

**The role of Biomechanical Alignment on Managing Knee Joint Osteoarthritis**

A Thesis

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By

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**DECLARATION**

I declare that the Master Thesis entitled (The role of Biomechanical Alignment on Managing Knee Joint Osteoarthritis) is my own original work, and hereby I certify that unless stated, all work contained within this thesis is my own independent research and has not been submitted for the award of any other degree at any institution, except where due acknowledgment is made in the text.

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**Dedication**

To the memory of my father who always supported me, whatever path I took

To the memory of my mother,

My beloved wife

My beloved brothers and sisters

My friends

With love and respect

**A CKNOWLEDGEMENTS**

I want to express my heartfelt gratitude to all those who have played an essential role in the successful completion of this thesis. First and foremost, I extend my deepest appreciation to my dedicated advisor (Assist. Prof. Ghassan Husni Ali), whose expertise, guidance, and unwavering support have been the cornerstone of this research endeavor. To my family, I owe an immense debt of gratitude. Their unshakable belief in my abilities and the continuous encouragement throughout this academic journey have been a constant source of motivation and strength. I would like to express my deepest gratitude and appreciation to my wife (Iman Ghafoor), whose unwavering support and encouragement were instrumental in the completion of this thesis. Her patience, understanding, and constant belief in my abilities provided the foundation for my academic journey. I am truly fortunate to have such a loving and supportive partner by my side. I am truly appreciative of the individuals who participated in this research and the Radiologists from the Rizgary and Erbil teaching hospital and Balsam private hospital. My truthful thanks are extended to Erbil Polytechnic University and the Deanery of Erbil Health and Medical Technical College for providing this opportunity to complete higher study and offering all requirements necessary to prepare this thesis. Most importantly, none of this would have been possible without Head of Physiotherapy Department (Dr. Mahdi Khaled Qadir) and my very special thanks goes to him.

***‘Mohammed’***

**Summary**

Knee joint osteoarthritis (OA) is a degenerative joint disease where the knee's articular cartilage gradually deteriorates. This condition affects a large number of individuals globally and can result in substantial pain, restricted functionality, and alterations in joint structure.

**Aim of the study**: To evaluate the effect of biomechanical alignment for patients with knee joint OA.

**Materials and Methods:** 40 patients were participated in this study, their ages between 30-80 years, both female and male. The patients were diagnosed by Rheumatologists and Orthopedists regarding their knee pain. The participants are divided into two groups: group A is experimental group 20 patients who underwent usual OA treatment with biomechanical intervention and group B is control group 20 patients who underwent usual OA treatment of physiotherapy and medication. The data was collected at Rizgary Teaching Hospital and Erbil Teaching Hospital during the period December 2021 to july 2023.

**Results:** The results showed that both groups were effective in decreasing pain and improving physical functions, in the study group the average of overall post pain score (1.10) is lower than the average of pre pain score (2.9) and the mean difference is (1.8). In the control group the average of overall post pain score (1.80) is lower than the average of pre pain score (2.7) and the mean difference is (0.9). It means that the study group is more effectively treated than the control group.

**Conclusion:** The reduction of knee joint pain, improving physical activities and realign the malalignment of the knee joint after using lateral wedge outsole are demonstrated.

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**List of Abbreviations**

|  |  |
| --- | --- |
| ACL | Anterior Cruciate Ligament |
| ANOVA | Analysis of Variance |
| BMI | Body mass index |
| CRP | C-reactive protein |
| CT | Computed tomography |
| ESR | Erythrocyte sedimentation rate |
| F | Frequency |
| LCL | Lateral Collateral Ligament |
| MCL | Medial Collateral Ligament |
| MRI | Magnetic resonance imaging |
| N | Number |
| NSAIDs | Nonsteroidal anti-inflammatory drugs |
| OA | Osteoarthritis |
| PCL | Posterior Cruciate Ligament |
| VAS | visual analog scale |
| WOMAC | Western Ontario and McMaster universities arthritis index |

1. **Introduction**

Osteoarthritis (OA) is a chronic degenerative joint disease and joint wear and tear, that causes significant pain and is a leading cause of disability worldwide (Guilak, 2011, Egloff et al., 2012). The knee is the largest joint that is frequently affected by osteoarthritis (Englund, 2010). Specifically, OA of the knee commonly occurs in the medial tibiofemoral compartment, where there is an increased regional load on the articular cartilage. This increased load is considered a significant contributing factor to the development and progression of the disease (Teichtahl et al., 2003).

The worldwide impact of knee OA is experienced by around 265 million individuals, and its occurrence is progressively increasing due to the aging population and the growing prevalence of obesity (Reichenbach et al., 2020). The risk of disability associated solely with knee OA is equivalent to or even greater than the risk associated with cardiac disease and surpasses that of any other medical condition among elderly individuals (Sharma et al., 2001). The knee joint experiences significant weight-bearing during daily activities. Improper biomechanics of the joint are a primary risk factor for the development of knee OA (Xie et al., 2019). The medial compartment of the knee carries approximately 60% to 70% of the force during weight-bearing when the knee is in a neutral alignment. Due to the higher load placed on the medial compartment compared to the lateral compartment, this could contribute to the development and progression of osteoarthritis in the medial tibiofemoral compartment (Hunter and Wilson, 2009). Studies have indicated that during walking, the ground reaction force on the proximal compartment of the knee joint is directed medially, passing through the center of the knee joint. This force generates a moment that tends to maintain the knee in an adducted position. During the stance phase of walking, there is an increased load on the medial compartment of the knee joint due to the generated moment. This increased load has been linked to the degeneration of the articular cartilage in the medial compartment of the knee (Naderi et al., 2014).

Malalignment of the lower leg, whether in a valgus (outward) or varus (inward) direction, has been shown to effect the load distribution on the knee joint's articular surfaces. Even slight changes in knee alignment have been demonstrated to cause abnormal distribution of forces within the joint. More specifically, studies have reported that a 4-6% increase in varus alignment can lead to a significant 20% increase in loading on the medial compartment of the knee. These elevated levels of compartment loading are believed to impose additional stress on the articular cartilage and other structures within the joint, ultimately resulting in degenerative changes (Tanamas et al., 2009).

There is no definitive remedy or cure available for knee osteoarthritis (Paterson et al., 2021). The pain associated with this condition is typically managed using medications such as acetaminophen, nonsteroidal anti-inflammatory drugs (NSAIDs), and opioids. However, it should be noted that these medications have limited efficacy and may be linked to undesirable side effects.

The prevalence of knee replacement surgery, primarily attributed to osteoarthritis cases, has been on the rise in the United States. This trend can be partly attributed to the limited effectiveness of non-surgical treatments for the condition (Reichenbach et al., 2020). While there have been advancements in biomechanical treatments for knee osteoarthritis with the objectives of reducing pain, enhancing physical function, and potentially slowing down the progression of the disease, the available evidence regarding their effectiveness remains inconclusive. Two small observational studies with prospective designs indicated that a personalized biomechanical footwear system could potentially enhance pain management and physical activities among individuals experiencing symptomatic knee osteoarthritis (Reichenbach et al., 2020).

**Aim:** The aim of the study to evaluate the effect of biomechanical alignment for patients with knee joint osteoarthritis.

**Objective:**

1. Identify socio-demographic characteristics of recovered OA Knee Joint Pain of patients included in the study.
2. To investigate pain score of patients pre and post alignment alteration.
3. To find out association between mean of pre and post pain score with each of the physical activities from two groups (case and control).

**2. Theoretical background and literature review**

**2.1. History of osteoarthritis**

Osteoarthritis is a chronic joint disease that is caused by the degeneration of cartilage and underlying bone in the joints. It is one of the most common types of arthritis, affecting millions of people worldwide (Yu et al., 2022).

The history of osteoarthritis dates back to ancient times, and there is evidence of the disease being present in human remains from thousands of years ago. The earliest evidence of osteoarthritis comes from the skeletons of prehistoric humans. In 1953, a group of archaeologists discovered the remains of a Neanderthal man in a cave in Shanidar, Iraq. The man, who lived approximately 50,000 years ago, had severe osteoarthritis in his right shoulder and elbow. This suggests that even early humans were susceptible to joint degeneration. In ancient Greece, the physician Hippocrates described a condition that he called "arthron kosmos," which is believed to be osteoarthritis. Hippocrates observed that the disease was more common in older individuals and that it affected weight-bearing joints such as the knees and hips. He also noted that the disease was more common in men than in women (van Tubergen and van der Linden, 2002, Spikins et al., 2018).

