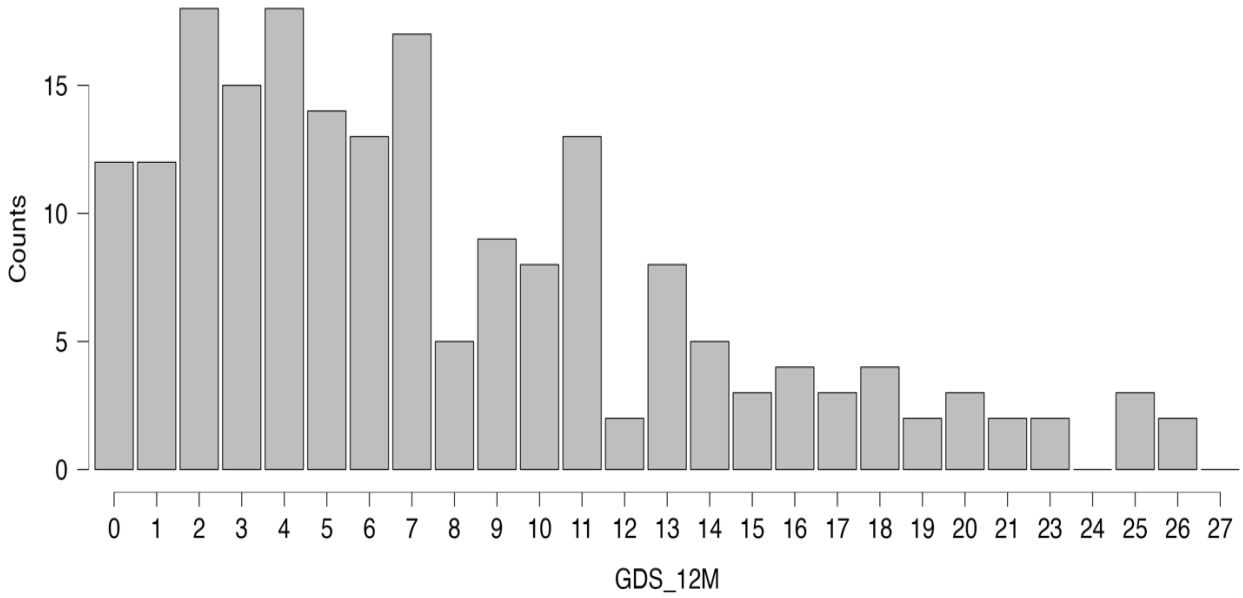

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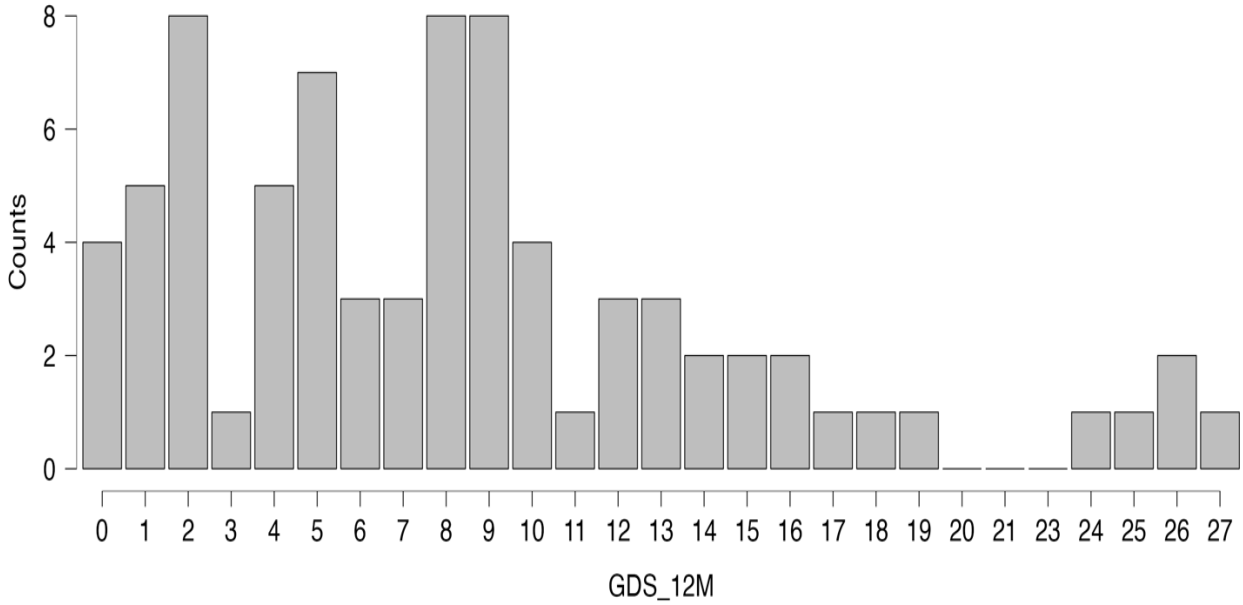

