CHARACTERIZATION OF UPPER EXTREMITY MUSCULOSKELETAL COMPLAINTS, HAND DIMENSIONS AND HAND GRIP STRENGTH OF KEYBOARD INSTRUMENTALISTS IN BENIN CITY

BY

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CERTIFICATION

This is to certify that this research work titled "**UPPER EXTREMITY MUSCULOSKELETAL COMPLAINTS, HAND DIMENSIONS AND HAND GRIP STRENGTH OF KEYBOARD INSTRUMENTALIST IN BENIN CITY"** was conducted by USIAGHAN ITSEOLUWA TEMISAN with matriculation number BMS1802705 under the supervision of DR. S. N. OGHUMU in the department of physiotherapy, School of Basic Medical Science, University of Benin as part of the requirement for the award of Bachelor of Physiotherapy.

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DEDICATION

This dissertation is dedicated to God, my mother and father, and my siblings who made this work a reality.

ABSTRACT

BACKGROUND: Keyboard instrumentalists are highly susceptible to Playing-Related Musculoskeletal Disorders (PRMDs). PRMDs affect keyboard players, especially in the wrists, hands, and neck. Despite existing global research, data on hand dimensions and hand grip strength (HGS) among keyboard instrumentalists in Benin City remain limited, necessitating further study.

AIM: The aim of this study was to investigate the upper extremity musculoskeletal complaints, hand dimension and HGS of keyboard instrumentalists in Benin City.

METHODS: Consecutive technique was utilized to select Participants, and 115 keyboardists participated in this research. Data collection involved completing the Maastricht Upper Extremity Questionnaire (MUEQ) which was used to assess their musculoskeletal complaints and physical measurements were also conducted. Hand dimensions, including length, span, width, circumference, and shape, were measured using a measuring tape. While HGS was assessed using a digital hand grip dynamometer. Body weight, height, and BMI were also measured. Descriptive statistics of mean, standard deviation, frequency and percentage were used to summarize the data. Pearson product moment correlation coefficient was used to test the relationship between variables at $p < 0.05$.

RESULTS: There was a high prevalence of musculoskeletal complaints, particularly in the neck (86.1%). Hand grip strength showed significant correlations with hand length (r=0.817 p=0.000), hand span (r=0.813, p=0.000), hand circumference (r=0.782, p=0.000), hand width (r=0.852, p=0.000), hand shape (r=0.306, p=0.001), and wrist circumference (r=0.765, p=0.000) for dominant hand. Then for the Non dominant hand HGS showed significant correlations with hand length (r=0.840 p=0.000), hand span (r=0.823, p=0.000), hand circumference (r=0.808, p=0.000), hand width (r=0.862, p=0.000), hand shape (r=0.296, p=0.001), and wrist circumference (r=0.792, p=0.000). Participants reported poor ergonomic practices, including awkward postures (73%) and prolonged playing (93%), contributing to physical strain. symptoms like fatigue and stiffness were alleviated by rest (98.2% and 98%).

CONCLUSION: The study revealed a high prevalence of musculoskeletal complaints among keyboard instrumentalists in Benin City, with neck pain being the most common. Hand grip strength showed significant correlations with Hand dimensions.

KEYWORDS: Musculoskeletal complaints, Hand dimensions, Hand grip strength, Keyboard instrumentalists.

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CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Playing musical instruments, especially those that require repetitive hand and finger movements, may result in a variety of musculoskeletal complaints. Keyboard instrumentalists, string players and guitarists were reported to have a high prevalence of Musculoskeletal disorders (MSDs) among musicians (Egwuonwu et al, 2016). MSDs are soft-tissue injuries caused by sudden or sustained exposure to repetitive motion, force, vibration, and awkward positions (CDC, 2024). Keyboard instrumentalists are susceptible to Musculoskeletal conditions (Yang et al., 2021). These conditions are often termed Playing-Related Musculoskeletal Disorders (PRMDs). PRMDs are defined as 'pain, weakness, numbness, tingling or other symptoms that interfere with the ability to play an instrument' (Shinde & Borkar, 2010).

Both professional pianists and non‑professional piano players are at risk of PRMDs, which include mainly soft tissue (muscle, ligament and tendon) conditions related to mechanical strain, but may also involve bone, cartilage and nerves, with such symptoms being experienced as pain and loss of function that relate specifically to piano playing (Allsop et al, 2010). Although clinical presentations are widely varied, the PRMDs that most acutely affect performance are localised to the wrist, forearms, and fingers (Takamizawa & Kenway, 2023). These disorders often limit the musicians' ability to play effectively and for extended periods. The reported lifetime prevalence of PRMD affecting all musicians is 50% to 88% (Yang et al, 2021). PRMDs prevalence was observed between 25.8% and 77.0% among keyboard musicians with a higher

prevalence in wrists and hands (13.8%-65.8%), neck (9.8%-64.2%), and shoulders (9.8%-59.8%) (Amaral Corrêa et al, 2018) .

Keyboard instrumentalists suffer from a variety of PRMDs including carpal tunnel syndrome, lateral epicondylalgia, trigger finger, and De Quervain's tenosynovitis (Ciurana Moñino et al., 2017). Carpal tunnel syndrome occurs when one of the major nerves to the hand — the median nerve — is squeezed or compressed as it travels through the wrist causing numbness, tingling, and pain in the hand and forearm (American Academy of Orthopaedic Surgeons, 2022). Lateral epicondylitis, also commonly referred to as tennis elbow, describes an overuse injury that occurs secondary to an eccentric overload of the common extensor tendon at the origin of the extensor carpi radialis brevis tendon (Buchanan & Varacallo, 2023). Trigger finger, also known as stenosing tenosynovitis, is a prevalent condition that arises due to the repetitive use of the fourth finger and thumb (Jeanmonod et al, 2024). De Quervain tenosynovitis, named after Swiss surgeon Fritz de Quervain, is a condition that involves tendon entrapment affecting the first dorsal compartment of the wrist (Satteson & Tannan, 2023). Although overuse is a widely used term to describe PRMDs, some researchers argue that this explanation is too simplistic. Lippmann (1991) suggests that attributing PRMDs solely to overuse neglects other factors such as improper technique or poor conditioning, both of which are correctable (Allsop & Ackland, 2010).

Piano performance techniques have evolved over time to meet the changing demands of the instrument. The traditional playing technique, which involves wrist postures ranging from neutral to flexed, was developed during the clavichord and harpsichord period and continues to be used today (Altenmüller et al, 2006). The weight playing technique, characterised by wrist postures that range from neutral to extended, emerged in response to the development of the more mechanically sophisticated nineteenth-century piano, which required greater force and speed to produce sound. The Levinskaya system, which combines both traditional and weight playing techniques, was developed to meet the evolving demands of twentieth-century piano literature (Allsop & Ackland, 2010). These varied techniques highlight the intricate balance

between force, speed, and energy efficiency that musicians must navigate to achieve optimal performance.

Hand dimensions and Hand grip strength also play a crucial role in determining a keyboard player's efficiency and susceptibility to injury. Hand span, length, width, circumference, shape and wrist circumference are key factors that influence a musician's ability to navigate the keyboard instrument. Hand size has been highlighted as a risk factor of PRMDs for pianists in literature (Amaral Correa et al, 2018; Chi et al, 2020). Research suggests that individuals with larger hand spans may have a biomechanical advantage, as they experience less strain during extended finger movements and chord stretches (Lai et al, 2015). Pianists with smaller hand dimensions are more susceptible to overuse disorders due to increased strain from hyper-abduction and hyper-extension (Sakai and Shimawaki, 2010). Pianists with smaller hand span used larger range of motion of the wrist flexion/extension to play the chords than those with larger hand span. Since a greater degree of active wrist flexion/extension movements and repetitive motion have been reported to play a role in median nerve compression in the wrist (Deahl and Wristen, 2003; Bower et al, 2006), this phenomenon could partly explain the frequent occurrence of carpal tunnel syndrome among pianists (Lai et al, 2015).

Similarly, Hand grip strength plays an essential role in maintaining dexterity, precision, and endurance. HGS is crucial for musicians, especially those who play instruments that require intricate hand movements and sustained use of finger and wrist muscles. From the grip needed to hold a guitar or strike tabla drums, to the dexterity involved in playing the piano or sitar, a musician’s ability to control and manipulate their instrument relies heavily on the strength and endurance of their hand muscles (Malshikare et al, 2017). Reduced HGS or imbalances in muscle groups can lead to compensatory movements, further increasing the risk of injury.

However, empirical studies examining the hand dimensions and HGS of musicians in specific populations, such as those in Benin City, remain limited.

1.2 Statement of the Problem

The increasing prevalence of musculoskeletal complaints among keyboard instrumentalists worldwide has become a significant concern, particularly due to the physical demands of playing that often lead to PRMDs. While this issue has been extensively researched in Western contexts, studies in Africa, especially Nigeria, remain sparse. Musicians in Benin City, who are exposed to unique cultural and environmental conditions, face specific challenges that exacerbate the risk of PRMDs. These challenges include the use of non-ergonomic instruments, lack of access to professional training, and irregular practice routines. Despite the growing body of knowledge on PRMDs, little attention has been directed toward understanding how these conditions manifest among local musicians in Benin City.

Research has shown that hand dimensions, such as span, length, and width, play a vital role in determining a player's biomechanical efficiency (Lai et al, 2015). Musicians with larger hand spans are often able to play with reduced strain, minimising their risk of injury during long performance sessions. Studies on hand dimensions of keyboard players in other parts of the world have not only highlighted the advantages of certain hand sizes but also suggested modifications in playing techniques for musicians with smaller hands (Boyle, 2012). Yet, empirical data specific to Nigerian musicians are limited, leaving a significant knowledge gap regarding how these factors influence performance and injury in local contexts.

Stronger HGS are necessary for maintaining endurance, precision, and dexterity during prolonged playing sessions (Malshikare et al, 2017). While research in other parts of the world has suggested specific strength-training protocols to mitigate PRMDs, the applicability of these

findings to local musicians remains unclear, largely due to the lack of region-specific data on HGS and its relationship to playing-related injuries.

This study investigated the upper extremity musculoskeletal complaints experienced by keyboard instrumentalists in Benin City. It also assessed their hand dimensions, including span, length, width, and circumference as well as evaluated their hand grip strength.

1.3 Research Question

The following research question were raised to guide this study;

1.What is the prevalence of musculoskeletal complaints among keyboard instrumentalists in Benin City?

2. What are the hand dimensions (hand span, width, length, circumference, shape, wrist circumference) of keyboard instrumentalists in Benin City?

3. What are the Hand grip strength profiles of Keyboard Instrumentalists in Benin City?

4. What is the relationship between Hand grip strength and Hand Dimension (hand span, width, length, circumference, shape, wrist circumference) of Keyboard Instrumentalists in Benin City?

1.4 Aim of study

The aim of this study was to investigate the musculoskeletal complaints (neck, shoulder, upper arm, elbow, lower arm, wrist, hand, low back) hand dimension (hand span, width, length, circumference, shape, wrist circumference) and grip strengths (HGS and PGS) of keyboard instrumentalists in Benin City.

1.5 Objective of the Study

The specific objectives of this study included:

1. To identify the musculoskeletal complaints (neck, shoulder, upper arm, elbow, lower arm, wrist, hand, low back) experienced by keyboard instrumentalists in Benin City.

2. To measure the hand dimensions (hand span, width, length, circumference, shape, wrist circumference) of keyboard instrumentalists in Benin City.

3. To assess the Hand Grip strength (HGS) of keyboard instrumentalists in Benin City.

4. To know the relationship between HGS and Hand Dimensions (hand span, width, length, circumference, shape, wrist circumference) of keyboard instrumentalists in Benin City.

1.6 Research Hypotheses

1.6.1 Main Hypothesis:

There would be no significant relationship between Hand grip strengths (HGS) and hand dimension (hand span, width, length, circumference, shape, wrist circumference) of keyboard instrumentalist in Benin City

1.6.2 Sub-hypotheses:

1. There would be no significant relationship between HGS dominant and the hand span of keyboard instrumentalists in Benin City.
2. There would be no significant relationship between HGS dominant and the hand width of keyboard instrumentalists in Benin City.
3. There would be no significant relationship between HGS dominant and the hand length of keyboard instrumentalists in Benin City.