In the Middle Ages, osteoarthritis was often attributed to a "cold and damp" environment. Physicians believed that the disease was caused by an excess of phlegm in the joints, and treatments often involved the use of heat and dryness to remove the phlegm. However, these treatments were often ineffective and could even be harmful (Sun et al., 2019). It wasn't until the 19th century that the medical community began to understand the true nature of osteoarthritis. In 1859, the French physician Jean-Martin Charcot described the degeneration of joint cartilage in detail. Later, in the early 20th century, the American physician Edward Cowles published a comprehensive study of osteoarthritis that included detailed descriptions of the histological changes that occur in the disease (Muthuri et al., 2011).

Today, there is still much to be learned about osteoarthritis, including its causes, risk factors, and potential treatments. However, advances in medical imaging, genetics, and other fields have helped researchers to better understand the disease and develop new strategies for managing its symptoms.

**2.2. Anatomy of the knee joint**

The knee joint is one of the most complex and important joints in the human body. It allows for a wide range of motion, including flexion (bending), extension (straightening), and a limited amount of rotation. The knee joint is formed by the articulation of three bones: the femur (thigh bone), the tibia (shin bone), and the patella (kneecap) (Abulhasan and Grey, 2017, Moore and Dalley, 2018). Here's an overview of the anatomy of the knee joint (Fig 2.1.).

The femur, constituting the upper leg bone, plays a crucial role in forming the upper part of the knee joint. At its distal end, the femur features two rounded condyles: the medial condyle and the lateral condyle, both of which articulate with the tibia. Oppositely, the tibia, commonly known as the shin bone, is the larger of the two lower leg bones and comprises the lower part of the knee joint. Its medial tibial plateau and lateral tibial plateau, two flat, plateau-like surfaces, articulate with the femoral condyles, contributing to the knee's structural integrity (He et al., 2023).

The patella, or kneecap, is a small, triangular bone positioned within the tendon of the quadriceps muscle on the anterior (front) aspect of the knee. Its primary function lies in acting as a fulcrum, enhancing the leverage of the quadriceps muscles during knee extension.

Situated between the femoral condyles and tibial plateaus are the menisci—two C-shaped cartilage structures identified as the medial meniscus and lateral meniscus. These menisci serve essential roles in the knee joint, providing cushioning, stability, and facilitating even load distribution (Standring, 2021, Meyler, 2022). Together, these components form a complex but finely tuned system that enables the knee's intricate movements and functions.

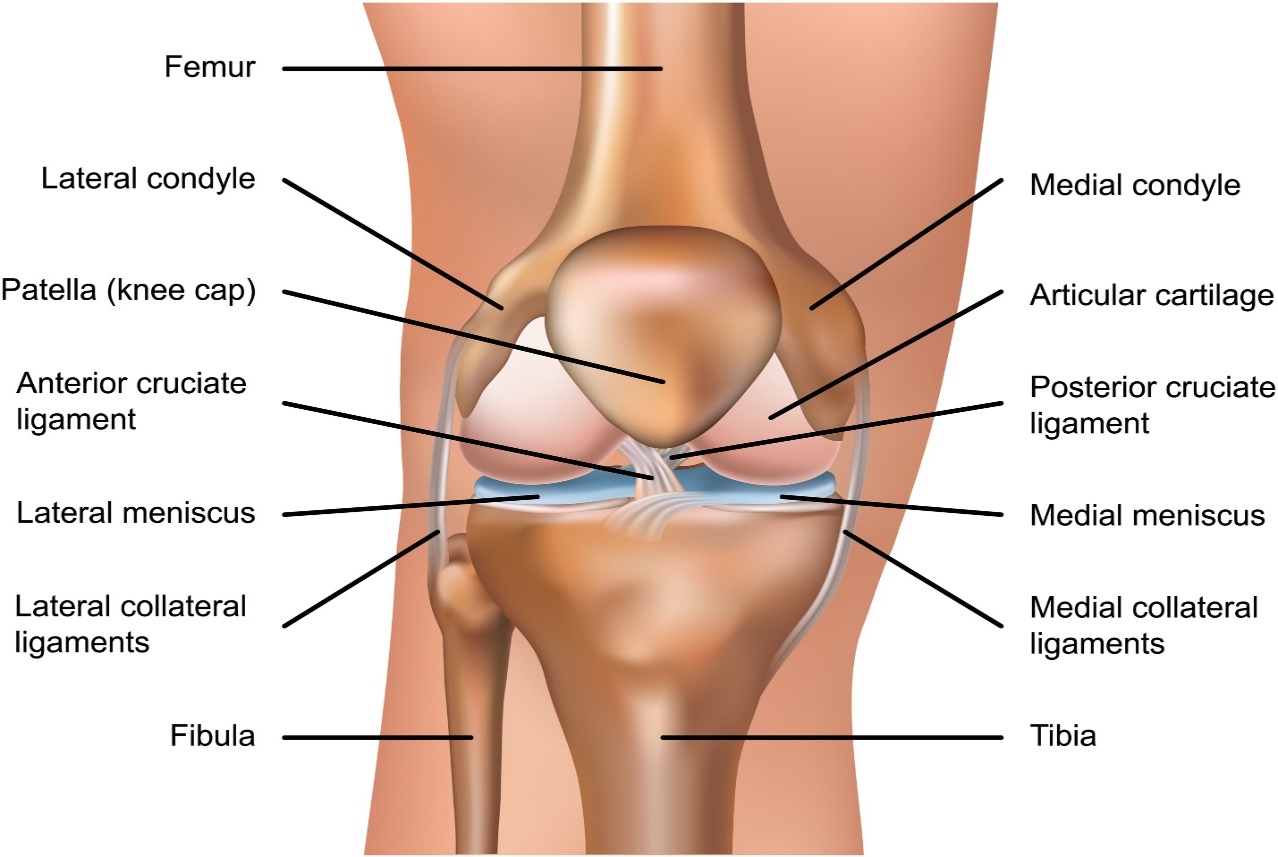


Fig 2.1. Anatomy of the knee joint

The stability of the knee joint is maintained through the collaboration of various ligaments, including the Anterior Cruciate Ligament (ACL), which prevents excessive forward movement of the tibia in relation to the femur, and the Posterior Cruciate Ligament (PCL), which hinders excessive backward movement. Adding to this stability are the Medial Collateral Ligament (MCL) on the inner side and the Lateral Collateral Ligament (LCL) on the outer side of the knee. The joint capsule, a robust and fibrous structure enveloping the knee joint, serves to bind the bones together, with its synovial membrane producing synovial fluid for lubrication and cartilage nourishment (Drake et al., 2009, Standring, 2021).

Contributing to the knee's movement are the Quadriceps muscles, located on the front of the thigh, responsible for knee extension, and the Hamstring muscles at the back of the thigh, facilitating knee flexion (Drake et al., 2012). Bursae, small fluid-filled sacs, minimize friction between tendons, ligaments, and bones, and the synovial membrane, lining the inner surface of the joint capsule, produces synovial fluid to further reduce friction.

Completing the intricate system are blood vessels supplying oxygen and nutrients to the knee joint, along with nerves that transmit signals for sensation and motor control (Drake et al., 2012, Standring, 2021). The harmonious interplay of these components is vital for the proper functioning of the knee joint. Injuries or conditions affecting any of these structures can result in knee pain and diminished mobility. Therefore, preserving the health of the knee joint is crucial for overall mobility and an individual's quality of life.