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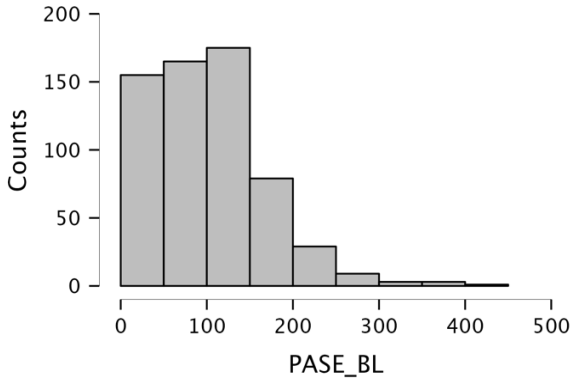

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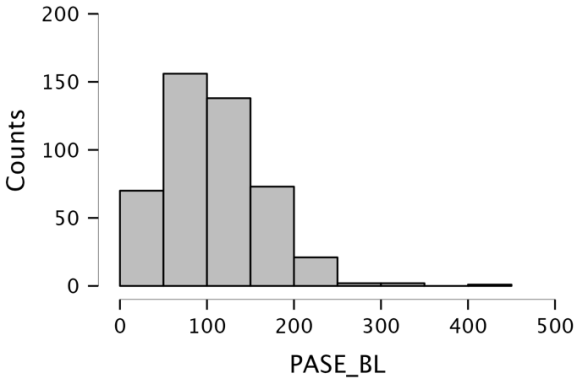

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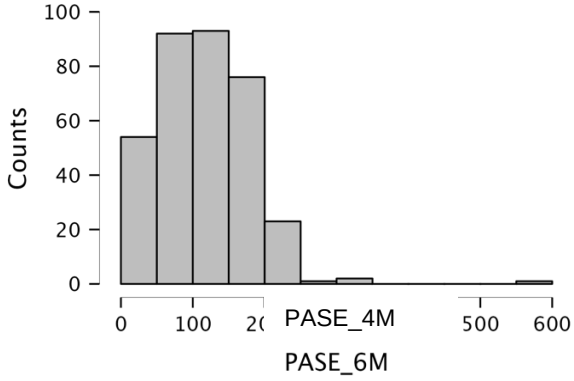

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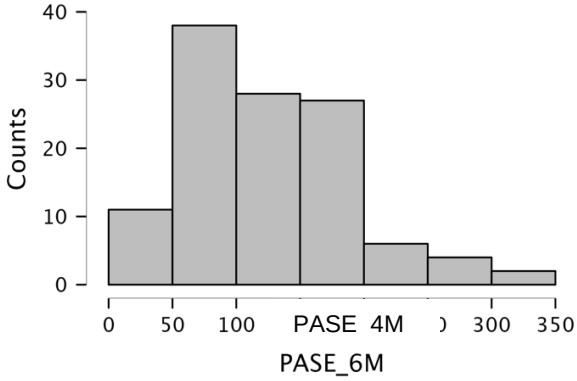