4. There would be no significant relationship between HGS dominant and the hand circumference of keyboard instrumentalists in Benin City.
5. There will be no significant relationship between HGS dominant and the hand shape of keyboard instrumentalists in Benin City.
6. There would be no significant relationship between HGS dominant and the wrist circumference of keyboard instrumentalists in Benin City.
7. There would be no significant relationship between HGS Non dominant and the hand span of keyboard instrumentalists in Benin City.
8. There would be no significant relationship between HGS Non dominant and the hand width of keyboard instrumentalists in Benin City.
9. There would be no significant relationship between non HGS dominant and the hand length of keyboard instrumentalists in Benin City.
10. There would be no significant relationship between HGS Non dominant and the hand circumference of keyboard instrumentalists in Benin City.
11. There would be no significant relationship between HGS Non dominant and the hand shape of keyboard instrumentalists in Benin City.
12. There would be no significant relationship between HGS Non dominant and the wrist circumference of keyboard instrumentalists in Benin City

1.7 Scope of the Study

This study characterised musculoskeletal complaints among keyboard instrumentalists in Benin City. And assessed their hand dimensions (hand span, width, length, circumference, shape, wrist circumference) and HGS. The study was restricted to keyboard instrumentalists who have actively performed or practised in the last 2 years. The Maastricht questionnaire was used to assess musculoskeletal complaints. Measuring tape was used to measure hand dimensions (hand

span, width, length, circumference, shape, wrist circumference). A dynamometer will be used to measure grip strength HGS

1.7 limitation of the study

Several limitations were acknowledged in this study:

Sample Size and Representation: The study focused on keyboard instrumentalists in Benin City, which may limit the generalizability of the findings to other regions or populations. Variations in music practice and culture in different areas may affect the prevalence of musculoskeletal complaints.

Reliance on Self-Reported Data: The data collected relied heavily on self-reported questionnaires, which may introduce biases, such as underreporting or misinterpretation of musculoskeletal complaints and practice routines by participants.

1.8 Significance of the Study

This study is significant for several key groups:

Musicians and Keyboard Instrumentalists: The findings will provide instrumentalists with valuable insights into how hand dimensions, HGS, and proper playing techniques influence their risk of developing musculoskeletal complaints. It will emphasise the importance of adopting ergonomic practices and maintaining physical fitness to prevent PRMDs.

Health Professionals: Physiotherapists and occupational therapists will gain a deeper understanding of the specific musculoskeletal issues that keyboard instrumentalists face. This knowledge will help health professionals develop targeted interventions, rehabilitation programs, and preventive measures that cater specifically to this population.

Music Educators: By understanding the risks associated with keyboard playing, educators can integrate injury prevention techniques and ergonomic practices into their teaching methods. This can reduce the prevalence of musculoskeletal complaints among students, leading to healthier long-term performance habits.

Ergonomics Experts and Instrument Manufacturers: The study's findings will inform the design and manufacturing of more ergonomic musical instruments and accessories, catering to the specific needs of keyboard instrumentalists with varying hand sizes. This can result in products that reduce strain during playing and improve player comfort.

Academic and Research Community: This research will contribute to the broader body of literature on musculoskeletal disorders in musicians, filling gaps in knowledge related to the specific experiences of keyboard instrumentalists in Benin City. The findings can serve as a basis for future research on ergonomics, injury prevention, and the relationship between hand dimensions and musculoskeletal complaints.

1.9 Definition of terms:

1. **Musculoskeletal complaints:** These refer to pain, discomfort, or injuries affecting the muscles, bones, joints, ligaments, and tendons.
2. **Hand dimension:** Refers to the various measurements of the hand, including hand length, hand span, hand circumference, wrist circumference, and hand width and shape
3. **Hand Grip strength:** The force applied by the hand to grip objects, which is a measure of hand function and muscle strength.
4. **Keyboard Instrumentalist:** Musicians who play keyboard-based instruments such as pianos, organs, and synthesisers.

CHAPTER TWO

LITERATURE REVIEW

2.1 Musculoskeletal Complaints in Music Professions

Only at the end of the nineteenth century, a number of physicians turned their interest to some specific musicians' complaints like musicians' cramps but real interest in the health and wellbeing of musicians by medical practitioners, researchers and music professionals was significantly increased since the 1980s (KOK et al., 2016). However, the level of knowledge on this topic and the necessary specialized healthcare is still in a developmental stage when compared to, for instance, sports medicine, and thus room for improvement remains (KOK et al., 2016).

A musician is a person who performs music. There are different types of musicians playing different instruments –percussionist, string musicians, pianist, wind musicians (Shinde & Borkar, 2021). The practice of musical instruments is associated with exposure to risk factors for injuries (mainly in the musculoskeletal system) in classical musicians and keyboard players due to the high physical effort required, as well as emotional, including performance anxiety related to competitions and performances (Amaral Correa et Al., 2018). A bit of studies disclosed that musicians consider treating pain and disorders caused due to playing an instrument as an indication of fragility and inability. Regrettably this perspective causes high incidence of impairment and expulsion from their profession (Zięba et al., 2019).

In a study with 1,353 instrumentalists, the highest prevalence of injuries was Musculoskeletal, followed by Peripheral Neuropathy, affecting mainly the hands, wrist and forearm (Lederman, 2003). Musicians frequently experience musculoskeletal complaints due to the unique physical demands of their profession. Work-related musculoskeletal disorders are the most frequent

complaints among instrumental musician (Zuskin et al., 2005). Work-related musculoskeletal disorders (WMSDs) refer to injuries to local muscles, tendons, bones, cartilage, ligaments, nerves, and other parts of the body caused or aggravated by occupational activities, resulting in varying degrees of damage (Ding et al., 2023). As 'playing' is the 'work' of musicians, 'playing-related musculoskeletal disorder' (PRMD) is an appropriate music-specific derivative of work-related musculoskeletal disorder (Bragge et al, 2006). These complaints encompass a wide range of issues, including pain and discomfort in the upper extremities, neck, back, and lower extremities. Impaired level of functioning at both work and daily activities at home due to these musculoskeletal complaints is reported in the majority, and sleep disturbances related to these complaints are reported in half of the professional musicians (Paarup et al. 2011; Kaneko et al. 2005). The reported lifetime prevalence of PRMD affecting all musicians is 50% to 88% and these complaints are prevalent among various music professions, from orchestral players to soloists and educators(Yang et al, 2021). 74.9% reported having had a PRMD in their lifetime (Macdonald et al., 2022) . These studies reported a lifetime PRMD frequency among musicians of between 63 and 78% (Baadjou et al., 2015; Berque et al, 2016; Ballenberger et al, 2018; Kok et al, 2018; Shanoff et al, 2019). Most professional musicians will suffer from musculoskeletal complaints during their life; some of them will stop playing their instrument due to these complaints (Kaufman-Cohen and Ratzon 2011; Parry 2003; Kaneko et al, 2005).

The aetiology of musculoskeletal complaints in musicians is multifactorial, involving both physical and psychological components (Rotter et al, 2020). The repetitive nature of playing instruments, coupled with prolonged periods of practice, places excessive strain on specific muscle groups and joints (Sataloff, 2017). For example, violinists may experience shoulder and neck pain due to the position of the instrument, while pianists often report issues in their wrists and hands (Sataloff, 2017). Additionally, improper posture and ergonomics during practice can exacerbate these conditions. According to a study by Allsop et al, (2010), musicians who

maintain poor posture while playing are more likely to develop chronic pain conditions, emphasising the importance of awareness regarding body mechanics.

Furthermore, the psychological factors associated with performance pressure and competition can also contribute to the prevalence of musculoskeletal complaints. Musicians often endure significant stress related to performances, auditions, and evaluations, which may lead to tension in the muscles and exacerbate pain symptoms (Ballenberger et al, 2018). The interplay between psychological stress and physical strain underscores the need for a holistic approach to the prevention and management of musculoskeletal issues in musicians.

Preventative strategies are essential in addressing musculoskeletal complaints within this population. These strategies can include proper warm-up routines, ergonomic assessments of instrument usage, and education on optimal body mechanics during practice and performance (Chi et al, 2021; Sataloff, 2017).

Musculoskeletal complaints are a significant concern in music professions, necessitating increased awareness and proactive measures for prevention and management. By recognizing the unique physical and psychological demands placed on musicians, appropriate strategies can be developed to mitigate the risk of injury and promote long-term health in this population.

2.2 Musculoskeletal Complaints Among Keyboard Instrumentalists

Keyboard instrumentalists, including pianists and organists, are particularly susceptible to musculoskeletal complaints due to the unique biomechanical demands associated with playing these instruments. The repetitive motions required in keyboard playing, combined with the static postures often adopted during practice and performance, contribute to a high prevalence of musculoskeletal disorders in this population (Allsop et al, 2010). Prevalence was observed between 25.8% and 77.0% of musculoskeletal pain among keyboard musicians, with a higher

prevalence in wrists and hands (13.8%-65.8%), neck (9.8%-64.2%), and shoulders (9.8%-59.8%) (Amaral Corrêa et al, 2018) .

The primary musculoskeletal complaints among keyboard instrumentalists often stem from the anatomical and physiological stresses placed on the upper extremities. Pianists, for example, frequently report discomfort in their wrists and hands due to the high demands of finger dexterity and repetitive finger movements necessary for producing music (Allsop et al, 2010). Prolonged sessions of intense practice can lead to overuse injuries, such as tendinitis, carpal tunnel syndrome, and other repetitive strain injuries which are often exacerbated by improper hand positioning and excessive force applied during playing (Allsop et al, 2010) .

Additionally, keyboard instrumentalists often adopt poor ergonomic postures while seated at their instruments, leading to neck and back pain. Posture plays a critical role in musicians' physical health. The alignment of the head, thorax, and pelvis along the body's longitudinal axis is essential to maintaining a neutral spine position, commonly known as the neutral zero position (Ohlendorf et al, 2017). Deviation from this position—such as leaning forward or slouching—can cause static muscle strain and discomfort. Over time, these issues can lead to chronic pain in the back, neck, and limbs, particularly in musicians who engage in repetitive, asymmetric movements (Ohlendorf et al, 2017). Also, Players who reported playing with elevated shoulders were more likely than those who played with non‐elevated shoulders to experience PRMDs (Hagberg, et al, 2005). This finding is congruent with the ergonomics literature on overuse injuries, showing that the greater the degree of arm abduction and shoulder elevation the more energy is expended (Allsop et al, 2010). The importance of ergonomics in preventing musculoskeletal disorders cannot be overstated. Ohlendorf et al. (2017) highlight that proper ergonomic chairs should support the musician's weight distribution evenly across the ischial tuberosities (the sitting bones), which helps in maintaining a balanced posture. The study used a three-dimensional back scan and pressure-measuring tools to assess the impact of

different chair designs on posture. Findings showed that poor chair ergonomics contributed to faults in posture at the spine, shoulder, and pelvis levels. Faulty posture in these areas can lead to excessive strain on muscles, tendons, and joints, ultimately resulting in musculoskeletal pain syndromes. Prolonged poor posture can even lead to the development of neuromuscular alterations and chronic pain, which may impair performance ability and cause avoidance behaviours (Ohlendorf et al, 2017).

Psychological factors also play a crucial role in the manifestation of musculoskeletal complaints among keyboard instrumentalists. Stress is one of the most prominent psychological factors linked to the development of musculoskeletal complaints in instrumentalists (Ballenberger et al, 2018). The heightened level of stress directly correlates with the incidence of musculoskeletal complaints. According to the findings, stress increases the likelihood of developing musculoskeletal complaints , with the odds ratio (OR) indicating that for each additional stress symptom, the probability of experiencing musculoskeletal complaints rises by 11% (OR 1.11) (Ballenberger et al., 2018). Performance anxiety and the pressure to maintain high levels of technical proficiency can significantly heighten stress levels (Ballenberger et al, 2018). Emotional distress can interfere with physical functioning, as individuals experiencing emotional strain are less likely to engage in behaviours that promote physical health, such as exercise or proper posture while playing (Ballenberger et al., 2018). . The study identified that musicians including keyboard instrumentalists with reduced emotional role functioning were more likely to experience musculoskeletal complaints, indicating that psychological well-being is intrinsically linked to physical health outcomes. This relationship underscores the need for a comprehensive approach that addresses both the physical and mental well-being of keyboard players.