**2.3. Signs and symptoms of osteoarthritis**

Osteoarthritis (OA) is a progressive joint disease characterized by the breakdown of cartilage, the tissue that cushions the ends of bones within a joint. The most prominent symptom of OA is joint pain, often manifesting as a deep, aching discomfort. This pain typically intensifies during or after periods of joint use. As the condition advances, individuals may notice a reduction in joint flexibility, leading to difficulties in bending, kneeling, or performing everyday activities(Favero et al., 2015, Sharma, 2021). Crepitus, a crackling or grating sensation during joint movement, may occur due to the roughened surfaces of bones rubbing against each other. Weight-bearing joints such as the knees, hips, and spine are often affected, impacting mobility and overall quality of life. In advanced stages, the formation of osteophytes, or bone spurs, can occur, further contributing to joint pain and limiting joint function. In severe cases of OA, the affected joint may become deformed or misaligned, a noticeable occurrence, particularly in the fingers and toes. While there is no cure for osteoarthritis, various treatment options, including lifestyle modifications, physical therapy, and medications, can help manage symptoms and improve joint function. Early detection and intervention play a crucial role in minimizing the impact of osteoarthritis on daily life. Individuals experiencing persistent joint symptoms should consult a healthcare professional for a comprehensive evaluation and personalized management plan (Mahmoudian et al., 2021, Sharma, 2021).

**2.4. Risk factors**

Osteoarthritis is a complex condition influenced by various factors, contributing to an increased likelihood of its development. Advancing age is a primary risk factor, as the cumulative wear and tear on joints over time can lead to the breakdown of cartilage. Obesity is another significant factor, as excess weight places additional stress on joints, particularly in the knees and hips, heightening the risk of osteoarthritis in these areas. Joint injuries, whether sustained through sports or accidents, also contribute to the risk, potentially leading to osteoarthritis later in life (Heidari, 2011, O'Neill et al., 2018).

Genetics play a role, with certain gene variations increasing susceptibility to the disease. Gender differences exist, with women being more prone than men to develop osteoarthritis, especially in the hands and knees. Repetitive stress on the joints, commonly associated with certain occupations or activities involving repetitive movements like typing or playing musical instruments, can elevate the risk of osteoarthritis in the affected joints. Muscle weakness is another factor, as weakened muscles may intensify stress on the joints, raising the risk of osteoarthritis(Spector and MacGregor, 2004, Yucesoy et al., 2015).

The presence of other medical conditions, such as rheumatoid arthritis, gout, or diabetes, can further heighten the risk of developing osteoarthritis. It's crucial to note that having one or more of these risk factors doesn't guarantee the onset of osteoarthritis. However, understanding these factors is essential, and individuals can take proactive measures to minimize their impact. Maintaining a healthy weight, avoiding repetitive stress on the joints, and engaging in joint-friendly exercises are key steps in managing and potentially reducing the risk of osteoarthritis (Blagojevic et al., 2010, Georgiev and Angelov, 2019).

**2.5. Diagnosis of osteoarthritis**

The diagnosis of osteoarthritis typically involves a comprehensive approach, combining clinical evaluation, imaging tests, and laboratory tests. Initiated by a physician, the diagnostic process begins with a thorough clinical evaluation that includes an in-depth review of the patient's medical history and a meticulous physical examination (Braun and Gold, 2012).

Imaging tests play a pivotal role in confirming the diagnosis and determining the severity of osteoarthritis. Commonly employed imaging techniques include X-rays, magnetic resonance imaging (MRI), and computed tomography (CT) scans. X-rays, often the initial choice, provide insights into joint damage and the presence of bone spurs. For more intricate views of joint structures like cartilage, ligaments, and tendons, MRI and CT scans are utilized (Doherty et al., 2017).

**2.6. Biomechanical alignment**

Biomechanical alignment refers to the optimal alignment of the musculoskeletal system that promotes efficient and safe movement. It involves the correct positioning of bones, muscles, and joints in relation to each other to optimize the distribution of forces throughout the body. Proper biomechanical alignment is important for preventing injuries, reducing pain, and improving performance in various activities, such as sports, exercise, and daily tasks (Madeti et al., 2015, Ro et al., 2022).

Reference to biomechanical alignment can be found in various fields such as physical therapy, sports medicine, and orthopedics. In physical therapy, biomechanical alignment is used to evaluate and treat movement disorders, such as malalignment or imbalance, to restore proper function and prevent further injuries (Hewett et al., 2005).

In sports medicine, biomechanical alignment is used to analyze and improve athletic performance by optimizing body mechanics and reducing the risk of injury. For example, a running analysis may be performed to evaluate the biomechanics of a runner's gait and identify any abnormalities that may lead to injury (Donelon et al., 2020).

In orthopedics, biomechanical alignment is used to assess and correct deformities or malalignments of the musculoskeletal system, such as scoliosis or leg length discrepancies. Surgical interventions, such as joint replacement or osteotomy, may be used to correct the alignment and restore proper function.

Overall, biomechanical alignment plays an essential role in maintaining the health and function of the musculoskeletal system and preventing injuries. By optimizing alignment and mechanics, individuals can improve their quality of life and performance in various activities (Davis et al., 2016).

**2.7. Advantages of biomechanical alignment**

Optimal biomechanical alignment of the knee joint offers a multitude of advantages. Achieving proper alignment significantly reduces joint pain, particularly beneficial for conditions like knee osteoarthritis where interventions focusing on alignment have proven effective in pain alleviation. Furthermore, biomechanical alignment interventions enhance joint functionality, as demonstrated in studies related to hip osteoarthritis, leading to increased mobility and improved performance in daily activities (Fransen et al., 2015, Kang et al., 2020). The potential to slow the progression of osteoarthritis is another key benefit, with research indicating that individuals undergoing biomechanical interventions for knee osteoarthritis experience a reduced rate of cartilage loss, suggesting a potential slowdown in the degenerative process (Primorac et al., 2020).

Moreover, correcting alignment issues plays a preventive role, mitigating further joint damage by distributing forces evenly across joint surfaces and reducing the risk of additional injuries and degeneration. Enhanced joint stability, biomechanical alignment contributes to improved joint stability. Proper alignment ensures that the structures surrounding the knee joint, including ligaments and tendons, function optimally, reducing the risk of instability-related issues and injuries (Niki, 2021). achieving and maintaining optimal biomechanical alignment in the knee joint provides a range of advantages, from pain relief and improved functionality to the potential delay in the progression of osteoarthritis and enhanced joint stability. These benefits are particularly significant for individuals with knee-related conditions and those seeking to prevent or manage musculoskeletal issues.

**2.8. Disadvantages of Biomechanical Alignment:**

While optimizing biomechanical alignment in the knee joint presents numerous benefits, it also brings forth potential drawbacks that merit consideration. The complexity of addressing alignment issues may necessitate intricate interventions, such as surgery or specialized rehabilitation programs, which can be invasive, time-consuming, and involve a protracted recovery period (Hankemeier et al., 2006). Additionally, biomechanical interventions may not universally suit or prove effective for all knee conditions, and alternative treatments may be more suitable for certain issues. Financial costs, particularly associated with surgical procedures, may pose a barrier to access for some individuals, limiting their ability to pursue specific treatments (Scherer et al., 2019).

Furthermore, surgical interventions carry inherent risks of complications, such as infection or adverse reactions to anesthesia, requiring careful consideration against anticipated benefits. Despite short-term effectiveness demonstrated in some studies, there may be limited long-term evidence on sustained benefits, contingent on factors like adherence to rehabilitation programs and lifestyle changes. Individual variability in responses to biomechanical interventions introduces a layer of uncertainty, influenced by factors like age, overall health, and adherence to post-intervention recommendations. It is crucial to recognize that these interventions may address specific aspects related to alignment, pain, or function but may not constitute a comprehensive cure for underlying conditions. Consequently, ongoing management and lifestyle modifications may remain necessary (Polderman et al., 2019). In conclusion, while biomechanical alignment interventions offer substantial advantages, a balanced decision should consider potential disadvantages, involving healthcare professionals in the decision-making process to align interventions with individual circumstances and preferences.