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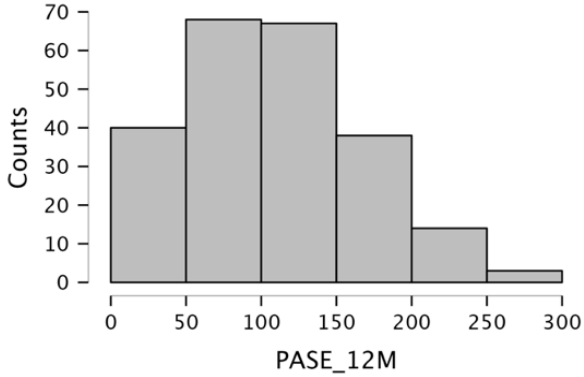

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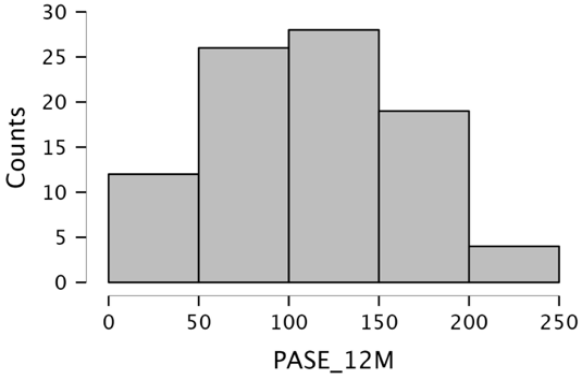

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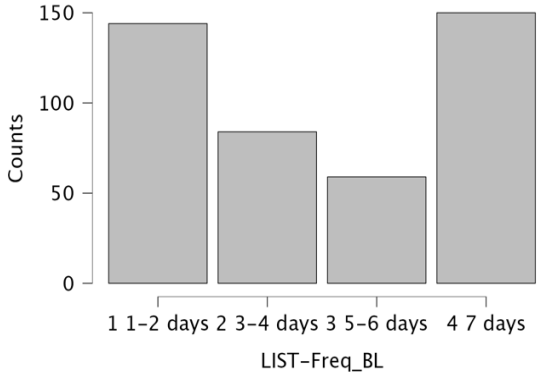

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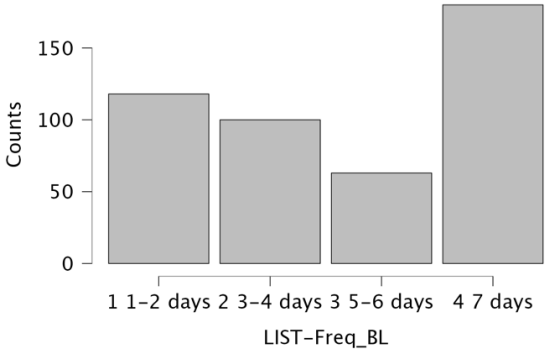

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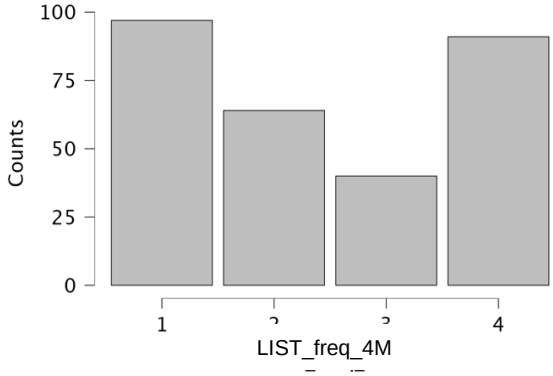

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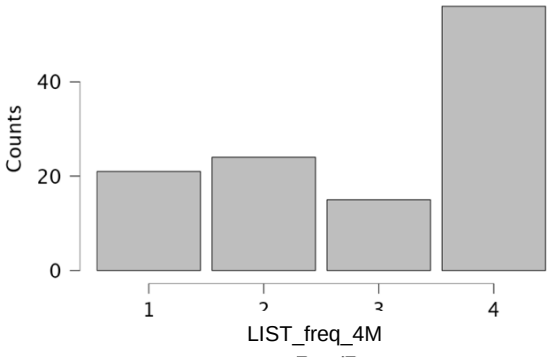