Preventative measures are vital for reducing the incidence of musculoskeletal complaints in keyboard instrumentalists. Recommendations include proper warm-up exercises, stretching routines, and ergonomic training to promote better playing techniques (Sataloff, 2017).

Musculoskeletal complaints among keyboard instrumentalists are prevalent and multifaceted, resulting from the unique physical demands of the instrument and the psychological pressures of performance. Recognizing these factors is essential for developing effective prevention and management strategies aimed at preserving the health and longevity of keyboard players.

2.3 Hand Dimensions and Its Relevance to Keyboard Instrumentalists

The dimensions of the hand play a significant role in a pianist's ability to perform on a keyboard, impacting everything from comfort to technique. Hand span, which is the distance between the thumb and fifth finger when fully spread, has been shown to affect pianists' experiences of muscle strain and exertion, particularly when performing on standard-sized pianos (Chi et al., 2021). Research indicates that smaller-handed pianists face increased physical challenges, such as excessive abduction of their fingers, sometimes beyond their natural static span which may in time affect their technical ability and can also increase the risk of hand injuries such as tendonitis and nerve compression (Lai et al., 2015). Pianists with smaller hand spans (under 18.2 cm) must exert more effort to play chords and octaves (Lai et al., 2015). These techniques often lead to greater muscle strain, particularly in the wrist extensors (WE) and wrist flexors (WF), and increased risk of injury, such as playing-related musculoskeletal disorders (PRMDs), particularly for those with a hand span smaller than 19.75 cm (Chi et al., 2021). Studies further highlight that these players are more likely to experience pain and reduced playing ability compared to larger-handed pianists (Yoshimura & Chesky, 2009). Smaller-handed pianist exhibit higher levels of muscle activity when playing on conventional-sized keyboards (6.5-inch octave) due to the increased reach required (Chi et al., 2021). In contrast, playing on smaller

keyboards (5.5-inch and 6.0-inch octaves) significantly reduces muscle activity in these same muscle groups. This reduction is especially pronounced in the distal muscles (wrist and finger muscles), highlighting the ergonomic advantage for pianists with smaller hand spans (Chi et al., 2021).

The relationship between hand size and playing technique is particularly evident among Keyboard Instrumentalists. Smaller hand span pianists experience a higher range of motion (ROM) in the wrist during complex movements like chords. This greater movement, combined with finger abduction, places increased strain on their wrists and fingers (Lai et al., 2015). The study by Chi et al., (2021) also examined how hand span affects pianists' ability to perform different types of musical techniques. The researchers selected three specific piano exercises for the participants; Chords, Split chords and octaves. These exercises were chosen for their varying demands on hand and finger extension. For small-handed pianists, playing chords and octaves on standard keyboards resulted in significant muscle strain, as these techniques required greater reach and hand extension. Pianists with smaller hand spans were often forced to compensate by using maladaptive techniques, such as hyperextending their fingers or shifting their hands awkwardly, which increased the risk of injury (Chi et al., 2021). Small-handed pianists often resort to techniques like refingering, redistributing notes between hands, or omitting notes to cope with the physical demands of large intervals. While these strategies can reduce physical strain, they may compromise the musical intensity and accuracy of the performance (Deahl & Wristen, 2003).

Lai et al (2015) suggest that standard keyboard sizes may not be optimal for all pianists, particularly those with smaller hands. This points to a need for ergonomic solutions, such as smaller keyboards, to mitigate injury risks and promote long-term career sustainability. The idea

that a one-size-fits-all approach to piano design may not be adequate. Ergonomically designed instruments that account for different hand sizes could improve both performance and reduce injury rate (Lai et al., 2015). Implementing adjustable or smaller keyboards would enable pianists of all hand sizes to play without the undue strain that can lead to chronic conditions.

In the research by Chi et al., (2021), there was also a collection of subjective data on the pianists' ratings of perceived exertion (RPE) and keyboard preference. These ratings were measured using the Borg 6-20 scale, which ranges from “no exertion at all” to “maximal exertion”. The results showed that small-handed pianists reported significantly lower physical exertion on the 5.5-inch keyboard compared to the standard-sized keyboard. They also overwhelmingly preferred the smaller keyboards for their comfort and ease of playing (Chi et al., 2021). They felt that smaller keyboards reduced the physical strain associated with playing large intervals, chords, and octaves. For large-handed pianists, there was no significant difference in perceived exertion across the different keyboard sizes, reinforcing the conclusion that the standard keyboard is more suitable for them. Nonetheless, even large-handed players expressed a slight preference for the 6.0-inch keyboard over the 6.5-inch keyboard, possibly due to its more balanced size (Chi et al., 2021).

The "one-size-fits-all" approach to piano keyboard design may disadvantage small-handed pianists, limiting their repertoire and increasing the risk of injury. Studies advocate for wider availability of Ergonomically Scaled Piano Keyboards (ESPKs), especially in teaching and professional settings, to create a more inclusive environment for pianists of all hand sizes (Chi et al., 2021, Lai et a., 2015). Interestingly, the use of ESPKs not only reduces physical discomfort but also enhances performance. Pianists report improved accuracy, speed, and comfort when using these modified keyboards (Wristen & Hallbeck, 2009).

Hand dimensions significantly impact the performance and health of instrumentalists, influencing their technical capabilities, ergonomic considerations, and susceptibility to injury. Acknowledging the importance of hand size is essential for developing effective training methods and injury prevention strategies tailored to the unique needs of musicians.

2.4 Hand Grip Strength and Its Role in Music Performance

A study by Kurian and Malarvizhi (2021) found that pianists who regularly perform exercises targeting the muscles in the upper limbs, especially the wrist and fingers, experience improved hand grip strength. This improvement allows for better control, speed, and endurance during piano playing. Hand Grip strength is a key indicator of overall hand function, and its assessment is widely accepted in clinical settings to gauge the functional integrity of the upper extremity. In the context of musicians, grip strength can provide insight into their ability to perform effectively and for long durations without risking injury (Malshikare et al., 2017). Hand grip strength varies significantly between the dominant and non-dominant hand, and musicians often experience a decline in Hand grip strength over time due to repetitive strain from playing their instruments (Malshikare et al., 2017). As musicians age, they may experience a decline in hand strength, particularly in the fourth decade of life (Malshikare et al., 2017). This loss of muscle strength can lead to an increased risk of injury and a decline in performance quality causing them to struggle with techniques they once found easy, such as pressing down hard strings on a guitar or rapidly moving fingers across a piano keyboard. Musicians who do not maintain their hand strength are more likely to suffer from performance-related musculoskeletal disorders (PRMDs) including conditions such as carpal tunnel syndrome, tendinitis, and focal hand dystonia, all of which are linked to overuse and muscle weakness (Malshikare et al., 2017). Different instruments place varying demands on hand strength. For example: Guitarists require strong grip strength to press down on strings and execute techniques such as bending or vibrato.

Without sufficient strength, these movements become difficult to sustain over time, leading to fatigue and potential injury (Malshikare et al., 2017).

In a study by Mariyam (2021), Finger and hand exercises were given to the participants for 4 weeks. After 4 weeks of study to analyse their level of pain, a hand held cornell musculoskeletal discomfort questionnaire, VAS score and hand grip dynamometer were used to find the effect of finger and hand exercise. The study concluded that as the Hand Grip Strength increased, the level of pain reduced.

Hand Grip strength is a vital component of music performance, significantly influencing technical proficiency, injury prevention, and expressive capabilities. Recognizing the importance of developing hand strength through targeted training and conditioning can greatly enhance a musician's overall performance and longevity in their craft.

2.5 Empirical Review

2.5.1 "Epidemiology of Musculoskeletal Disorders in Musicians – Systematic Review" by Shinde and Borkar (2021)

This systematic review by Shinde and Borkar (2021) focused on Playing-Related Musculoskeletal Disorders (PRMDs) among musicians. The review addressed both intrinsic (age, gender, body size) and extrinsic (posture, environment) factors influencing the development of these disorders. Musicians face occupational hazards, including awkward postures and prolonged practice hours, contributing to high PRMD prevalence.

The systematic review utilised multiple databases (PubMed, Google Scholar, etc.) to identify studies on PRMDs among musicians. The inclusion criteria were clear, focusing on full-text, cross-sectional or observational studies from the past 10 years, including musicians aged 18-79.

Studies were excluded if they were duplicates or lacked adequate statistical analysis. The article follows the PRISMA framework, ensuring a transparent and replicable review process. A thorough screening process yielded 19 studies for synthesis, chosen based on the QUADAS tool, which assessed the methodological quality. This adds credibility, though there was room for improvement, as 7 studies were classified as low quality and 14 as moderate.

The review consistently found:

- high PRMD rates, with 83% to 90% of musicians experiencing symptoms in the past year.
- Women were more likely to report musculoskeletal pain, particularly in the neck, shoulders and wrists
- Performance anxiety and stage fright were found to exacerbate musculoskeletal symptoms
- Awkward postures and prolonged use of upper extremities put Musicians at risk of PRMDs

2.5.2 "The Prevalence of Playing-Related Musculoskeletal Disorders in Relation to Piano Players' Playing Techniques and Practising Strategies" by Lili Allsop and Tim Ackland (2010)

This study investigates the prevalence of Playing-Related Musculoskeletal Disorders (PRMDs) among piano players, focusing on their playing techniques and practice strategies. PRMDs are common in musicians due to repetitive movements, awkward postures, and prolonged practice sessions. The study explores how various factors like wrist, shoulder, and elbow postures, practice habits, and hand span contribute to the development of PRMDs.

The study employed a self-administered questionnaire distributed to both professional and non-professional pianists. The sample size was large (505 respondents), and the questionnaire showed high reliability (test-retest reliability r = .92). Respondents ranged in age from 12 to 89, with a mix of professional musicians, non-professional players, teachers, and performers. Key

methods of analysis included Chi-square tests and ANOVAs, which were used to assess relationships between PRMDs and playing techniques, hand span, professional status, practice habits, and demographics.

The key findings were:

High PRMD Prevalence: 42.4% of respondents reported experiencing PRMDs. Among professional pianists, this rate was much higher at 71.9%, indicating that more frequent and intense playing increases the risk of PRMDs.

Playing Techniques and Postures: Neutral wrist posture was associated with the highest rate of PRMDs (47%), while players using weight-playing or traditional techniques had lower rates. Elevated shoulder posture was significantly associated with PRMDs, but no significant relationship was found for elbow or finger postures.

Practice Habits: Longer practice hours were strongly associated with PRMDs, particularly among those practising more than 11 hours per week. Interestingly, professional players who took more frequent breaks were less likely to experience PRMDs, while non-professionals who experienced PRMDs tended to take longer breaks in response to their discomfort.

Age and Gender: Older respondents were more likely to report PRMDs, with the highest prevalence among those aged 41-89 years. Female respondents were also more likely to experience PRMDs than males (45.9% vs. 33.8%).

2.5.3 “Assessing Hand Grip Strength and Screening of Performance-Related Upper Limb Injuries Experienced by Indian Musicians" by Ajay Malshikare et al.

The study aims to assess hand grip strength and screen for performance-related upper limb injuries among Indian musicians. The research includes guitar, sitar, keyboard, harmonium, and tabla players, exploring the connection between musical performance and musculoskeletal

issues. The focus is on the hand grip strength, a critical factor for musicians, and the prevalence of upper limb injuries related to overuse, faulty technique, and prolonged practice sessions.

This is a cross-sectional survey conducted on 100 Indian musicians between the ages of 20 and 60 years. The inclusion criteria required musicians to have been playing their instrument for at least two years and practising for a minimum of two hours daily. Exclusion criteria included pre-existing musculoskeletal or neurological injuries and musicians engaged in other forms of repetitive upper limb activities, such as heavy computer usage or industrial work. Hand grip strength was measured using a modified mercurial type sphygmomanometer, following the protocol established by the American Society of Hand Therapists. Musicians were asked to press the cuff as hard as possible three times, with a rest period of five minutes between each trial. Data was analysed using paired sample t-tests and other statistical methods to compare hand grip strength between the dominant and non-dominant hands.