**2.9. Malalignment**

Malalignment refers to an abnormal distribution of forces and load-bearing in the musculoskeletal system. Malalignment can occur in various parts of the body, including the feet, ankles, knees, hips, and spine. Abnormal biomechanical alignment has been associated with an increased risk of developing musculoskeletal disorders such as osteoarthritis, patellofemoral pain syndrome, and stress fractures (Fig 2.2.). Here are some examples of malalignment and their potential consequences:

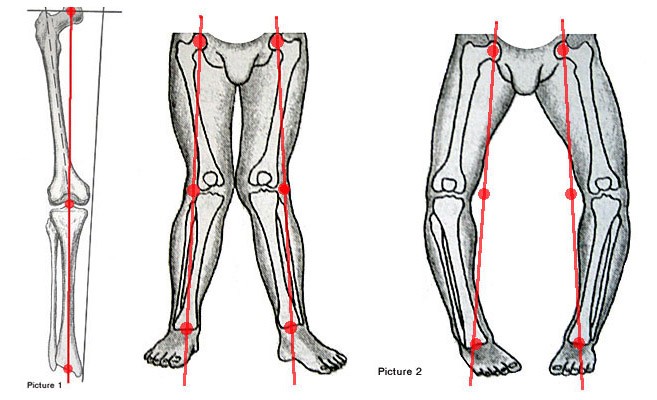


Fig 2.2. Malalignment

**2.9.1. Knee malalignment**

Knee malalignment refers to an abnormal positioning or deviation from the optimal biomechanical alignment in the knee joint. This malalignment can occur in various planes, including the frontal, sagittal, or transverse planes, and may involve deviations in the positioning of bones, ligaments, and other structures within the knee. Common examples of knee malalignment include conditions like genu valgum (knock-knee) or genu varum (bowleg), where the knee joint deviates inward or outward from the normal alignment, respectively. Knee malalignment can result in uneven distribution of forces across the joint, leading to increased stress on certain structures, such as cartilage and ligaments (Sharma et al., 2010). This condition is associated with an increased risk of musculoskeletal problems, including osteoarthritis, and may contribute to pain, instability, and functional limitations. Management of knee malalignment often involves a combination of therapeutic interventions, such as physical therapy, braces, or in severe cases, surgical procedures, aimed at restoring proper alignment and minimizing associated symptoms and complications. Regular monitoring and appropriate intervention are crucial for individuals with knee malalignment to prevent long-term complications and maintain optimal joint health (van der Heijden et al., 2015).

**2.9.2. Hip malalignment**

Hip malalignment refers to an abnormal positioning or deviation from the optimal biomechanical alignment in the hip joint. This malalignment can manifest in various ways, involving deviations in the positioning of the femoral head, acetabulum, and other structures within the hip (Ganz et al., 2003). Common examples include femoroacetabular impingement (FAI), where there is abnormal contact between the hip's ball and socket, or hip dysplasia, characterized by a shallow hip socket. Hip malalignment can lead to increased stress on the joint, affecting the distribution of forces and potentially causing wear and tear on the cartilage and other structures. This condition is associated with an elevated risk of musculoskeletal issues, including osteoarthritis, pain, and limited range of motion (Lerch et al., 2020).

Management of hip malalignment often involves a comprehensive approach. Conservative measures may include physical therapy to improve muscle strength and joint stability, lifestyle modifications, and the use of assistive devices. In some cases, surgical interventions such as hip arthroscopy or joint reconstruction may be considered to correct the malalignment and address associated problems. The goal of treatment is to alleviate symptoms, improve joint function, and prevent further complications. Regular monitoring and appropriate intervention are essential for individuals with hip malalignment to optimize their hip health and overall well-being (Vaquero-Picado et al., 2019).

* + 1. **Foot malalignment**

Foot malalignment refers to an abnormal positioning or deviation from the optimal biomechanical alignment in the feet. This condition can manifest in various ways, affecting the positioning of the bones, joints, and soft tissues in the foot. Common examples of foot malalignment include pes planus (flat feet), where the arch of the foot collapses, or pes cavus (high arches), where the arch is excessively raised. Other conditions, such as bunions or hammertoes, can also contribute to foot malalignment(Krause and Seidel, 2018, Myerson and Li, 2022). Foot malalignment can lead to improper weight distribution, affecting the alignment of the lower limbs and potentially causing issues such as pain, instability, and altered gait. It may contribute to various musculoskeletal problems, including plantar fasciitis, shin splints, and knee or hip pain (Simic et al., 2013).

Management of foot malalignment often involves a multifaceted approach. Conservative measures may include the use of orthotic devices or supportive footwear to help correct the alignment and provide stability. Physical therapy exercises may be recommended to strengthen muscles and improve foot function. In some cases, surgical interventions may be considered to address severe malalignments or correct deformities(Deben and Pomeroy, 2014).

* 1. **Varus malalignment**

Varus malalignment of the knee is a condition characterized by an abnormal inward angulation of the lower leg in relation to the thigh. In this alignment, the tibia deviates towards the midline of the body, resulting in a bow-legged appearance. This malalignment disrupts the normal biomechanics of the knee joint, affecting the distribution of forces and potentially leading to various musculoskeletal issues (Thienpont and Parvizi, 2016). Common causes of varus malalignment include:

1. **Genetics:** In some cases, varus malalignment may have a hereditary component, where individuals inherit a predisposition for the condition.
2. **Osteoarthritis:** Progressive degeneration of the knee joint, often associated with aging, can contribute to varus malalignment.
3. **Trauma:** Previous injuries, such as fractures or ligament damage, can disrupt the normal alignment of the knee and lead to varus malalignment.
4. **Obesity:** Excess body weight can exert additional stress on the knee joint, contributing to malalignment.

Varus malalignment can result in increased pressure on the medial (inner) compartment of the knee, leading to accelerated wear and tear of the joint surfaces. This can eventually contribute to the development or progression of osteoarthritis (Kakihana et al., 2007).

There are various methods used to diagnose varus malalignment, including physical examination, imaging tests such as X-rays or MRI, and biomechanical assessments.

Management of varus malalignment may involve a combination of conservative and, in some cases, surgical interventions. Conservative measures may include physical therapy to strengthen muscles around the knee, orthotic devices, and weight management. In more severe cases or when conservative measures are not sufficient, surgical options such as osteotomy (repositioning of bones) or joint replacement may be considered to correct the malalignment and alleviate symptoms (Sherman et al., 2018).

* 1. **Valgus malalignment**

Valgus malalignment of the knees is a condition characterized by an abnormal outward angulation of the lower leg in relation to the thigh. In this alignment, the tibia deviates away from the midline of the body, resulting in a knock-kneed appearance. Valgus malalignment disrupts the normal biomechanics of the knee joint, affecting the distribution of forces and potentially leading to various musculoskeletal issues (Felson et al., 2013).

Valgus malalignment can be caused by various factors, including congenital or developmental abnormalities, trauma to the knee, or degenerative changes in the knee joint. It is commonly seen in individuals who participate in high-impact sports, such as football, basketball, and soccer (Hunter et al., 2005).

Valgus malalignment can result in increased pressure on the lateral (outer) compartment of the knee, leading to accelerated wear and tear of the joint surfaces. This can eventually contribute to the development or progression of osteoarthritis.

Management of valgus malalignment may involve a combination of conservative and, in some cases, surgical interventions. Conservative measures may include physical therapy to strengthen muscles around the knee, orthotic devices, and weight management. In more severe cases or when conservative measures are not sufficient, surgical options such as osteotomy (repositioning of bones) or joint replacement may be considered to correct the malalignment and alleviate symptoms (Felson et al., 2013).

**2.12. Effect of biomechanic on body**

Biomechanics, an interdisciplinary field encompassing biology, physics, engineering, and mathematics, delves into the mechanical principles governing the movement and structure of living organisms. Its impact on the human body is extensive and diverse, with effects ranging from positive to negative contingent on various factors. A profound understanding of biomechanics facilitates injury prevention, as insights into movement and posture help individuals avoid injuries resulting from improper form or overuse. Additionally, biomechanical analysis aids in rehabilitation by identifying underlying causes of injuries or movement dysfunction, allowing for targeted corrective exercises (Bolgla and Boling, 2011). The optimization of movement patterns through biomechanics also contributes to performance enhancement, enabling individuals to elevate their athletic prowess and overall physical abilities. Crucially, biomechanics plays a pivotal role in safeguarding joint health, mitigating the risk of degenerative conditions like arthritis, and fostering efficient muscular development. Conversely, poor biomechanics can have adverse effects, leading to joint pain, muscle strains, injuries, and, if neglected over time, chronic pain and musculoskeletal disorders. Hence, the application of biomechanical principles to movement and posture holds the potential for significant positive impacts on the body, emphasizing the importance of understanding and incorporating these principles for holistic well-being (Zhou et al., 2021, Chen et al., 2022).