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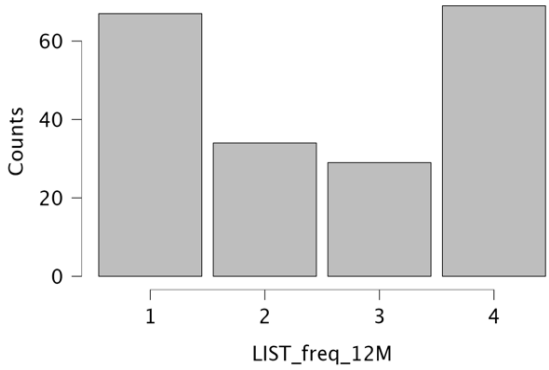

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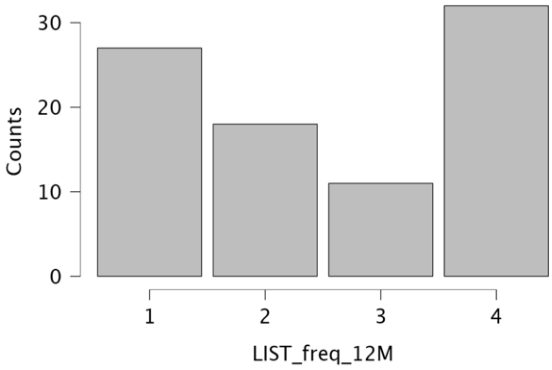

BIBLIOGRAPHY

Alexopoulos, G. S. (2005). Depression in the elderly. *The Lancet*, *365*(9475), 1961–1970. https://doi.org/10.1016/S0140-6736(05)66665-2

Altar, C. A. (1999). Neurotrophins and depression. *Trends in Pharmacological Sciences*, *20*(2), 59–62. https://doi.org/10.1016/S0165-6147(99)01309-7

Amal Dev, S. K. R. R. P. (2015). Music Therapy for institutionalised elderly persons with depression. *Open Journal of Psychiatry & Allied Sciences*, *6*(1), 15–19.

American Psychiatric Association. (2013). *Diagnostic and Statistical Manual of Mental Disorders*. American Psychiatric Association. https://doi.org/10.1176/appi.books.9780890425596

Andrade, P. E., & Bhattacharya, J. (2003). Brain Tuned to Music. *Journal of the Royal Society of Medicine*, *96*(6), 284–287. https://doi.org/10.1177/014107680309600607

Ayuso-Mateos, J. L., Nuevo, R., Verdes, E., Naidoo, N., & Chatterji, S. (2010). From depressive symptoms to depressive disorders: the relevance of thresholds. *British Journal of Psychiatry*, *196*(5), 365–371. https://doi.org/10.1192/bjp.bp.109.071191

Babyak, M., Blumenthal, J. A., Herman, S., Khatri, P., Doraiswamy, M., Moore, K., Edward Craighead, W., Baldewicz, T. T., & Ranga Krishnan, K. (2000). Exercise treatment for major depression: Maintenance of therapeutic benefit at 10 months. *Psychosomatic Medicine*, *62*(5). https://doi.org/10.1097/00006842-200009000-00006

Banerjee, D. (2020). *The impact of Covid-19 pandemic on elderly mental health*. https://doi.org/10.1002/gps.5320

Bathina, S., & Das, U. N. (2015). Brain-derived neurotrophic factor and its clinical implications. *Archives of Medical Science*, *6*, 1164–1178. https://doi.org/10.5114/aoms.2015.56342

Blumenthal, J. A., Babyak, M. A., Moore, K. A., Craighead, W. E., Herman, S., Khatri, P., Waugh, R., Napolitano, M. A., Forman, L. M., Appelbaum, M., Doraiswamy, P. M., & Krishnan, K. R. (1999). Effects of Exercise Training on Older Patients With Major Depression. *Archives of Internal Medicine*, *159*(19). https://doi.org/10.1001/archinte.159.19.2349