They key findings were:

High Prevalence of Upper Limb Injuries: The study found that 66% of the musicians experienced some form of performance-related upper limb symptom, with significant pain being the most common complaint (45%). Other symptoms included abnormal sensations, muscle weakness, numbness, and lack of coordination.

Hand Grip Strength Differences: There was a significant difference between dominant and non-dominant hand grip strength ($p = 0.034$), with the dominant hand typically being stronger.

Gender and Age Impact: Male musicians had significantly higher hand grip strength than female musicians, in line with general trends observed in grip strength research. Additionally,

grip strength tended to decline with age, beginning in the fourth decade of life (ages 40 and above).

Instrument-Specific Findings:

-Guitarists showed the highest incidence of performance-related symptoms (75%), likely due to the high demand for grip strength and repetitive motions.

-Tabla players were found to experience significant strain on their wrist and shoulder muscles due to the continuous use of the extensor muscles during performances.

-Keyboard players had lower overall hand grip strength compared to string players but still faced issues with pain and muscle fatigue, particularly due to poor posture and improper technique.

2.5.4 "Effects of Hand Span Size and Right-Left Hand Side on the Piano Playing Performances: Exploration of the Potential Risk Factors with Regard to Piano-Related Musculoskeletal Disorders" by Lai et al. (2015)

Lai et al. (2015) investigate the biomechanical effects of hand span size and hand side (right vs. left) on piano performance, focusing on risk factors that may contribute to piano-related musculoskeletal disorders (PRMDs). The primary objective of the study is to explore whether small-handed pianists face greater risks of PRMDs due to biomechanical constraints while playing the piano, specifically in terms of finger and wrist motion. The study also examines whether there are notable differences in performance and strain between the right and left hands.

This study involved 20 female pianists divided into two groups based on hand span size (small hand span and large hand span. Using a combination of biomechanical analysis techniques, the researchers measured key parameters, including:

- The ratio of maximal digit-to-digit abduction angle.

- Range of motion (ROM) in finger and wrist flexion-extension.

- Radial-ulnar deviation.

- Movement units of finger joints and fingertip force during piano playing.

Data were collected using eight motion-capture cameras, pressure sensors to estimate fingertip force, and other advanced biomechanical tools. The participants played both chords and octaves during testing, and the collected data was analysed for differences between the SHS and LHS groups, as well as between the left and right hands.

The study found several significant differences in the performance of pianists with small and large hand spans:

Finger Abduction: Pianists with smaller hand spans displayed significantly larger maximal digit-to-digit abduction angles when playing both chords and octaves. In some cases, the angles exceeded their self-perceived maximal static hand span, indicating overextension.

Wrist ROM: Small hand-span pianists exhibited larger wrist flexion/extension ROM when playing chords, which suggests they are compensating for their smaller hands by increasing wrist movement.

Fingertip Force: While the fingertip force did not differ significantly between the SHS and LHS groups, the right hand generally exhibited higher striking force than the left hand, indicating a greater workload for the dominant hand.

Movement Units: There were significant differences in movement units between the left and right hands, particularly in the small hand-span group. The right hand showed more joint excursions and movement units, which suggests that it is subject to greater strain.

2.5.5 "Effect of Upper Limb Exercises on Grip Strength in Piano Players" by Kurian and Malarvizhi (2021)

The study by Kurian and Malarvizhi (2021) investigates the effects of upper limb exercises on grip strength among piano players. The study is grounded in the understanding that piano players often overuse the distal musculature of the upper limb, while neglecting the proximal muscles. This imbalance can lead to musculoskeletal disorders (MSDs), pain, and reduced grip strength. The researchers aimed to determine whether a targeted upper limb exercise regimen could improve grip strength and alleviate the musculoskeletal challenges faced by piano players.

The study followed an experimental design with a pre- and post-test structure. Thirty piano players, aged 18 to 30, were selected using convenience sampling and divided into two groups:

-Group A (15 participants): Experimental group, which followed a three-week upper limb exercise protocol.
-Group B (15 participants): Control group, which received postural correction advice.

The participants were assessed for grip strength using a hand dynamometer both before and after the intervention. Group A followed a progressive exercise program over three weeks, targeting intrinsic and extrinsic muscles of the hand, fingers, and proximal upper limbs. The exercises included squeezing therapeutic putty, resistance web exercises, and finger independence exercises. Group B received only postural correction instructions. Data were analyzed using IBM SPSS version 20.

The results demonstrated a significant improvement in grip strength in both groups, but the experimental group (Group A) showed a greater increase in strength compared to the control group.

Pre-Test Results: Group A had a mean grip strength of 29.53, and Group B had a mean of 31.47.

Post-Test Results: Group A improved to a mean grip strength of 38.73, while Group B improved to 34.47.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Participants

3.1.1 Participant Selection

This study focused on keyboard instrumentalists in Benin City who have engaged in regular performance and practice in the past 2 years. The recruitment process entailed outreach to churches and local music schools. Interested participants underwent a screening process to confirm their eligibility based on the inclusion criteria outlined below:

3.1.2 Inclusion Criteria

Participants satisfied the following criteria to be eligible for this study:

-Active engagement as keyboard instrumentalists in the past two years.

-Age range: 18 years and above

-No history of major hand or wrist surgeries within the last five years.

-Capability to provide informed consent for participation.

3.1.3 Exclusion Criteria

Participants were excluded from the study if they meet any of the following criteria:

-A history of significant musculoskeletal injuries or disorders affecting the hands, wrists, arms, shoulders or low back within the past five years.

-Use of assistive devices while playing the keyboard.

-Inability to communicate effectively in English, as the questionnaires will be administered in English.

3.2 Materials

3.2.1 Apparatus/Instruments

The following materials was employed for data collection:

Questionnaires: The Maastricht questionnaire was used to assess musculoskeletal complaints.

A measuring tape: This was used to measure hand dimensions (hand span, width, length, circumference, shape, wrist circumference) and the height of the participants.

Camry Hand Grip Dynamometer: This was used to measure the hand grip strength

Weighing scale: This was used to measure body weight.

BMI : This was calculated by dividing the weight in kg by the height in metres squared (NHS, 2023).

3.3 Methods

3.4.1 Research Design

A cross-sectional research design was employed in this study.

3.4.2 Sampling Technique

A consecutive technique was utilized to select participants who fulfill the specified inclusion criteria. This technique allowed for a concentrated approach ensuring that the sample consisted of individuals who can provide relevant data pertaining to the research objectives.

3.4.3 Sample size

The sample size for this study was determined using Cochran's formula, which is appropriate for estimating sample sizes in studies where the population size is unknown. The formula is defined as follows: $n = \frac{Z^2 p(1-p)}{e^2}$

Where:

n = initial sample size

Z = Z-score corresponding to the desired confidence level (1.96 for a 95% confidence level)

p = estimated proportion of the population (0.5 is used to maximise variability)

e= margin of error (set at 0.05)

Using these parameters, the initial sample size was calculated as follows:

n = ((1.96)2 (0.5) (0.5)) / (0.05)2 = 384

But a total of 115 participants were finally recruited for this study.

3.4.4 Ethical Considerations

Ethical approval for the study was obtained from the Ministry Of Health Benin City, prior to the initiation of data collection. Informed consent was secured from all participants, ensuring they understand the study's purpose, procedures, potential risks, and their right to withdraw at any time without penalty. The confidentiality of participant information was maintained throughout the research.

3.4.5 Procedure for Data Collection

Upon obtaining ethical approval, data collection occurred. During this time, participants were approached for participation in the study. They were required to complete the maastricht

questionnaire. Furthermore, participants underwent physical assessments for hand dimensions and hand grip strength using the previously mentioned measuring tools.

3.4.4 Procedure for Assessments and Measurements

Hand Dimensions: Participants' hand dimensions were measured using a tape rule. Hand dimensions parameters measured were hand length, hand span, hand circumference, wrist circumference, hand width, and hand shape following the protocol described by earlier studies (Nacul et al., 2018, Kaplan, 2016). Hand length was measured from the tip of the middle finger to the midline of the distal wrist crease with the forearm in supination. Hand span was measured as the distance from the tip of the thumb to the tip of the small finger in full extension of all fingers. Hand circumference was measured by wrapping the tape around the hand at the transverse palmar crease beginning from the side of the palm just below the pinky finger to the inside of the hand between the index finger and the thumb. Wrist circumference will be measured by taking the circumference of the wrist at the wrist crease. Hand width was measured from the radial side of the second metacarpal joint of the thumb to the ulnar side of the fifth metacarpal joint. Hand shape was calculated as the ratio of the hand width to hand length.

Hand Grip Strength: HGS was measured in kilogram (kg) using the digital hand grip dynamometer. The participants were seated in a chair with shoulder adducted and neutrally rotated and elbow supported in 90° flexion with no radio-ulnar deviation. The participants were required to squeeze the handle maximally and sustain it for 3–5 seconds. All measurements were performed for both hands. Participants' handedness (dominance and non-dominance) were determined based on self-reports as reported in previous studies (Hardie and Wright, 2014; Adamo and Taufiq, 2011). Results were recorded in kilograms. Each participant performed three trials, and the maximum recorded value was used for analysis.

Body weight: Body weight was measured using a portable Bathroom weighing scale.

Height : Height was measured with a measuring tape.

BMI : This was calculated by dividing the weight in kg by the height in metres squared (Khanna, 2022)

Musculoskeletal Complaints: The Maastricht Upper Extremity Questionnaire (MUEQ) is one of the best assessment tools for Upper extremity musculoskeletal disorders that considers workplace and psychosocial factors. Its validity and reliability have been measured and confirmed across countries (Rahnama et al, 2020). The maastricht questionnaire was used to assess the musculoskeletal complaints of the keyboard instrumentalist. It comprised of different sections;

Section A (General Information): This included informations like Demographics (age, gender), anthropometrics (height, weight and BMI), years of experience, daily and weekly duration.

Section B (Workstation): This section assessed the physical setup of the instrumentalist's workstation

Section C (body posture during playing): This section described the specific body postures adopted during playing.

Section C (Job Control) : This section evaluated the instrumentalist's control over their practice routine and playing environment. It included questions about how much autonomy they have in deciding how to perform their tasks, manage their practice time, and solve any problems that arise during practice. The level of job control is important in understanding whether instrumentalists can adjust their workload and practice sessions to prevent overuse injuries. A high degree of control can allow for better self-regulation, reducing strain and stress.

Section D (Job Demand) : In this section, the focus was on the physical and mental demands placed on the instrumentalist. Questions explored whether they felt pressure to achieve mastery

over their instrument, struggle to complete practice sessions on time, or feel the need to extend their practice hours. These demands could lead to stress and physical overexertion, which are both risk factors for PRMDs

Section E (Break Time) : This section assessed the instrumentalist's ability to take breaks during practice sessions. Questions examined whether they plan breaks, alternate their posture, or take sufficient rest periods to relieve physical strain.

Section F (Work Environment) : This section evaluated the physical environment where the instrumentalist practices, focusing on factors such as comfort, noise levels, air quality, and lighting. These environmental factors can affect both the mental and physical well-being of the instrumentalist.

Section G (Musculoskeletal Complaints) : This section investigated specific musculoskeletal complaints experienced by keyboard instrumentalists over the past year. It covered various body regions that are commonly affected by playing, including the neck, shoulders, upper arms, elbows, lower arms, wrists, hands, and the low back. The instrumentalist was asked to indicate whether they have experienced pain in any of these areas and to specify the affected side (left, right, or both).

Section H (Complaints After Playing) : This section examined the symptoms that develop specifically after playing the keyboard. It included questions about pain, fatigue, stiffness, numbness, weakness, and swelling in the upper body and low back.