**2.13. Relation between biomechanic and osteoarthritis**

Biomechanics and osteoarthritis are closely related as abnormal biomechanics can lead to the development and progression of osteoarthritis. Biomechanics is the study of how forces and movements affect the human body, while osteoarthritis is a degenerative joint disease characterized by the breakdown of joint cartilage and bone, often causing pain and stiffness (Guilak, 2011). Abnormal biomechanics, such as poor posture, repetitive stress, and abnormal joint alignment, can cause increased wear and tear on joint surfaces, leading to cartilage breakdown and osteoarthritis. For example, individuals with flat feet or high arches may have altered biomechanics that can lead to increased stress on their knees, which may increase the risk of developing osteoarthritis in the knee joint (Guilak, 2011). Additionally, obesity, which alters the biomechanics of weight-bearing joints, is a significant risk factor for the development and progression of osteoarthritis, particularly in the knees and hips. The excessive weight increases the load on the joint surfaces, causing increased wear and tear on the cartilage. In conclusion, maintaining proper biomechanics through appropriate exercise, footwear, and posture can help reduce the risk of developing osteoarthritis or slow its progression in individuals who have already been diagnosed (Heijink et al., 2012).

There are numerous studies that have investigated the relationship between biomechanics and osteoarthritis:

A study published in the journal Osteoarthritis and Cartilage found that individuals with abnormal knee biomechanics, such as increased knee adduction moment and internal rotation during walking, had a higher risk of developing knee osteoarthritis. The study concluded that abnormal biomechanics may be a modifiable risk factor for knee osteoarthritis (Bennell et al., 2011).

A review published in the journal Arthritis Research and Therapy examined the relationship between obesity, biomechanics, and osteoarthritis. The review concluded that obesity alters biomechanics and increases the load on weight-bearing joints, leading to an increased risk of developing osteoarthritis. The authors suggested that weight loss interventions aimed at reducing the load on joints may be effective in reducing the risk of osteoarthritis (Guilak, 2011).

**2.14. Role of biomechanical alignment in managing Osteoarthritis**

Biomechanical alignment plays an important role in managing osteoarthritis (OA) as it helps to reduce stress and strain on the affected joints. Biomechanical alignment refers to the alignment and positioning of the body during movement, which affects the distribution of forces throughout the joints. Studies have shown that abnormal biomechanical alignment can increase the risk of OA and accelerate its progression. For example, malalignment of the knee joint, such as Varus or valgus alignment, has been associated with an increased risk of developing knee OA (Sharma et al., 2010). Similarly, abnormal alignment of the hip joint, such as hip dysplasia, has been linked to the development of hip OA. Proper biomechanical alignment can help reduce pain and improve joint function in patients with OA. Here are some ways in which biomechanical alignment can be used to manage OA:

1. **Gait analysis:** Gait analysis involves evaluating the way a person walks to identify any abnormal movement patterns that may be contributing to joint stress. Based on the findings of gait analysis, a physical therapist can design an exercise program that focuses on correcting movement patterns and improving biomechanical alignment (Hall et al., 2012).
2. **Footwear:** Proper footwear is important for maintaining good biomechanical alignment. Shoes that provide good arch support and cushioning can help distribute forces evenly throughout the foot and reduce stress on the knee and hip joints. In some cases, custom orthotics may be prescribed to help correct biomechanical alignment (Sharma et al., 2010).
3. **Exercise:** Exercise is an important component of OA management, and certain types of exercise can help improve biomechanical alignment. Low-impact activities like walking, cycling, and swimming can help improve joint function and reduce pain by promoting proper alignment and reducing joint stress (Goff et al., 2021).
4. **Manual therapy:** Manual therapy techniques like joint mobilization and soft tissue massage can help improve joint mobility and reduce pain by releasing tension in muscles and correcting joint alignment (Xu et al., 2017).
5. **Bracing:** Bracing can be used to help support the joint and promote proper biomechanical alignment. Knee braces, for example, can help reduce stress on the knee joint by shifting forces to other areas of the leg (Duivenvoorden et al., 2015).

Biomechanical alignment is an important factor to consider in the management of osteoarthritis. Correcting abnormal movement patterns and promoting proper alignment can help reduce joint stress, improve joint function, and reduce pain. Consultation with a healthcare professional and/or physical therapist is recommended to determine the best course of treatment for individual patients with OA (Sharma et al., 2010). Overall, the literature suggests that biomechanical alignment interventions, including footwear modifications, may be effective in managing knee osteoarthritis. These interventions may improve pain and function in patients with knee osteoarthritis. However, further research is needed to fully understand the long-term effectiveness of these interventions and to determine the optimal treatment approach for different types and stages of knee osteoarthritis.

**2.15. Literature review**

Knee osteoarthritis (OA) is a common degenerative joint disease that affects millions of people worldwide. Biomechanical alignment interventions have been suggested as a potential approach for managing knee OA. Here is a literature review of recent studies on biomechanical alignment for knee osteoarthritis management:

study published in the Journal of Orthopaedic and Sports Physical Therapy found that a knee brace combined with an exercise program was effective in reducing pain and improving function in patients with knee osteoarthritis (Shakoor and Block, 2006).

Knee osteoarthritis (OA), primarily affecting the medial compartment, involves the adduction moment around the knee—a surrogate for medial knee compression influenced by external forces and limb orientation during walking. This parameter is closely linked to OA development and progression, prompting exploration of conservative biomechanical interventions in this review. The review discusses evidence supporting interventions like barefoot walking, the use of lateral wedge insoles, and choosing thin-soled, flexible shoes to alleviate the knee adduction moment in OA patients. Strategies directly influencing gait, such as walking with an externally rotated foot ('toe-out gait'), employing a cane, lateral trunk sway, and gait retraining, are examined. Additionally, the potential impact of valgus knee braces and muscle strengthening in reducing the knee adduction moment is addressed (Reeves and Bowling, 2011).

This study compared the effects of unloader knee orthoses and laterally wedged insoles on gait parameters and pain in patients with medial compartment knee osteoarthritis (OA). In a quasi-experimental design, 24 subjects (mean age 59.29 ± 2.23 years) were randomly assigned to either intervention. Assessments at baseline and after six weeks, using a visual analog scale for pain and gait analysis, showed significant improvements in all parameters for both interventions compared to the baseline (p = 0.000). However, no significant differences were observed in pain (p = 0.649), adduction moment (p = 0.205), walking speed (p = 0.056), or step length (p = 0.687) between the two interventions. A notable difference was found in knee range of motion (p = 0.000). In conclusion, both interventions effectively alleviated knee pain and improved gait parameters in medial compartment knee OA, with a slight 3-degree reduction in maximum knee range of motion when using the knee orthosis (Arazpour et al., 2013).

A systematic review and meta-analysis published in the journal Osteoarthritis and Cartilage evaluated the effectiveness of biomechanical alignment interventions in patients with knee osteoarthritis. The review found that biomechanical interventions, including orthotics, braces, and shoe modifications, were effective in improving pain and function in patients with knee osteoarthritis (Collins et al., 2013).

study published in the journal Osteoarthritis and Cartilage found that a 3-degree wedge was the most effective in reducing the knee adduction moment, which is associated with knee OA progression (Parkes et al., 2013).

This study aimed to assess the effectiveness of lateral-wedge insoles in reducing pain and improving function in patients with medial knee osteoarthritis. A systematic search of three databases identified ten studies, encompassing 938 patients. The overall analysis did not reveal significant improvements in knee pain (SMD = −0.21) or knee function (SMD = 0.22) with lateral-wedge insoles compared to controls. Subgroup analysis by research area indicated a positive outcome for Asian patients in pain reduction (SMD = −0.88). However, there was no significant improvement observed in patients from the USA and other regions. Sensitivity analysis and the absence of publication bias supported the overall findings. In conclusion, while lateral-wedge insoles may be beneficial for young Asian patients within normal BMI, the current data suggests their overall ineffectiveness in alleviating knee pain and improving function (Zhang et al., 2018).