Callow, D. D., Arnold-Nedimala, N. A., Jordan, L. S., Pena, G. S., Won, J., Woodard, J. L., & Smith, J. C. (2020). The Mental Health Benefits of Physical Activity in Older Adults Survive the COVID-19 Pandemic. *The American Journal of Geriatric Psychiatry*, *28*(10), 1046–1057. https://doi.org/10.1016/J.JAGP.2020.06.024

Castillo-Pérez, S., Gómez-Pérez, V., Velasco, M. C., Pérez-Campos, E., & Mayoral, M.-A. (2010). Effects of music therapy on depression compared with psychotherapy. *The Arts in Psychotherapy*, *37*(5), 387–390. https://doi.org/10.1016/j.aip.2010.07.001

CASTREN, E., VOIKAR, V., & RANTAMAKI, T. (2007). Role of neurotrophic factors in depression. *Current Opinion in Pharmacology*, *7*(1), 18–21. https://doi.org/10.1016/j.coph.2006.08.009

Chan, M. F., Chan, E. A., Mok, E., & Kwan Tse, F. Y. (2009). Effect of music on depression levels and physiological responses in community-based older adults. *International Journal of Mental Health Nursing*, *18*(4), 285–294. https://doi.org/10.1111/j.1447-0349.2009.00614.x

Chan, M. F., Wong, Z. Y., & Thayala, N. V. (2011). The effectiveness of music listening in reducing depressive symptoms in adults: A systematic review. *Complementary Therapies in Medicine*, *19*(6), 332–348. https://doi.org/10.1016/j.ctim.2011.08.003

Chan, M. F., Wong, Z. Y., & Thayala, N. V. (2010). A systematic review on the effectiveness of music listening in reducing depressive symptoms in adults. *JBI Library of Systematic Reviews*, *8*(31). https://doi.org/10.11124/jbisrir-2010-163

Chikahisa, S., Sei, H., Morishima, M., Sano, A., Kitaoka, K., Nakaya, Y., & Morita, Y. (2006). Exposure to music in the perinatal period enhances learning performance and alters BDNF/TrkB signaling in mice as adults. *Behavioural Brain Research*, *169*(2), 312–319. https://doi.org/10.1016/J.BBR.2006.01.021

Ciotti, M., Ciccozzi, M., Terrinoni, A., Jiang, W.-C., Wang, C.-B., & Bernardini, S. (2020). The COVID-19 pandemic. *Critical Reviews in Clinical Laboratory Sciences*, *57*(6), 365–388. https://doi.org/10.1080/10408363.2020.1783198

Das, S., Arun, P., Rohilla, R., Parashar, K., & Roy, A. (2021). Anxiety and depression in the elderly due to COVID-19 pandemic: a pilot study. *Middle East Current Psychiatry*, *28*(1). https://doi.org/10.1186/s43045-021-00145-1

De Mello, M. T., Lemos, V. D. A., Antunes, H. K. M., Bittencourt, L., Santos-Silva, R., & Tufik, S. (2013). Relationship between physical activity and depression and anxiety symptoms: A population study. *Journal of Affective Disorders*, *149*(1–3), 241–246. https://doi.org/10.1016/J.JAD.2013.01.035

Edwards, J. (2006). Music therapy in the treatment and management of mental disorders. *Irish Journal of Psychological Medicine*, *23*(1), 33–35. https://doi.org/10.1017/S0790966700009459

FARMER, M. E., LOCKE, B. Z., MOŚCICKI, E. K., DANNENBERG, A. L., LARSON, D. B., & RADLOFF, L. S. (1988). PHYSICAL ACTIVITY AND DEPRESSIVE SYMPTOMS: THE NHANES I EPIDEMIOLOGIC FOLLOW-UP STUDY. *American Journal of Epidemiology*, *128*(6), 1340–1351. https://doi.org/10.1093/oxfordjournals.aje.a115087

Fukui, H., & Toyoshima, K. (2008). Music facilitate the neurogenesis, regeneration and repair of neurons. *Medical Hypotheses*, *71*(5), 765–769. https://doi.org/10.1016/J.MEHY.2008.06.019