3.5 Data Analysis

The data collected from the questionnaires and assessments was coded and analyzed using statistical software (e.g., SPSS version 25). Descriptive statistics of mean, standard deviation, frequency and percentage was used to summarize the data. was computed to summarize participant demographics and key variables. Inferential statistics of Pearson product moment of

correlation coefficient was employed to examine relationships between hand grip strength and hand dimensions.. A significance level of $p < 0.05$ was established for all statistical tests.

CHAPTER 4

RESULTS

Table 4.1 analyzed key variables, including age, height, weight, hand dimensions, and grip strength, for a sample of 115 keyboard instrumentalists in Benin City. These metrics help contextualize the findings and establish the physical profiles of the participants. The mean age of participants was 23.75 years (SD = 3.8), with a range of 18 to 39 years.

The average height of participants was 1.74 m (SD= 0.10), while the average weight was 73.44 kg (SD =7.58). These values suggest a generally healthy BMI distribution, with a mean BMI of 23.92 (1.36).

The mean Hand Length was 19.34 cm (SD= 1.40). The mean Hand Span was 20.39 cm (SD=1.59). The mean Hand Circumference was 19.16 cm (SD=1.56). The mean Hand Width was 8.97 cm (SD=0.72). The mean wrist circumference was 17.59cm (SD=1.68).

The mean Dominant Hand HGS was 44.22kg (SD = 8.04). The mean Non-Dominant Hand HGS was 39.31kg (SD = 8.22)

TABLE 4.1: PARTICIPANTS' PHYSICAL CHARACTERISTICS (N = 115)

Variables	Mean± SD	Minimum	Maximum
Age (Years)	23.7478 ± 3.80637	18.00	39.00
Height (m)	1.7403 ± .10375	0.75	1.82
Weight (kg)	73.4435 ± 7.5811	58.00	92.00
Hand length (cm)	19.3435 ± 1.40232	16.50	23.00
Handspan (cm)	20.3870 ± 1.58676	17.50	25.00
Hand circumference (cm)	19.1565 ± 1.56352	16.00	23.00
Hand width (cm)	8.9722 ± .71911	7.00	11.00
Handshape (cm)	0.4680 ± .01607	0.43	0.50
Wrist circumference (cm)	17.5886 ±1.68285	14.50	21.00
HGS dominant (cm)	44.2174 ± 8.03805	24.00	68.00
HGS non dominant (cm)	39.3130 ± 8.21569	21.00	64.00
Bmi	23.9239 ± 1.36153	21.48	28.39

Table 4.2 shows that the majority of respondents are male (81.7%), while a smaller proportion are female (18.3%). This indicates a significant gender disparity among the participants. Most participants reported playing two keyboard instruments (53.9%), followed by those who play only one instrument (19.1%). A smaller proportion played three instruments (18.3%) and four instruments (8.7%). A significant majority (95.7%) currently play one instrument, with only 4.3% playing two instruments. The majority of participants have been playing for 1–5 years (62.6%). About 30.4% have been playing for 6–10 years, while only 7% have over 11 years of experience. The number of days participants practice in a week varies, with 31.3% practicing 5 days or more. Practice durations of 3 days and 4 days were reported by 25.2% and 20.6% of respondents, respectively, while 2 days had the least frequency (13.9%). Most participants practice for 1 hour per day (37.4%). Other durations include 2 hours (23.5%), 3 hours (16.5%), and 4 hours (13%). Only 9.6% practice for 5 hours or more. Over half (58.3%) of the respondents spend more than 5 hours practicing per day, including breaks and overtime. Smaller proportions practice 4 hours (14.8%), 3 hours (13.9%), 2 hours (10.4%), and 1 hour (2.6%).

Table 4.2: PARTICIPANTS' GENERAL INFORMATION ON PLAYING THE KEYBOARD INSTRUMENT (N = 115)

	Frequencies (n)	Percentage (%)
Gender		
Male	94	81.7
Female	21	18.3
Keyboard instrument Played		
1 instrument	22	19.1
2 instruments	62	53.9
3 instruments	21	18.3
4 instruments	10	8.7
Keyboard instrument Played currently		
1 instrument	110	95.7
2 instrument	5	4.3
Years of playing		
1 – 5years	72	62.6
6 – 10 years	35	30.4
11 years and above	8	100.0
Week		
2 days	16	13.9
3 days	29	25.2
4 days	34	29.6
5 days and above	36	31.3
1 hours	43	37.4
2 hours	27	23.5
3 hours	19	16.5
4 hours	15	13.0
5 hours and above	11	9.6
Hours per day plus Breaks and overtime		
1 hour	3	2.6
2 hours	12	10.4
3 hours	16	13.9
4 hours	17	14.8
5 hours and above	67	58.3

Table 4.3 shows that a vast majority of respondents (95.7%) indicated that the height of their keyboard is appropriate, with only 4.3% considering it too high. Most participants (83.5%) do not maintain a standing position for extended periods, while 16.5% reported doing. A majority of participants (92.2%) do not bend their back while playing, whereas 7.8% often play with their back bent. About 22.6% of respondents often play with their elbows bent, while 77.4% do not. Nearly a quarter of the respondents (23.5%) reported repeatedly using their fingers throughout their playing period, while 76.5% do not engage in this behavior. Approximately 19.1% of respondents repeatedly bend their neck while playing, with 80.9% indicating they do not. A smaller proportion (18.3%) engage in vigorous playing with their fingers and wrist, while the majority (81.7%) do not. Only 12.2% of participants repeatedly twist their wrist while playing, whereas 87.8% do not.

TABLE 4.3: PARTICIPANTS' KEYBOARD WORK STATION (N = 115)

	Frequencies (n)	Percentage (%)
Keyboard is too high		
Yes	5	4.3
No	110	95.7
I maintain standing position For a long period of time		
Yes	19	16.5
No	96	83.5
My back is often bent while playing		
Yes	9	7.8
No	106	92.2
My elbow is often bent while playing		
Yes	26	22.6
No	89	77.4
I repeatedly use my fingers throughout my playing period		
Yes	27	23.5
No	88	76.5
I repeatedly bend my neck while playing		
Yes	22	19.1
No	93	80.9
I do vigorous playing with my fingers and wrist		
Yes	21	18.3
No	94	81.7
I repeatedly twist my wrist while playing		
Yes	14	12.2
No	101	87.8

Table 4.4 shows that the majority of participants (78.3%) reported "often" maintaining a good playing posture, with 10.4% indicating they "always" or "sometimes" do so.

A negligible percentage (0.9%) seldom maintain a good posture, and none reported never maintaining one. Most participants (73.9%) "often" sit for extended periods in the same position, while 17.4% "always" do so. Only 5.2% reported "sometimes," and even fewer (2.6%) "seldom" or "never" sit for long hours. The majority of participants (73.0%) "sometimes" play for more than two hours daily, with 16.5% "often" doing so. Only 3.5% "always" play for such extended periods, while 6.1% "seldom" and 0.9% "never" exceed two hours. More than half of the participants (58.3%) "sometimes" take awkward postures while playing, with 10.4% "often" and 4.3% "always" adopting such postures. About 25.3% "seldom" take awkward postures, and 1.7% "never" do. A significant proportion (40.9%) "sometimes" perform repetitive tasks during playing sessions, while 17.4% "often" and 7.8% "always" do so. A smaller percentage (32.2%) "seldom" perform repetitive tasks, and 1.7% "never" engage in them. Playing the keyboard was reported as "sometimes" physically exhausting by 41.7% of participants, with 7.0% experiencing exhaustion "often" and 1.7% "always." A substantial proportion (37.4%) "seldom" find it exhausting, and 12.2% "never" feel exhausted. Half of the participants (50.4%)"sometimes" keep their arms and forearms aligned, while 13.0% "often" and 5.2% "always" do so.

About 26.1% "seldom" maintain alignment, and 5.2% "never" align their forearms.

Head bending during playing is "sometimes" reported by 46.1% of participants, with 13.9% "often" and 2.6% "always" bending their heads. Meanwhile, 31.3% "seldom" and 6.1% "never" bend their heads while playing. Nearly half of the participants (48.7%) "sometimes" twist their heads to the left or right during playing. Smaller proportions "often" (7.0%) or "always" (3.5%) experience this, while 35.7% "seldom" and 5.2% "never" twist their heads. A majority (53.9%) reported "sometimes" twisting their trunk during playing, with smaller percentages "often" (5.2%) or "always" (2.6%) twisting. About 27.0% "seldom" twist their trunk, and 11.0% "never" do. The trunk being in an asymmetrical position was reported "sometimes" by 36.5% of participants, with an equal proportion (36.5%) "seldom" experiencing this. A small percentage "often" (6.1%) or "always" (3.5%) report an asymmetrical trunk, while 17.4%"never" have this posture.

TABLE 4.4: PARTICIPANTS' BODY POSTURE WHILE PLAYING THE KEYBOARD INSTRUMENT(N = 115)

	Frequencies (n)	Percentage (%)
I keep a good playing posture		
Always & Often	102	88.7
Sometimes	12	10.4
Seldom & Never	1	0.9
I sit for long hours in one position		
Always & Often	105	91.3
Sometimes	6	5.2
Seldom & Never	4	3.5
I play for more than two hours per day		
Always & Often	23	20.0
Sometimes	84	73.0
Seldom & Never	8	7.0
I take awkward posture		
Always & Often	17	14.7
Sometimes	67	58.3
Seldom & Never	31	27.0
I perform repetitive tasks		
Always & Often	29	25.2
Sometimes	47	40.9
Seldom & Never	39	33.9
Playing is physically exhausting		
Always & Often	10	8.7
Sometimes	48	41.7
Seldom & Never	57	49.6
my arms & forearms are aligned		
Always & Often	21	18.2
Sometimes	58	50.4
Seldom & Never	36	31.3
My head is bent		
Always & Often	19	16.5
Sometimes	53	46.1
Seldom & Never	43	37.4
Head is twisted towards the left or right		
Always & Often	12	10.5
Sometimes	56	48.7
Seldom & Never	47	40.9
Trunk is twisted towards the left or right		
Always & Often	9	7.8
Sometimes	62	53.9
Seldom & Never	44	38.0
My trunk asymmetrical		
Always & Often	11	9.6
Sometimes	42	36.5
Seldom & Never	62	53.9

Table 4.5 shows a majority (76.5%) of participants often decide how to perform their tasks, while 16.5% always make such decisions. Very few (7.0%) sometimes decide on tasks, and none reported seldom or never having control over task decisions. 60.9% of participants often engage in decision-making, and 30.4% always participate. Only a small percentage (7.0%) sometimes participate, while 1.7% seldom do. Most participants (60.9%) often decide their own playing tasks, with 27.0% always doing so. A smaller proportion (11.3%) sometimes choose their tasks, and just 0.9% reported seldom making these decisions. A significant majority (60.0%) often determine the time speed of their playing tasks, with 30.4% always having this control. Only 8.7% sometimes have control, and 0.9% seldom do. More than half (57.4%) of participants often solve problems independently, while 28.7% always do so. A smaller percentage (13.9%) sometimes engage in problem-solving. Playing tasks are seen as developmental, with 58.3% often and 35.7% always agree that playing develops their ability. Creativity is a key component, as 57.1% often and 33.9% always report the need to be creative during playing. 65.2% of participants often learn new skills during playing, with 27.8% always gaining new skills. Over half (55.7%) often perform different tasks during playing, while 27.8% always do so.