This randomized clinical trial conducted at a Swiss university hospital involved 220 participants with symptomatic knee osteoarthritis to assess the effects of biomechanical footwear therapy compared to control footwear over 24 weeks. The participants were randomized into two groups: one receiving biomechanical footwear with individually adjustable external convex pods, and the other receiving control footwear with non-adjustable visible outsole pods. The primary outcome, knee pain at 24 weeks measured by the WOMAC pain subscore, showed a statistically significant improvement in the biomechanical footwear group compared to the control group. Secondary outcomes, including WOMAC physical function, stiffness subscores, and global score, also favored the biomechanical footwear group. The incidence of serious adverse events was lower in the biomechanical footwear group. While the improvement in pain was statistically significant, its clinical relevance remains uncertain, highlighting the need for further research to determine the long-term efficacy and safety of biomechanical footwear therapy (Reichenbach et al., 2020).

A randomized controlled trial published in the Annals of Internal Medicine evaluated the effectiveness of footwear modifications in patients with knee osteoarthritis. The study found that patients who wore customized footwear had significant improvements in pain and function compared to those who wore standard footwear (Reichenbach et al., 2020).

In this randomized trial involving 164 participants with moderate to severe symptomatic radiographic medial knee osteoarthritis, the objective was to compare the effectiveness of flat flexible shoes versus stable supportive shoes. Participants wore their assigned shoes for at least 6 hours a day for 6 months. The primary outcomes, changes in walking pain and physical function at 6 months, showed no evidence that flat flexible shoes were superior. While there was a between-group difference favoring stable supportive shoes in pain improvement, no significant difference was observed in function. Additionally, stable supportive shoes were associated with better knee-related quality of life and less ipsilateral hip pain. Adverse events were reported less frequently with stable supportive shoes. The study concludes that flat flexible shoes did not outperform stable supportive shoes, contrary to the hypothesis, and that stable supportive shoes demonstrated better improvement in knee pain during walking. The limitations include the absence of a "usual shoes" control group and the study's applicability to a select patient subgroup (Paterson et al., 2021).

Overall, the literature suggests that biomechanical alignment interventions, including knee braces and footwear modifications, may be effective in managing knee osteoarthritis. These interventions may improve pain and function in patients with knee osteoarthritis. However, further research is needed to fully understand the long-term effectiveness of these interventions and to determine the optimal treatment approach for different types and stages of knee osteoarthritis.

1. **Methodology**
   1. **Methodology and data collection:**

40 patients were participated in this study, their ages between 30-80 years, both female and male. The patients were diagnosed by Rheumatologists and Orthopedists regarding their knee pain. The participants are divided into two groups: group A is experimental group 20 patients (all of them Varus), who underwent usual OA treatment with biomechanical intervention and group B is control group 20 patients (18 Varus and 2 Valgus), who underwent usual OA treatment of physiotherapy like (aerobic and strengthening exercises) and medication like (acetaminophen, NSAIDs and opioids). All of the participants from the city center. The data was collected at Rizgary Teaching Hospital and Erbil Teaching Hospital during the period December 2021 to July 2023.

* 1. **Inclusion and Exclusion criteria:**

The patients were included in this study those who had knee joint osteoarthritis that is with biomechanical malalignment.

The patients were excluded if they had a history of Rheumatoid Arthritis, knee surgery, pregnancy, hip disorders and those who had OA but did not develop a biomechanical malalignment.

* 1. **Intervention**

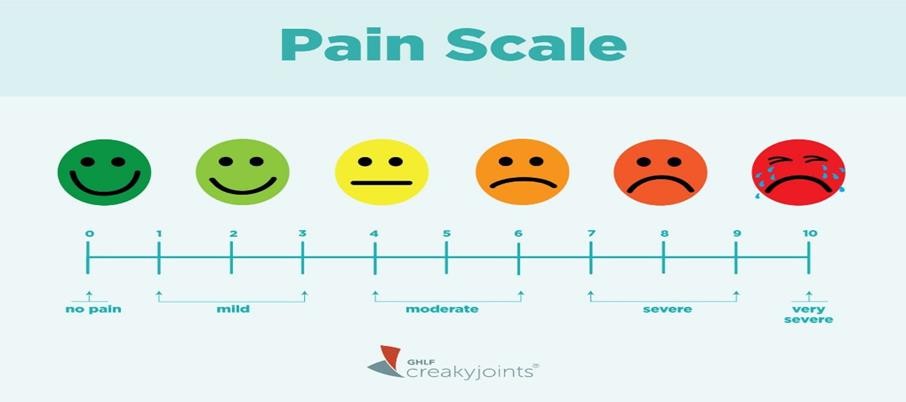
The study involved improving the biomechanical alignment of the patients with knee joint osteoarthritis, by adding a wedge on the outside shoe sole (Fig 3.1.), to alter the weight distribution on the knee joint by moving the action line of the weight and ground reaction force to be more laterally and to be used at least for the duration of three to six months.



Fig 3.1. Lateral wedge outsole

* 1. **Procedure**

The patients were referred by Rheumatologists and Orthopedists and we recorded the history of the patients, their pain score used VAS (0-10) (Fig 3.2.), and physical activities used WOMAC questionnaire (Apendix1). Then according to the patients X-ray and using the LASER line from the anterior superior iliac supine to the middle of the ankle joint. We could indicate the kind of mal-alignment of the patient has whether it Varus or Valgus. To ensure that patients we chosen according to the criteria mentioned above. Then we followed-up the pain, physical activities, and alignment of the patients after six months.



**Fig 3.2.:** Show rate pain scale. Raja SN, Carr DB, Cohen M, Finnerup NB, Flor H, Gibson S, Keefe F, Mogil JS, Ringkamp M, Sluka KA, Song XJ (2020).

* 1. **Western Ontario and McMaster Universities Osteoarthritis Index**

The WOMAC (Western Ontario and McMaster Universities Osteoarthritis Index) questionnaire is a standardized assessment tool used to measure the symptoms and functional limitations of individuals with osteoarthritis. It consists of three subscales:

1. Pain: Assesses the level of pain experienced by the individual during various activities.
2. Stiffness: Evaluates the degree of stiffness felt by the individual, particularly in the morning or after rest.
3. Physical Function: Measures the individual's ability to perform daily activities and tasks.

Respondents answer questions related to each subscale, and the scores are combined to provide an overall assessment of the impact of osteoarthritis on a person's quality of life. It's often used in clinical research and patient care to quantify the severity of osteoarthritis and monitor changes over time.

* 1. **Pain evaluation**

Pain evaluation is a crucial process in healthcare, involving the assessment and understanding of an individual's pain experience. Accurate evaluation by healthcare providers is essential for determining the cause, severity, and impact of pain on a person's overall well-being, thereby guiding appropriate treatment and management strategies. Using the Visual Analog Scale (VAS), patients were provided with a horizontal paper spanning 10 cm, marked with numbers from 1 to 10. They were instructed to rate their pain, with '0' representing no pain and '10' indicating the most intense pain they had experienced in their life.

* 1. **Statistical Analysis**

The data was analyzed using SPSS software version (26). The results are shown in descriptive statistics such as, mean and standard deviation for each group. Normality assumptions were assessed and based on their results, Parametric approach was utilized like Paired Sample t-test, to evaluate the methods per the each follow up. For all test p < 0.05 was considered to be statistically significant.

**4. Results and Discussion**

**4.1. Introduction**

The results of the research project were discussed, and sections were arranged based on the research objectives. The results were presented via graphs and tables, with the identification of the effects through statistical analysis for each case. The results were compared with benchmark research and international protocols during the interpretation of results, as follows!

**4.2. Descriptive Statistics**

**Table 4.1.** the descriptive statistics for all demographic information’s including the age, gender, BMI, occupation, grades of OA, and type of malalignment from patients with knee joint pain.