Hamilton, M. (1960). A RATING SCALE FOR DEPRESSION. *Journal of Neurology, Neurosurgery & Psychiatry*, *23*(1), 56–62. https://doi.org/10.1136/jnnp.23.1.56

Hanser, S. B. (1990). A Music Therapy Strategy for Depressed Older Adults in the Community. *Journal of Applied Gerontology*, *9*(3), 283–298. https://doi.org/10.1177/073346489000900304

Hanser, S. B., & Thompson, L. W. (1994). Effects of a Music Therapy Strategy on Depressed Older Adults. *Journal of Gerontology*, *49*(6), P265–P269. https://doi.org/10.1093/geronj/49.6.P265

Harney, C., & Johnson, J. (2021). *Music and mood regulation during the early-stages of the COVID-19 pandemic*. https://www.researchgate.net/publication/364239472

Hennessy, S., Sachs, M., Kaplan, J., & Habibi, A. (2021). Music and mood regulation during the early stages of the COVID-19 pandemic. *PLOS One*, *16*(10).

Ishii, K., Shibata, A., & Oka, K. (2011). Association between recommended levels of physical activity and depressive symptoms among Japanese adults: A cross-

sectional study. *Mental Health and Physical Activity*, *4*(2), 57–63. https://doi.org/10.1016/j.mhpa.2011.09.001

Jackson-Koku, G. (2016). Beck Depression Inventory. *Occupational Medicine*, *66*(2), 174–175. https://doi.org/10.1093/occmed/kqv087

Kim, H., Lee, M.-H., Chang, H.-K., Lee, T.-H., Lee, H.-H., Shin, M.-C., Shin, M.-S., Won, R., Shin, H.-S., & Kim, C.-J. (2006). Influence of prenatal noise and music on the spatial memory and neurogenesis in the hippocampus of developing rats. *Brain and Development*, *28*(2), 109–114. https://doi.org/10.1016/j.braindev.2005.05.008

Kuehner, C. (2017). Why is depression more common among women than among men? In *The Lancet Psychiatry* (Vol. 4, Issue 2). https://doi.org/10.1016/S2215-0366(16)30263-2

Kurlowicz, L., & Greenberg, S. A. (2007). The Geriatric Depression Scale (GDS). *AJN, American Journal of Nursing*, *107*(10), 67–68. https://doi.org/10.1097/01.NAJ.0000292207.37066.2f

Lampinen, P., Heikkinen, R.-L., & Ruoppila, I. (2000). Changes in Intensity of Physical Exercise as Predictors of Depressive Symptoms among Older Adults: An Eight-Year Follow-Up. *Preventive Medicine*, *30*(5), 371–380. https://doi.org/10.1006/pmed.2000.0641

Leng, X. , &, & Shaw, G. L. (1991). (1991). Toward a neural theory of higher brain function using music as a window. World Scientific Publishing Company. *World Scientific Publishing Company.*

López, J., Perez-Rojo, G., Noriega, C., Martinez-Huertas, J. A., & Velasco, C. (2022). Emotional distress among older adults during the COVID-19 outbreak:

understanding the longitudinal psychological impact of the COVID-19 pandemic. *Psychogeriatrics*, *22*(1). https://doi.org/10.1111/psyg.12781

Marques, A., Bordado, J., Peralta, M., Gouveia, E. R., Tesler, R., Demetriou, Y., & Gomez Baya, D. (2020). Cross-sectional and prospective relationship between physical activity and depression symptoms. *Scientific Reports*, *10*(1), 16114. https://doi.org/10.1038/s41598-020-72987-4

Martinsen, E. W. (2009). *Nordic Journal of Psychiatry Physical activity in the prevention and treatment of anxiety and depression*. https://doi.org/10.1080/08039480802315640

Miranda, M., Morici, J. F., Zanoni, M. B., & Bekinschtein, P. (2019). Brain-Derived Neurotrophic Factor: A Key Molecule for Memory in the Healthy and the Pathological Brain. *Frontiers in Cellular Neuroscience*, *13*. https://doi.org/10.3389/fncel.2019.00363