TABLE 4.5: PARTICIPANTS' JOB CONTROL WHILE PLAYING THE KEYBOARD INSTRUMENT (N = 115)

	Frequency (n)	Percentage (%)
I decide how to perform tasks		
Always & Often	107	93.0
Sometimes	8	7.0
Seldom & Never	0	0.0
I participate in decision making		
Always & Often	105	91.3
Sometimes	8	7.0
Seldom & Never	2	1.7
I decide my own playing tasks		
Always & Often	101	87.9
Sometimes	13	11.3
Seldom & Never	1	0.9
I determine time speed of my playing task		
Always & Often	104	90.4
Sometimes	10	8.7
Seldom & Never	1	0.9
I solve playing problems by myself		
Always & Often	99	86.1
Sometimes	16	13.9
Seldom & Never	0	0.0
Playing develops my ability		
Always & Often	108	94.0
Sometimes	7	6.1
Seldom & Never	0	0.0
I learn new skills during playing		
Always & Often	107	93.0
Sometimes	8	7.0
Seldom & Never	0	0.0
I have to be creative during playing		
Always & Often	107	91.0
Sometimes	8	7.0
Seldom & Never	0	0.0
I do different tasks during playing		
Always & Often	96	83.5
Sometimes	13	11.3
Seldom & Never	6	5.2

Table 4.6 The data highlights that participants generally experience minimal pressure or difficulty while playing. A significant majority (72.2%) never play under extensive pressure, and 65.2% find it easy to master new techniques, as they never struggle with it. Most participants (59.1%) rarely play extra hours to improve performance, and 58.3% seldom lack time to prepare adequately. Additionally, 47.8% never feel the need to speed up practice sessions, and 74.8% do not find playing the keyboard difficult. Finally, 57.4% report they never have too many tasks while playing. These results suggest that playing is largely a low-stress and manageable activity for the participants.

TABLE 4.6: PARTICIPANTS' JOB DEMAND WHILE PLAYING THE KEYBOARD INSTRUMENT (N = 115)

	Frequency (n)	Percentage (%)
I play under extensive pressure		
Always & Often	5	4.3
Sometimes	13	11.3
Seldom & Never	97	84.4
I find it difficult to master new technique		
Always & Often	3	2.6
Sometimes	8	7.0
Seldom & Never	104	90.4
I play extra hours to improve my performance		
Always & Often	13	11.3
Sometimes	12	10.4
Seldom & Never	90	78.3
I don't have enough time to prepare for performance		
Always & Often	20	17.3
Sometimes	28	24.3
Seldom & Never	67	58.3
I speed up my practice to complete performance		
Always & Often	8	7.0
Sometimes	18	15.7
Seldom & Never	89	77.4
I find playing the keyboard difficult		
Always & Often	3	2.6
Sometimes	7	6.1
Seldom & Never	105	91.3
I have too many tasks while playing		
Always & Often	5	4.3
Sometimes	11	9.6
Seldom & Never	99	86.1

Table 4.7 indicates that participants generally have good control over planning and managing their practice sessions and breaks. A large proportion can plan their breaks (78.3% often, 11.3% always) and divide practice sessions (51.4% often, 36.5% always). Most can decide when to take breaks (54.8% often, 31.4% always) and alternate their body posture (53.9% often, 26.1% always). Alternating practice time is common, with 60.0% often and 20.0% always doing so. Participants frequently perform without intense finger and wrist movements (53.9% often, 23.5% always) and take breaks after 2 hours (53.9% often, 20.9% always). Additionally, 56.5% find their playing breaks sufficient, while 30.4% always do. This suggests a well-balanced and sustainable approach to practice and playing routines.

TABLE 4.7: PARTICIPANTS' BREAK TIMING WHILE PLAYING THE KEYBOARD INSTRUMENT (N = 115)

	Frequency (n)	Percentage (%)
I can plan my breaks		
Always & Often	103	89.6
Sometimes	11	9.6
Seldom & Never	1	0.9
I can divide my practice session		
Always & Often	101	87.9
Sometimes	14	12.2
Seldom & Never	0	0.0
I can decide when to take breaks		
Always & Often	99	86.2
Sometimes	15	13.0
Seldom & Never	1	0.9
I alternate my body posture		
Always & Often	92	80.0
Sometimes	21	18.3
Seldom & Never	2	1.7
I alternate my practice time		
Always & Often	92	80.0
Sometimes	20	17.4
Seldom & Never	3	2.6
I perform without intense finger and wrist movements		
Always & Often	89	77.4
Sometimes	21	18.3
Seldom & Never	5	4.4
I take a break after 2 hours		
Always & Often	86	74.8
Sometimes	27	23.5
Seldom & Never	2	1.7
My playing break is sufficient		
Always & Often	100	87.0
Sometimes	14	12.2
Seldom & Never	1	0.9

Table 4.8 reflects that most participants have a conducive playing environment, with 78.3% reporting a good environment often and 15.7% always. A significant majority (73.9% often, 18.3% always) carry out their practice independently. However, assistance during playing is rare, with 67.0% sometimes assisted and 13.9% often. Carrying other instruments on the neck is infrequent, as 34.8% never do so, and 49.6% only sometimes. Fresh air availability is common (45.2% often, 41.7% sometimes), but noisy environments are uncommon, with 63.5% reporting noise sometimes and 18.3% seldom. Playing at night is rare, with 68.7% doing so sometimes and 17.4% seldom. Assistive devices are not widely used (41.7% never use them, 43.5% sometimes), and carrying heavy instruments on the neck is uncommon, as 48.7% never find them heavy. Overall, participants enjoy favorable environmental conditions with minimal strain or assistance requirements.

TABLE 4.8: PARTICIPANTS' WORK ENVIRONMENT WHILE PLAYING THE KEYBOARD INSTRUMENT (N = 115)

	Frequency (n)	Percentage (%)
My playing environment is good		
Always & Often	108	94.0
Sometimes	6	5.2
Seldom & Never	1	0.9
I carry out my practice myself		
Always & Often	106	92.2
Sometimes	8	7.0
Seldom & Never	1	0.9
I am assisted when playing		
Always & Often	20	17.4
Sometimes	77	67.0
Seldom & Never	18	15.6
I carry other instrument on my neck when playing		
Always & Often	11	9.6
Sometimes	57	49.6
Seldom & Never	47	40.9
There is available fresh air in my playing area		
Always & Often	58	50.4
Sometimes	48	41.7
Seldom & Never	9	7.9
My playing environment is noisy		
Always & Often	13	11.3
Sometimes	73	63.5
Seldom & Never	29	25.3
I play at night		
Always & Often	11	9.6
Sometimes	79	68.7
Seldom & Never	25	21.7
I use assistive devices while playing		
Always & Often	8	7.0
Sometimes	50	43.5
Seldom & Never	57	49.6
The other instrument on my neck is heavy		
Always & Often	4	3.5
Sometimes	42	36.5
Seldom & Never	69	60.0

Table 4.9 indicates that playing tasks generally proceed smoothly, with 79.1% often experiencing smooth sessions and 16.5% always. A majority (74.8% often, 14.8% always) feel comfortable asking questions. Dependency on colleagues is moderate, with 55.7% often and 28.7% sometimes relying on them. The playing atmosphere is largely comfortable for most (69.6% often, 15.7% always). Support from colleagues after mistakes is common (62.6% often, 23.5% sometimes), while supervisor support is slightly less frequent, with 66.1% often and 24.3% sometimes finding it. Colleagues are generally friendly, as 62.6% report this often and 23.5% sometimes. Supervisors are perceived as friendly by 54.8% often and 31.3% sometimes. Overall, the environment supports collaboration and comfort.

TABLE 4.9: PARTICIPANT'S SOCIAL SUPPORT WHILE PLAYING THE KEYBOARD INSTRUMENT (N = 115)

	Frequency (n)	Percentage (%)
Playing goes smoothly		
Always & Often	110	95.7
Sometimes	5	4.3
Seldom & Never	0	0.0
I can ask and enquire in my playing task		
Always & Often	103	89.6
Sometimes	11	9.6
Seldom & Never	1	0.9
My play depends on colleagues		
Always & Often	75	65.3
Sometimes	33	28.7
Seldom & Never	7	6.1
My playing atmosphere is comfortable		
Always & Often	98	85.3
Sometimes	16	13.9
Seldom & Never	1	0.9
If I make mistakes, I find support from my colleagues		
Always & Often	83	72.2
Sometimes	27	23.5
Seldom & Never	5	4.4
If I make mistakes, I find support from my supervisors		
Always & Often	80	69.6
Sometimes	28	24.3
Seldom & Never	7	6.1
My colleagues are friendly		
Always & Often	88	76.5
Sometimes	27	23.5
Seldom & Never	0	0.0
My supervisors are friendly		
Always & Often	76	66.1
Sometimes	36	31.3
Seldom & Never	3	2.6

Table 4.10 indicates that the majority of participants reported experiencing pain in various parts. For the neck, 86.1% of participants reported experiencing pain, while 13% indicated no pain. In the shoulder, the highest percentage (61.7%) reported pain on the right side, followed by 15.7% who reported pain on the left side, 14.8% with no pain, and 7.8% experiencing pain on both sides. For the upper arm, 62.6% reported pain on the right, 16.5% on the left, 15.7% no pain, and 5.2% on both sides. In the elbow region, 67% experienced pain on the right, 17.4% on the left, 12.2% no pain, and 3.5% pain on both sides. In the lower arm, pain on the right side was most common at 63.5%, followed by 18.3% who reported no pain, 15.7% with pain on the left side, and 2.6% experiencing pain on both sides. For the wrist, 63.5% reported pain on the right, 18.3% on the left, 11.3% pain on both sides, and 7% no pain. Finally, for the hand, 61.7% reported pain on the right, 16.5% on the left, 14.8% no pain, and 7% experiencing pain on both sides. This distribution suggests that the right side of the body is more commonly affected by pain among the participants.

TABLE 4.10: PREVALENCE OF MUSCULOSKELETAL COMPLAINTS OF PARTICIPANTS' IN THE NECK AND UPPER EXTREMITY (N = 115)

	Frequency (n)	Percentage (%)
Neck		
There is pain	99	86.1
No pain	16	13.0
Shoulder		
No pain	17	14.8
Pain on left	18	15.7
Pain on right	71	61.7
Pain on both sides	9	7.8
Upper arm		
No pain	18	15.7
Pain on left	19	16.5
Pain on right	72	62.6
Pain on both sides	6	5.2
Elbow		
No pain	14	12.2
Pain on left	20	17.4
Pain on right	77	67.0
Pain on both sides	4	3.5
Lower arm		
No pain	21	18.3
Pain on left	18	15.7
Pain on right	73	63.5
Pain on both sides	3	2.6
Wrist		
No pain	8	7.0
Pain on left	21	18.3
Pain on right	73	63.5
Pain on both sides	13	11.3
Hand		
No pain	17	14.8
Pain on left	19	16.5
Pain on right	71	61.7
Pain on both sides	8	7.0

Table 4.11 shows that most individuals report had musculoskeletal complaints in the past year (98.3%). However, only 31.3% of individuals were referred to a physician, and 29.6% received treatment from a Physiotherapist. Despite the prevalence of pain, only 3.5% lost their job due to pain, and 1.7% were absent from work because of it. Pain was reported to hinder 6.1% of individuals while playing and 4.3% during leisure activities. Most individuals (98.3%) do not attribute their complaint to a past accident.

TABLE 4.11: PARTICIPANTS' ADAPTATION TO MUSCULOSKELETAL COMPLAINTS WHILE PLAYING THE KEYBOARD INSTRUMENT (N = 115)

	Frequency (n)	Percentage (%)
Had complaints in the past year		
Yes	113	98.3
No	2	1.7
Referred to Physician		
Yes	36	31.3
No	79	68.7
Kind of treatment received		
Physiotherapy	34	29.6
None	81	70.4
I have lost job because of pain		
Yes	4	3.5
No	111	96.5
I was absent from work because of pain		
Yes	2	1.7
No	113	98.3
Pain hinders me while playing		
Yes	7	6.1
No	108	93.9
Pain hinders me during leisure		
Yes	5	4.3
No	110	95.7
My complaint is due to past accident		
Yes	2	1.7
No	113	98.3

Table 4.12 shows that majority of participants (53.9%) reported feeling pain immediately after playing, though nearly all (96.8%) stated that the pain subsides with rest.

Fatigue after playing was experienced by 48.7% of participants, with 98.2% noting that it goes away with rest. Finger stiffness was reported by 43.5% of participants, with 98% of those affected stated that rest alleviates the stiffness. Numbness in the fingers was rare, occurring in only 0.9% of participants, and persisted even after rest. Similarly, tingling sensations in the fingers were reported by 0.9% of participants and also continued after playing.