Most of the participants are aged more than 49 years (60%) followed by 40-49 years (22.5%), and 30-39 (17.5%) respectively. The average of their ages are 52 years (Fig 4.1.). The percentage of female (72.5%) is higher than the percentage of male’s participants (27.5%) (Fig 4.2.). Most of the patients are obese of BMI (55%) followed by over weight (32.5%), normal (12.5%) respectively since none of the patients are underweight (0%) (Fig 4.3.), as well as their average of BMI are 30.62. Furthermore, majority of patient in this study do not have work (housewife) (65%), most of them have grade 2 of OA (47.5%). Finally, the percentage of Varus as a type of malalignment (95%) is higher than the percentage of valgus (5%). (Fig 4.4, Fig 4.5 and Fig 4.6)

**Table 4.1.** Descriptive Statistics for Socio Demographic

Questions from Patients with Knee OA

|  |  |  |  |
| --- | --- | --- | --- |
|  | | F | % |
| Age | 30 – 39 | 7 | 17.5% |
| 40 – 49 | 9 | 22.5% |
| 50 and more | 24 | 60.0% |
| (Mean ± SD) | (52 ± 11.94) | |
| Gender | Male | 11 | 27.5% |
| Female | 29 | 72.5% |
| BMI group | Less than 18.5 (Underweight) | 0 | 0.0% |
| 18.5 - 24.9 (Normal) | 5 | 12.5% |
| 25 - 29.9 (Over weight) | 13 | 32.5% |
| 30 and more (Obese) | 22 | 55.0% |
| (Mean ± SD) | (30.62 ± 4.68) | |
| Occupation | Housewife | 26 | 65.0% |
| Teacher | 8 | 20.0% |
| Worker | 6 | 15.0% |
| OA grade | Grade 1 | 0 | 0.0% |
| Grade 2 | 19 | 47.5% |
| Grade 3 | 17 | 42.5% |
| Grade 4 | 4 | 10.0% |
| Type of malalignment | Varus | 38 | 95.0% |
| Valgus(from control group) | 2 | 5.0% |

Fig 4.1. Percentage to show age of participants

Fig 4.2. Percentage to show gender of participants

Fig 4.3. Percentage to show BMI of participants

Fig 4.4. Percentage to show occupation of participants

Fig 4.5. Percentage to show grades of Osteoarthritis

Fig 4.6. Percentage to show type of malalignment

**4.3. Instrument of Reliability Test**

The research tool was tested for reliability and foundational validity before the results are presented. A reliability test was carried out using Cronbach’s alpha, which measures the internal consistency of a construct. The recommended minimum acceptable limit of reliability “alpha” for this measure is 0.60 (Babin et al., 2003). Cronbach's alpha values were estimated to check the internal consistency of the data after data collection, and Cronbach‘s alpha is a scale tool of reliability (Zhong et al., 2017); (Vaske et al., 2017); (Taber, 2018). More specifically, alpha is a lower bound for true scan reliability.

For an exploratory or experimental study, it is suggested that the reliability be equal to 0.60 or higher (Straub et al., 2004, Hinton, 2014) suggested four cut-off points for reliability, which include excellent reliability (0.90 and above), high reliability (0.70-0.90), moderate reliability (0.50-0.70), and low reliability (0.50 and below) (Hinton, 2014). Although reliability is important to study, it is not sufficient unless combined with validity. In other words, for a test to be reliable, it must also be valid (Blbas et al., 2017). Table 4.2. illustrates the reliability of each construct. Cronbach's high value for all formulations indicates that it is internally consistent and measures the content of the same construct.

Table 4.2. shows the values of the Cronbach‘s coefficient estimated for testing the internal consistency of the measurement. The result for Cronbach‘s alpha is (0.819, 0.927, and 0.969) for pre pain, stiffness, and physical activity scores respectively

In addition, the result for Cronbach‘s alpha is (0.963, 0.909, and 0.972) for post pain, stiffness, and physical activity scores respectively.

**The table 4.2.** represents that all the constructs have passed the reliability test where all α–values have exceeded the recommended minimum value of Cronbach’s alpha (Blbas, 2017).

**Table 4.2.** Reliability of measurements for all variables

|  |  |  |  |
| --- | --- | --- | --- |
|  | Constructs | Number of items | Cronbach's Alpha |
| Pre | Pain | 5 | 0.819 |
| Stiffness | 2 | 0.927 |
| Physical activity | 17 | 0.969 |
| Post | Pain | 5 | 0.863 |
| Stiffness | 2 | 0.909 |
| Physical activity | 17 | 0.972 |

**Table 4.3.** the descriptive statistics for pre-treatment pain scores, most of the participants in this survey said that they have severe pre-treatment pain (80%) compared to moderate pre-treatment pain score (20%) since none of them have mild or no pain. (Fig 4.7.)

On the other hand, the mean of pre-treatment pain score (2.8) and it is closer to 3, it means, they have severe pain in general.

**Table 4.3.** Descriptive Statistics for pre-treatment pain score

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | No of Pt. | % | Mean | SD |
| Moderate | 8 | 20 | 2.80 | 1.45 |
| Severe | 32 | 80 |

Fig 4.7. Percentage for pre- treatment pain score using Bar Chart

**Table 4.4.** the descriptive statistics for post treatment pain scores, most of the patients in this survey have mild pain (55%) in the end of intervention (posttest) followed by moderate (22.5%), severe (15%), and no pain (7.5%) respectively. (Fig 4.8.) Comparing result between pre- treatment in table 4.3. and post treatment in table 4.4. showed that 7.5% of patients do not have any pain more at all, 55% of them have reduced their pain to mild, moderate pain is increased from (20%) in pre- treatment to (22.5%) in post treatment, and severe pain is reduced from (80%) in pre- treatment to (15%) in post treatment. On the other hand, the mean of post pain score (1.45) and it is closer to one, it means, they have mild pain in general.

Table 4.4Descriptive Statistics for post treatment pain score

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | F | % | Mean | SD |
| None | 3 | 7.5 | 1.45 | 0.85 |
| Mild | 22 | 55 |
| Moderate | 9 | 22.5 |
| Severe | 6 | 15 |

Fig 4.8. Percentage for post treatment pain score using Bar Chart

**Table 4.5.** The descriptive statistics between study and control for both pre and post treatment pain scores. The result shows that (5%) of patients do not have any pain at all in posttest from study group, since (2.5%) have no pain from control group.

Also, (35%) of patients have mild pain in posttest from study group and (20%) have mild pain from control group which we do not have mild pain from the pretest.

In addition, in the case study, the percentage for severe pain decreased from pre- treatment (45%) to post treatment (0%) while is less reduced from pre (35%) to post (15%) in the control group. (Fig 4.9.)

**Table 4.5.** Descriptive Statistics between two groups and both pre and post treatment pain scores

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | | Group | | | | | |
| Study | | | Control | | |
| N | % | N | | % |
| Pre pain score | Moderate | 2 | 5% | 6 | | 15% |
| Severe | 18 | 45% | 14 | | 35% |
| Post pain score | None | 2 | **5%** | 1 | | 2.5% |
| Mild | 14 | 35% | 8 | | 20% |
| Moderate | 4 | 10% | 5 | | 12.5% |
| Severe | 0 | 0% | 6 | | 15% |

Fig 4.9. Association between two groups and both

pre and post treatment pain scores using Bar Chart

**4.4. Paired Sample T Test.**

Paired sample t test compares the mean between two related (paired, repeated or matched) variables (Blbas et al., 2022).

Paired sample t-test were used to analyze the relationship between pre and post treatment pain scores with each of the (Walking, Stair Climbing, Nocturnal, Rest, and Weight Bearing).

**Table 4.6.** there is a statistical significant difference between the mean pre and post treatment pain scores with each of the (Walking, Stair Climbing, Nocturnal, Rest, and Weight Bearing) individually from study group because their p-values are less than the significant level of α=0.05. In addition, the average of post treatment pain for each of them is lower than the average for pre- treatment pain scores, it means, the pain of patients are decreased in the end of biomechanical intervention.

Walking pain is much effective rather than other to reduce patients pain in case study because it has the highest value of mean difference (2.05) followed by Stair Climbing (1.95), Weight Bearing (1.85), Nocturnal (1.6), and Rest (1.35) respectively.