Mirowsky, J., & Ross, C. E. (1992). Age and depression. *Journal of Health and Social Behavior*, *33*(3). https://doi.org/10.2307/2137349

Mota-Pereira, J., Silverio, J., Carvalho, S., Ribeiro, J. C., Fonte, D., & Ramos, J. (2011). Moderate exercise improves depression parameters in treatment-resistant patients with major depressive disorder. *Journal of Psychiatric Research*, *45*(8), 1005–1011. https://doi.org/10.1016/J.JPSYCHIRES.2011.02.005

NIH. (n.d.). *Depression and Older Adults*. Retrieved September 10, 2022, from https://www.nia.nih.gov/health/depression-and-older-adults#treatment

Nolen-Hoeksema, S., & Keita, G. P. (2003). Women and depression: Introduction. In *Psychology of Women Quarterly* (Vol. 27, Issue 2). https://doi.org/10.1111/1471-6402.00088

Pfefferbaum, B., & North, C. S. (2020). Mental Health and the Covid-19 Pandemic. *New England Journal of Medicine*, *383*(6), 510–512. https://doi.org/10.1056/NEJMP2008017

Phillips, C. (2017). Brain-Derived Neurotrophic Factor, Depression, and Physical Activity: Making the Neuroplastic Connection. *Neural Plasticity*, *2017*, 1–17. https://doi.org/10.1155/2017/7260130

Phillips, W. T., Kiernan, M., & King, A. C. (2003). ARTICLE Physical Activity as a Nonpharmacological Treatment for Depression: A Review. *Complementary Health Practice Review*, *8*(2), 139–152. https://doi.org/10.1177/1076167502250792

Puccinelli, P. J., da Costa, T. S., Seffrin, A., de Lira, C. A. B., Vancini, R. L., Nikolaidis, P. T., Knechtle, B., Rosemann, T., Hill, L., & Andrade, M. S. (2021). Reduced level of physical activity during COVID-19 pandemic is associated with depression and anxiety levels: an internet-based survey. *BMC Public Health*, *21*(1). https://doi.org/10.1186/s12889-021-10470-z

Randall, W. M., Rickard, N. S., & Vella-Brodrick, D. A. (2014). Emotional outcomes of regulation strategies used during personal music listening: A mobile experience sampling study. *Musicae Scientiae*, *18*(3). https://doi.org/10.1177/1029864914536430

Rauschecker, J. P. (n.d.). *Cortical Plasticity and Music*. https://doi.org/10.1111/j.1749-6632.2001.tb05742.x

Rauscher, F. H., & Shaw, G. L. (1998). Key Components of the Mozart Effect. *Perceptual and Motor Skills*, *86*, 835–841.

Reybrouck, M., Leuven, K., Tamplin, J., Krause, A. E., Leubner, D., & Hinterberger, T. (2017). Leubner D and Hinterberger T (2017) Reviewing the Effectiveness of Music Interventions in Treating Depression. *Front. Psychol*, *8*, 1109. https://doi.org/10.3389/fpsyg.2017.01109

Ribeiro, F. S., Lessa, J. P. A., Delmolin, G., & Santos, F. H. (2021). Music Listening in Times of COVID-19 Outbreak: A Brazilian Study. *Frontiers in Psychology*, *12*. https://doi.org/10.3389/fpsyg.2021.647473

Riecher-Rössler, A. (2017). Sex and gender differences in mental disorders. In *The Lancet Psychiatry* (Vol. 4, Issue 1). https://doi.org/10.1016/S2215-0366(16)30348-0

Saarikallio, S. (2012). *Music, Health, and Wellbeing* (R. mac Donald, G. Kreutz, & L. Mitchell, Eds.). Oxford University Press.

Saarikallio, S., Alluri, V., Maksimainen, J., & Toiviainen, P. (2021). Emotions of music listening in Finland and in India: Comparison of an individualistic and a collectivistic culture. *Psychology of Music*, *49*(4), 989–1005. https://doi.org/10.1177/0305735620917730

Slobada, J. A. , and O. S. A. (2001). Emotions in Everyday Listening to Music. *Newcastle: Oxford University Press*, 415–429.