TABLE 4.12: PARTICIPANTS' MUSCULOSKELETAL COMPLAINTS IN THE UPPER EXTREMITY (N = 115)

	Frequency (n)	Percentage (%)
I feel pain as soon as I finish playing		
Yes	62	53.9
No	53	46.1
I feel pain as soon as I finish playing but it goes with rest		
Yes	60	96.8
No	2	3.2
I feel fatigue after playing		
Yes	56	48.7
No	59	51.3
I feel fatigue after playing and it goes with rest		
Yes	54	98.2
No	1	1.8
I feel stiffness in my finger		
Yes	50	43.5
No	65	56.5
I feel stiffness in my finger but it goes with rest		
Yes	49	98.0
No	1	2.0
I feel numbness in my finger		
Yes:	1	0.9
No:	114	99.1
I feel numbness in my finger which continues after rest		
Yes	1	100
No	0	0
I feel tingling sensation in my finger		
Yes	1	0.9
No	114	99.1
Tingling in my finger continues after play		
Yes	1	100
No	0	0

Table 4.13 shows that weakness in the upper extremity was reported by 6.1% of participants, and for all of them, the weakness persisted beyond playing. Swelling in the hand was noted by 1.7% of participants, and it continued after playing for those affected. Continuous pain and stiffness in the upper musculoskeletal extremity were reported by 2.6% of participants, indicating that these issues are uncommon but persistent in some individuals.

Changes in color, temperature, and sweat were experienced by 3.5% of participants. A very small number of participants (0.9%) reported using a mouse pad, file holder, or foot support, while 1.7% reported using a neck collar or belt. This data suggests that most participants do not rely on assistive devices or supports during their activities. Overall, while many symptoms are temporary and resolve with rest, a small subset of participants experience persistent issues that may require further attention.

TABLE 4.13 PARTICIPANTS' MUSCULOSKELETAL COMPLAINTS IN THE UPPER EXTREMITY (N = 115)

	Frequency (n)	Percentage (%)
I feel weakness in the Upper Extremity		
Yes	7	6.1
No	108	93.9
Weakness in the Upper Extremity continues after playing		
Yes	5	100
No	0	0
I suffer from swelling in the hand		
Yes	2	1.7
No	113	98.3
Swelling in the hand continues after play		
Yes	2	100
No	0	0
I feel swelling/ stiffness in my upper musculoskeletal extremity		
Yes	3	2.6
No	112	97.4
Feel continuous pain in my Upper Musculoskeletal extremity		
Yes	3	2.6
No	112	97.4
I have a change in color, temperature, and sweat		
Yes	4	3.5
No	111	96.5
Use mouse pad, file holder, or foot support		
Yes	1	0.9
No	114	99.1
Use neck collar or belt		
Yes	2	1.7
No	113	98.3

Table 4.14 shows that nearly half of the respondents (49.6%) reported complaints lasting between 1 to 20 days. A significant portion (31.3%) experienced complaints for more than 20 but up to 50 days, while 13.9% reported complaints lasting over 50 days. Only 5.2% of respondents had no complaints. This suggests that the majority experienced short to moderate durations of complaints, with fewer reporting prolonged issues.

TABLE 4.14: PARTICIPANTS' PERIOD OF MUSCULOSKELETAL COMPLAINTS (N = 115)

	Frequency (n)	Percentage (%)
Longest period of complaint		
No complaint	6	5.2
1 to 20 days	57	49.6
21 to 50 days	36	31.3
Above 50 days	16	13.9

TABLE 4.15 RELATIONSHIP BETWEEN HAND GRIP STRENGTH AND HAND DIMENSIONS

VARIABLE 1 * VARIABLE 2	r	p-value
HGS. Dominant * Hand length.	0.817	0.000
HGS Dominant * Hand span.	0.813	0.000
HGS Dominant. * Hand Circumference	0.782	0.000
HGS Dominant * Hand width	0.852	0.000
HGS Dominant * Hand shape	0.306	0.001
HGS Dominant. * Wrist Circumference	0.765	0.000
HGS non Dominant. * Hand length	0.840	0.000
HGS non Dominant * Hand span	0.823	0.000
HGS non Dominant. * Hand Circumference	0.808	0.000
HGS non Dominant * Hand width	0.862	0.000
HGS non Dominant * Hand shape	0.296	0.001
HGS non Dominant. * Wrist Circumference	0.792	0.000

4.16 HYPOTHESIS TESTING

1.**NULL HYPOTHESIS:** There would be no significant relationship between HGS dominant and Hand length of keyboard instrumentalists in Benin City

Test statistic: Pearson's correlation

Stated Alpha value: 0.05

Observed p value: p = 0.000

Since the observed p value is less than 0.05, the null hypothesis is therefore **REJECTED.**

2.NULL HYPOTHESIS: There would be no significant relationship between HGS dominant and Hand span of keyboard instrumentalists in Benin City

Test statistic: Pearson's correlation

Stated Alpha value: 0.05

Observed p value: p = 0.000

Since the observed p value is less than 0.05, the null hypothesis is therefore **REJECTED**

3. NULL HYPOTHESIS: There would be no significant relationship between HGS dominant and Hand circumference of keyboard instrumentalists in Benin City

Test statistic: Pearson's correlation

Stated Alpha value: 0.05

Observed p value: p = 0.000

Since the observed p value is less than 0.05, the null hypothesis is therefore **REJECTED**

4. NULL HYPOTHESIS: There would be no significant relationship between HGS dominant and Hand width of keyboard instrumentalists in Benin City

Test statistic: Pearson's correlation

Stated Alpha value: 0.05

Observed p value: p = 0.000

Since the observed p value is less than 0.05, the null hypothesis is therefore **REJECTED**

5. **NULL HYPOTHESIS:** There would be no significant relationship between HGS dominant and Hand Shape of keyboard instrumentalists in Benin City

Test statistic: Pearson's correlation

Stated Alpha value: 0.05

Observed p value: p = 0.001

Since the observed p value is less than 0.05, the null hypothesis is therefore **REJECTED**

6. **NULL HYPOTHESIS:** There would be no significant relationship between HGS dominant and wrist circumference of keyboard instrumentalists in Benin City.

Test statistic: Pearson's correlation

Stated Alpha value: 0.05

Observed p value: p = 0.000

Since the observed p value is less than 0.05, the null hypothesis is therefore **REJECTED**

7. **NULL HYPOTHESIS:** There would be no significant relationship between HGS Non dominant and Hand length of keyboard instrumentalists in Benin City

Test statistic: Pearson's correlation

Stated Alpha value: 0.05

Observed p value: p = 0.000

Since the observed p value is less than 0.05, the null hypothesis is therefore **REJECTED**

8. **NULL HYPOTHESIS**: There would be no significant relationship between HGS Non dominant and Hand span of keyboard instrumentalists in Benin City

Test statistic: Pearson's correlation

Stated Alpha value: 0.05

Observed p value: p = 0.000

Since the observed p value is less than 0.05, the null hypothesis is therefore **REJECTED**

9. **NULL HYPOTHESIS:** There would be no significant relationship between HGS Non dominant and Hand circumference of keyboard instrumentalists in Benin City

Test statistic: Pearson's correlation

Stated Alpha value: 0.05

Observed p value: p = 0.000

Since the observed p value is less than 0.05, the null hypothesis is therefore **REJECTED**

10. **NULL HYPOTHESIS:** There would be no significant relationship between HGS Non dominant and Hand width of keyboard instrumentalists in Benin City

Test statistic: Pearson's correlation

Stated Alpha value: 0.05

Observed p value: p = 0.000

Since the observed p value is less than 0.05, the null hypothesis is therefore **REJECTED**

11. **NULL HYPOTHESIS:** There would be no significant relationship between HGS Non dominant and Hand shape of keyboard instrumentalists in Benin City

Test statistic: Pearson's correlation

Stated Alpha value: 0.05

Observed p value: p = 0.001

Since the observed p value is less than 0.05, the null hypothesis is therefore **REJECTED**

12. **NULL HYPOTHESIS:** There would be no significant relationship between HGS Non dominant and wrist circumference of keyboard instrumentalists in Benin City

Test statistic: Pearson's correlation

Stated Alpha value: 0.05

Observed p value: p = 0.000

Since the observed p value is less than 0.05, the null hypothesis is therefore **REJECTED.**

CHAPTER 5

DISCUSSION, RECOMMENDATION AND CONCLUSION

5.1 DISCUSSION

5.1.1 MUSCULOSKELETAL COMPLAINTS IN KEYBOARD INSTRUMENTALISTS

The study revealed a high prevalence of musculoskeletal complaints, with 86.1% of participants reporting neck pain, making it the most common complaint. Other significant complaints included right wrist pain (63.5%), right elbow pain (62.6%), and right-hand pain (62.6%). These findings align with Amaral Corrêa et al. (2018), who reported a high prevalence of musculoskeletal pain among keyboard musicians, particularly in the wrists and hands (13.8–65.8%) and neck (9.8–64.2%). However, the percentages in this study exceed the upper range of those reported globally, likely reflecting unique challenges such as inadequate ergonomic resources and improper training in Benin City.

The dominance of right-side complaints corresponds to the frequent use of the dominant hand in playing, particularly for tasks requiring repetitive motion and sustained force. Similar findings were reported by Kok et al. (2016), who observed higher musculoskeletal complaints in musicians' dominant hands due to prolonged use during performances and practice.

Additionally, poor posture during play significantly contributed to these complaints. A majority of participants reported bending their necks and twisting their wrists while playing. This finding is consistent with Ohlendorf et al. (2017), who identified poor posture as a leading cause of chronic pain among musicians. The static muscle strain resulting from sustained awkward postures places excessive mechanical stress on joints and soft tissues, increasing the risk of overuse injuries.

5.1.2 Hand grip strength and its relationship relationship with hand dimension

Hand dimensions were shown to significantly influence participants' performance and risk of injury. The mean hand span of participants was 20.39 cm, while the mean hand length was 19.34 cm. These dimensions were positively correlated with grip strength, particularly in the dominant hand, highlighting the ergonomic advantages of larger hand sizes.

Smaller-handed participants faced greater challenges navigating the keyboard, consistent with findings by Lai et al. (2015), who reported that pianists with smaller hand spans experienced increased strain and required larger ranges of motion in the wrists and fingers. The study supports the recommendation by Chi et al. (2021) to consider ergonomically scaled keyboards for individuals with smaller hand spans to minimize physical strain and enhance performance.

The study found significant differences in HGS between the dominant and non-dominant hands. The mean HGS for the dominant hand was 44.22 kg, compared to 39.31 kg for the non-dominant hand. This disparity reflects the functional demands placed on the dominant hand during playing. These values are higher than those reported by Malshikare et al. (2017), who found lower mean HGS among Indian musicians. This difference could be attributed to the specific demands of keyboard playing in Benin City or to differences in participants' physical conditioning.

The correlation between hand dimensions and HGS was significant. Participants with larger hand spans and lengths exhibited higher grip strength, supporting findings by Kamarul et al. (2016), who demonstrated the biomechanical advantage of larger hands in performing tasks requiring strength and dexterity. This relationship underscores the importance of strengthening exercises tailored to musicians' specific hand dimensions to enhance endurance and prevent injury.

5.1.3 Comparison with Existing Literature

The results of this study align with global trends in musculoskeletal complaints and their associated risk factors among musicians. Zaza (1998) and Kok et al. (2016) reported similarly high prevalence rates of musculoskeletal disorders among instrumentalists, particularly in the upper extremities. However, this study highlights unique challenges faced by keyboard instrumentalists in Benin City, including limited access to ergonomic instruments and professional training, as well as the lack of awareness regarding injury prevention.

The psychological dimension of musculoskeletal complaints, while not directly measured in this study, warrants attention. Stress and performance pressure are known to exacerbate physical symptoms (Ballenberger et al., 2018). Addressing both the physical and mental well-being of musicians is therefore critical for effective prevention and management of musculoskeletal disorders.

5.2 RECOMMENDATIONS

Based on the findings of this study, the researcher makes the following recommendations below:

Ergonomic Interventions: It is essential for keyboard players to adopt proper ergonomic practices when playing. This includes adjusting seating, keyboard height, and hand positioning to reduce strain on the musculoskeletal system. Players should also consider using supportive accessories like wrist rests or adjustable chairs.