Stephens, T. (1988). Physical activity and mental health in the United States and Canada: Evidence from four population surveys. *Preventive Medicine*, *17*(1), 35–47. https://doi.org/10.1016/0091-7435(88)90070-9

Stubbs, B., Koyanagi, A., Schuch, F. B., Firth, J., Rosenbaum, S., Veronese, N., Solmi, M., Mugisha, J., Vancampfort, D., & Stubbs, B. (2016). Physical activity and depression: a large cross-sectional, population-based study across 36 low-and middle-income countries. *Acta Psychiatr Scand*, *134*, 546–556. https://doi.org/10.1111/acps.12654

Verrusio, W., Andreozzi, P., Marigliano, B., Renzi, A., Gianturco, V., Pecci, M. T., Ettorre, E., Cacciafesta, M., & Gueli, N. (2014a). Exercise training and music therapy in elderly with depressive syndrome: A pilot study. *Complementary Therapies in Medicine*, *22*(4), 614–620. https://doi.org/10.1016/j.ctim.2014.05.012

Verrusio, W., Andreozzi, P., Marigliano, B., Renzi, A., Gianturco, V., Pecci, M. T., Ettorre, E., Cacciafesta, M., & Gueli, N. (2014b). Exercise training and music therapy in elderly with depressive syndrome: A pilot study. *Complementary Therapies in Medicine*, *22*(4), 614–620. https://doi.org/10.1016/j.ctim.2014.05.012

Wang, D., Hu, B., Hu, C., Zhu, F., Liu, X., Zhang, J., Wang, B., Xiang, H., Cheng, Z., Xiong, Y., Zhao, Y., Li, Y., Wang, X., & Peng, Z. (2020). Clinical Characteristics of 138 Hospitalized Patients With 2019 Novel Coronavirus–Infected Pneumonia in Wuhan, China. *JAMA*, *323*(11), 1061. https://doi.org/10.1001/jama.2020.1585

Washburn, R. A., Smith, K. W., Jette, A. M., & Janney, C. A. (1993). The physical activity scale for the elderly (PASE): Development and evaluation. *Journal of Clinical Epidemiology*, *46*(2), 153–162. https://doi.org/10.1016/0895-4356(93)90053-4

Watt, R.], & Ash, R. 1. (1998). A psychological investigation of meaning in music. In *Muslcae Sclentlae Spring: Vol. II* (Issue 1).

Xiang, Y.-T., Yang, Y., Li, W., Zhang, L., Zhang, Q., Cheung, T., & Ng, C. H. (2020). Timely mental health care for the 2019 novel coronavirus outbreak is urgently needed. *The Lancet Psychiatry*, *7*(3), 228–229. https://doi.org/10.1016/S2215-0366(20)30046-8

Yeh, S.-H., Lin, L.-W., Chuang, Y. K., Liu, C.-L., Tsai, L.-J., Tsuei, F.-S., Lee, M.-T., Hsiao, C.-Y., & Yang, K. D. (2015). Effects of Music Aerobic Exercise on Depression and Brain-Derived Neurotrophic Factor Levels in Community Dwelling Women. *BioMed Research International*, *2015*, 1–10. https://doi.org/10.1155/2015/135893

Yesavage, J. A., & Sheikh, J. I. (1986). 9/Geriatric Depression Scale (GDS). *Clinical Gerontologist*, *5*(1–2), 165–173. https://doi.org/10.1300/J018v05n01_09

Zhao, K., Bai, Z. G., Bo, A., & Chi, I. (2016a). A systematic review and meta-analysis of music therapy for the older adults with depression. *International Journal of Geriatric Psychiatry*, *31*(11), 1188–1198. https://doi.org/10.1002/gps.4494

Zhao, K., Bai, Z. G., Bo, A., & Chi, I. (2016b). A systematic review and meta-analysis of music therapy for the older adults with depression. *International Journal of Geriatric Psychiatry*, *31*(11), 1188–1198. https://doi.org/10.1002/gps.4494