Regular Breaks and Rest Periods: Keyboard players should incorporate short breaks during practice sessions, allowing their muscles to relax and recover. Following the 20-20 rule (20 minutes of playing followed by a 20-second break) could help reduce the strain caused by prolonged playing.

Physical Conditioning and Stretching: Incorporating regular exercises that strengthen and stretch the muscles of the upper body, including the fingers, wrists, and shoulders, is crucial. Physiotherapy or targeted strength and flexibility routines could mitigate the risk of injury.

Awareness and Education: Musicians should be educated on the importance of maintaining good posture and the risks of musculoskeletal disorders. Regular workshops or information sessions could increase awareness of these issues and promote healthy playing habits.

Monitoring and Early Intervention: Keyboard players experiencing discomfort should seek early medical intervention to prevent chronic conditions. Regular assessments of musculoskeletal health should be encouraged among musicians, enabling prompt management of any emerging issues.

Use of Assistive Devices: The adoption of ergonomically designed keyboard stands, wrist supports, and other assistive devices should be encouraged to minimize strain. Musicians should be encouraged to experiment with such devices to identify which options best suit their needs.

Postural Adjustments and Environmental Modifications: Keyboard players should be mindful of their posture during practice and performance. Adjustments such as ensuring that the keyboard is at an appropriate height and angle can prevent unnecessary stress on the neck, back, and wrists.

5.3 Conclusion

This study provides valuable insights into the prevalence and determinants of musculoskeletal complaints among keyboard instrumentalists in Benin City. By comparing these findings with existing literature, it is evident that both universal and context-specific factors influence the development of these complaints. The significant correlations between hand dimensions, grip strength, and physical discomfort underscore the importance of targeted interventions to enhance musicians' health and performance. Addressing these challenges through ergonomic

solutions, education, and preventive strategies will contribute to the long-term well-being and artistic success of keyboard instrumentalists.

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APPENDICES

Appendix 1

Maastricht Upper Extremity Questionnaire (MUEQ)

General Information:

1.	Gender	□ Male □ Female
2.	Surname initials	_____
3.	Date of birth?	___-___-19___
4.	What keyboard instrument (s) have you played?	□ piano □ Synthesizer □ Harpsichord □ Clavichord □ Organ □ Digital piano □ MIDI Keyboard controller □Keytar □ Electric organ □ Accordion □ Melodica □ Celesta □ if other, specify _____
5.	What keyboard instrument do you currently play?	_____
6.	How long have you been playing this Instrument ?	___ Year
7.	How many days do you play per week? (*over time not included*)	___ Day
8.	How many hours do you play per day? *(breaks and over time not included)*	___ Hour
9.	How many hours per working day do you play?	___ Hour

Work Station

10.	The keyboard is too high for my sitting position	□ No □ Yes
11.	I maintain standing position for a long period of time	□ No □ Yes

12. My back is often bent while playing	□ No □ Yes
13. My elbow is often bent while playing	□ No □ Yes
14. I repeatedly use my fingers throughout my playing period	□ No □ Yes
15. I repeatedly bend my neck while playing	□ No □ Yes
16. I do vigorous playing with my fingers and wrist	□ No □ Yes
17. I repeatedly twist my wrist while playing	□ No □ Yes

Body Posture

	Always	Often	Someti-mes	Seldom	Never
18. During playing I keep a good playing posture	□	□	□	□	□
19. While playing I sit for long hours in one position	□	□	□	□	□
20. I play for more than two hours per day	□	□	□	□	□
21. During playing I take awkward posture	□	□	□	□	□
22. During playing I perform repetitive tasks	□	□	□	□	□
23. I find playing the keyboard physically exhausting.	□	□	□	□	□
24. I keep my arms and forearms aligned while playing.	□	□	□	□	□
25. When I play, my head is bent	□	□	□	□	□
26. Head is twisted towards the left or right	□	□	□	□	□
27. Trunk is twisted towards the left or right	□	□	□	□	□
28. My Trunk is in asymmetrical position	□	□	□	□	□

Job Control

	Always	Often	Sometimes	Seldom	Never
29. I decide how to perform my playing task	□	□	□	□	□
30. I participate with others in playing decision taking	□	□	□	□	□
31. I decide my own playing task changes	□	□	□	□	□
32. I determine the time & speed of playing task	□	□	□	□	□
33. I solve playing problems by myself	□	□	□	□	□
34. Playing the keyboard develops my abilities	□	□	□	□	□
35. During Playing I learn new skills and techniques	□	□	□	□	□
36. I have to be creative while playing	□	□	□	□	□
37. I under take different tasks during playing	□	□	□	□	□

Job Demand

	Always	Often	Sometimes	Seldom	Never
38. I play under extensive pressure	□	□	□	□	□
39. I find it difficult to master new techniques on time	□	□	□	□	□
40. I take extra hours to improve my performance	□	□	□	□	□
41. I have no enough time to prepare for performance	□	□	□	□	□
42. I speed up my practice to complete session on time	□	□	□	□	□
43. I find playing the keyboard difficult	□	□	□	□	□
44. I have too many task while playing	□	□	□	□	□

Break Time

	Always	Often	Sometimes	Seldom	Never
45. I can plan my breaks during performance or practice	□	□	□	□	□
46. I can divide my practice sessions	□	□	□	□	□
47. I can decide when to take a break	□	□	□	□	□
48. I alternate in my body posture	□	□	□	□	□
49. I alternate in my practice time	□	□	□	□	□
50. I perform playing task without intense finger or wrist movement	□	□	□	□	□
51. After two hours I take a break for 10 minutes.	□	□	□	□	□
52. I find my playing breaks sufficient.	□	□	□	□	□

Work environment

	Always	Often	Sometimes	Seldom	Never
53. I find my playing environment good	□	□	□	□	□
54. I carry out my practice by myself	□	□	□	□	□
55. Someone always assist me when practicing	□	□	□	□	□
56. I carry other instrument on my neck while playing	□	□	□	□	□
57. There is available fresh air in my playing area	□	□	□	□	□
58. My playing environment is noisy.	□	□	□	□	□
59. I also play at night	□	□	□	□	□
60. I use assistive device while playing	□	□	□	□	□
61. The other instrument I carry on my neck is heavy	□	□	□	□	□

Social Support

	Always	Often	Sometimes	Seldom	Never
62. Playing goes smoothly	□	□	□	□	□
63. I can ask and enquire in my playing task	□	□	□	□	□
64. My playing tasks depend on other colleagues	□	□	□	□	□
65. My playing atmosphere is comfortable	□	□	□	□	□
66. If I made a mistake in my playing task I find support from my colleagues	□	□	□	□	□
67. If I made a mistake in my playing task I find support from my supervisors	□	□	□	□	□
68. My colleagues are friendly	□	□	□	□	□
69. My supervisors are friendly	□	□	□	□	□

Complaints

During the past year I had pain or complaints for at least one week in one or more of the following body regions

70. Neck	□ No □ Yes		
71. Shoulder(s)	□ No □ Yes →	If Yes,	□ Left □ Right □ Both
72. Upper Arm	□ No □ Yes →	If Yes,	□ Left □ Right □ Both
73. Elbow (s)	□ No □ Yes →	If Yes,	□ Left □ Right □ Both
74. Lower Arm	□ No □ Yes →	If Yes,	□ Left □ Right □ Both

75. Wrists	□ No □ Yes →	If Yes,	□ Left □ Right □ Both
76. Hand	□ No □ Yes →	If Yes,	□ Left □ Right □ Both

From here (upper musculoskeletal extremity) would be used to represent (neck, shoulder, hand, wrist, arm and elbow)

77.	During the past year I had pain/complaint/disability in my upper musculoskeletal extremity	□ No □ Yes
78.	The longest period of complaint (in the past year) whereby I could not perform my daily activity was	□ ____Days □ ____weeks
79.	During the past year I was referred to the physician due to bmy upper extremity pain?	□ No □ Yes→ The physician. Diagnosis of the complaint was? _____
80.	What kind of treatment did you receive (during the past year)	□ Physiotherapy □ Medication □ Operation □ Other _____
81.	Because of my upper extremity pain I have lost a job before	□ No □ Yes
82.	Because of my upper extremity complaints (during the past year) I was absent from work	□ No □ Yes
83.	Due to upper extremity complaints in the past year my activities were hindered - while playing - in my leisure time	□ No □ Yes □ No □ Yes
84.	My complaints are due to a previous accident	□ No □ Yes

The next questions are related to pain complaints in the neck, shoulder, hand, wrist, and elbow in the past year

85.	I feel pain in my upper musculoskeletal extremity as soon as I finish playing	□ No □ Yes →	This pain disappears after a short rest	□ No □ Yes
86.	I feel fatigue and exhaustion in my upper musculoskeletal extremity	□ No □ Yes →	This complaint disappears after a short rest	□ No □ Yes

87.	I feel stiffness in my finger	□ No □ Yes →	This stiffness disappears after a short rest	□ No □ Yes
88.	I feel numbness in my fingers	□ No □ Yes →	This numbness continues after a short rest	□ No □ Yes
89.	I feel tingling in my fingers	□ No □ Yes →	This tingling continue after work	□ No □ Yes
90.	I feel weakness in my upper musculoskeletal extremity	□ No □ Yes →	This weakness continue after work	□ No □ Yes
91.	I suffer from swelling in my hands	□ No □ Yes →	This swelling continue after work	□ No □ Yes
92.	I feel swelling/ stiffness in my upper musculoskeletal extremity	□ No □ Yes		
93.	I feel continuous pain in my upper musculoskeletal extremity	□ No □ Yes		
94.	I feel a change in the colour, temperature, sweating in my upper musculoskeletal extremity	□ No □ Yes		
95.	I use mouse pad, file holder, foot supporter to reduce upper musculoskeletal extremity pain	□ No □ Yes		
96.	I use neck collar or belts or other to reduce upper musculoskeletal extremity pain	□ No □ Yes		

APPENDIX 2

INFORMED CONSENT FORM

Title of the study: CHARACTERIZATION OF MUSCULOSKELETAL COMPLAINTS, HAND DIMENSIONS AND GRIP STRENGTH OF KEYBOARD INSTRUMENTALISTS IN BENIN CITY.

Researcher: MISS USIAGHAN ITSEOLUWA TEMISAN

Supervisor: DR. NICHOLAS S. OGHUMU

Financial Sponsorship: this research is self-sponsored

Contact phone number: 08165625303, 09036670734, 08034215928

Purpose of the study: You are invited to take part in the research aimed at helping us to characterise the musculoskeletal complaints, hand dimension and grip strength of keyboard instrumentalists in Benin City.

Participation: As a keyboard instrumentalist, you can participate based on the assurance that you are a keyboard instrumentalist who has actively performed in the last two years and is still active in performance and you are aged 18 and above.

Procedure: Self-report questionnaire will be administered to assess musculoskeletal complaints. Measurement of height, weight, hand dimensions (hand span, width, length, circumference, shape, wrist circumference), grip strength (hand grip and pincer grip strength) will be carried out using the height metre, weighing scale, tape rule, hand dynamometer and a pinch metre, respectively.

Benefit of participation: This study will provide you the opportunity to know your values for measurements such as your hand dimensions (hand span, width, length, circumference, shape, wrist circumference) and also your grip strength (hand grip and pincer grip strength). It will enlighten you on the relationship between hand dimensions (hand span, width, length, circumference, shape, wrist circumference), grip strength (hand grip and pincer grip strength) and musculoskeletal complaints.

Risk of participation: The procedures for this study are normal anthropometric measurements and grip strength measurement with no obvious harm or having a negative impact on your health.

Cost/compensation: There is no cost or compensation for this study apart from your highly esteemed time and compliance.

Contact information: If you have any questions or concerns about this study, you can contact the named investigator (project student) on the stated phone numbers.

Voluntary participation: Your participation in this study is voluntary. You have the right to decline from participating in this study, in case you are not comfortable participating after your initial consent has been given.

Confidentiality: All information gathered in this study will be kept completely confidential. No references will be made in written or oral material that will link you to the study.

Participant Consent: Note that the study has been well explained to me and I fully understand the content of the study process. I will be willing to take part in the study.

_____ _____

Participant's signature and date Witness's signature and date

_____

Researcher's signature and date