**Table 4.6.** Paired Sample T Test between the mean of pre and post treatment pain score with each of the (Walking, Stair Climbing, Nocturnal, Rest, and Weight Bearing) from study group

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | | Mean | Mean Difference | Std. Deviation | t | p-value |
| Walking | Pre | 2.7500 | 2.0500 | 0.5501 | 12.08 | 0.000 |
| Post | 0.7000 | 0.5712 |
| Stair Climbing | Pre | 3.2500 | 1.9500 | 0.8507 | 10.57 | 0.000 |
| Post | 1.3000 | 0.8013 |
| Nocturnal | Pre | 2.1000 | 1.6000 | 1.0208 | 7.139 | 0.000 |
| Post | 0.5000 | 0.6882 |
| Rest | Pre | 1.6500 | 1.3500 | 1.0400 | 6.463 | 0.000 |
| Post | 0.3000 | 0.6569 |
| Weight Bearing | Pre | 2.6500 | 1.8500 | 0.9881 | 8.865 | 0.000 |
| Post | 0.8000 | 0.6156 |

**Table 4.7.** there is a statistical significant difference between the mean pre and post treatment pain scores with each of the (Walking, Stair Climbing, Nocturnal, Rest, and Weight Bearing) individually from control group because their p-values are less than the significant level of α=0.05. In addition, the average of post treatment pain for each of them is less lower than the average for pre- treatment pain scores compared to study group, it means, the pain of patients are decreased in the end of duration.

Weight Bearing pain is much effective rather than other to reduce patients pain in control group because it has the highest value of mean difference (1.10) followed by walking (0.850), Stair Climbing (0.70), Nocturnal (0.60), and rest (0.40) respectively. The result showed there is less significant difference compare to the study group.

**Table 4.7.** Paired Sample T Test between the mean of pre and post treatment pain score with each of the (Walking, Stair Climbing, Nocturnal, Rest, and Weight Bearing) from control group

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | | Mean | Mean Difference | Std. Deviation | t | p-value |
| Walking | Pre | 2.700 | 0.850 | 0.470 | 5.667 | 0.000 |
| Post | 1.850 | 0.933 |
| Stair Climbing | Pre | 2.650 | 0.700 | 0.933 | 4.765 | 0.000 |
| Post | 1.950 | 1.395 |
| Nocturnal | Pre | 1.100 | 0.600 | 0.852 | 5.339 | 0.000 |
| Post | 0.500 | 0.607 |
| Rest | Pre | 0.650 | 0.400 | 0.745 | 3.599 | 0.002 |
| Post | 0.250 | 0.444 |
| Weight Bearing | Pre | 2.450 | 1.100 | 0.826 | 6.85 | 0.000 |
| Post | 1.350 | 0.933 |

**Table 4.8.** there is a statistical significant difference between the mean pre and post treatment pain scores with each of the physical activities individually from study group because their p-values are less than the significant level of α=0.05. In addition, the average of post treatment pain for each of them is lower than the average for pre- treatment pain scores, it means, the pain of patients are decreased in the end of intervention.

In the case study, standing is considerably more successful than any other approach for reducing patients' pain because it has the largest mean difference value (2), which is followed by the other approaches, as seen in figure (4.10.).

**Table 4.8.** Paired Sample T Test between the mean of pre and post treatment pain score with each of the sixteen physical activates from study group

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | | Mean | Mean Difference | Std. Deviation | t | p-value |
| Descending stairs | Pre | 3.2500 | 1.9000 | 0.8507 | 9.318 | 0.000 |
| Post | 1.3500 | 0.8127 |
| Ascending stairs | Pre | 3.2500 | 1.9000 | 0.8507 | 9.318 | 0.000 |
| Post | 1.3500 | 0.8127 |
| Rising from sitting | Pre | 2.6500 | 1.6000 | 0.8751 | 8.107 | 0.000 |
| Post | 1.0500 | 0.8256 |
| Standing | Pre | 2.5000 | 2.0000 | 0.8885 | 9.747 | 0.000 |
| Post | 0.5000 | 0.6882 |
| Bending to the floor | Pre | 2.7000 | 1.7500 | 0.7327 | 9.952 | 0.000 |
| Post | 0.9500 | 0.5104 |
| Getting in/out of the car | Pre | 2.3500 | 1.8500 | 0.8127 | 8.373 | 0.000 |
| Post | 0.5000 | 0.6882 |
| Going shopping | Pre | 2.6500 | 1.8500 | 0.8127 | 7.955 | 0.000 |
| Post | 0.8000 | 0.7678 |
| Putting socks | Pre | 2.4000 | 1.6000 | 0.9403 | 7.61 | 0.000 |
| Post | 0.8000 | 0.6959 |
| Rising from the bed | Pre | 2.4500 | 1.7500 | 0.8256 | 8.097 | 0.000 |
| Post | 0.7000 | 0.6569 |
| Taking of socks | Pre | 2.4000 | 1.6000 | 0.9403 | 7.61 | 0.000 |
| Post | 0.8000 | 0.6959 |
| Lying in bed | Pre | 1.7000 | 1.4500 | 1.0311 | 6.868 | 0.000 |
| Post | 0.2500 | 0.5501 |
| Getting in/out bath | Pre | 2.4500 | 1.7000 | 0.7592 | 9.488 | 0.000 |
| Post | 0.7500 | 0.7864 |
| Sitting | Pre | 2.7000 | 1.8000 | 0.7327 | 10.49 | 0.000 |
| Post | 0.9000 | 0.7182 |
| Getting on/off toilet | Pre | 2.8500 | 1.6500 | 0.6708 | 8.435 | 0.000 |
| Post | 1.2000 | 0.7678 |
| Performing heavy domestic duties | Pre | 2.6500 | 1.4500 | 0.8127 | 8.542 | 0.000 |
| Post | 1.2000 | 0.6959 |
| Performing light domestic duties | Pre | 2.0500 | 1.6000 | 0.9445 | 7.193 | 0.000 |
| Post | 0.4500 | 0.6863 |

Fig 4.10. Mean difference between pre and post treatment pain score with each of the sixteen physical activates from study group using Bar Chart

**Table 4.9.** there is a statistical significant difference between the mean pre and post treatment pain scores with physical activates except Lying in bed from control group because their p-values are less than the significant level of α=0.05. In addition, the average of post treatment pain for each of them is less than the average for pre- treatment pain scores compared to study group.

In the case study, standing is considerably more successful than any other approach for reducing patients' pain because it has the largest mean difference value (1.1), which is followed by the other approaches but all of them are less effective than study group, as seen in figure (4.11.).

**Table 4.9.** Paired Sample T Test between the mean of pre and post treatment pain score with each of the sixteen physical activates from control group

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | | Mean | Mean Difference | Std. Deviation | t | p-value |
| Descending stairs | Pre | 2.600 | 0.650 | 0.883 | 4.333 | 0.000 |
| Post | 1.950 | 1.395 |
| Ascending stairs | Pre | 2.600 | 0.650 | 0.883 | 4.333 | 0.000 |
| Post | 1.950 | 1.395 |
| Rising from sitting | Pre | 2.400 | 0.950 | 0.681 | 7.025 | 0.000 |
| Post | 1.450 | 0.945 |
| Standing | Pre | 2.600 | 1.100 | 0.503 | 6.85 | 0.000 |
| Post | 1.500 | 0.827 |
| Bending to the floor | Pre | 2.100 | 0.800 | 0.852 | 8.718 | 0.000 |
| Post | 1.300 | 0.865 |
| Gettingin in/out of the car | Pre | 1.100 | 0.400 | 0.788 | 3.559 | 0.002 |
| Post | 0.700 | 0.733 |
| Going shoping | Pre | 2.400 | 0.800 | 0.681 | 6.835 | 0.000 |
| Post | 1.600 | 0.821 |
| Putting socks | Pre | 0.950 | 0.350 | 0.945 | 3.199 | 0.005 |
| Post | 0.600 | 0.754 |
| Rising from the bed | Pre | 1.100 | 0.450 | 0.968 | 3.943 | 0.001 |
| Post | 0.650 | 0.813 |
| Taking of socks | Pre | 0.950 | 0.350 | 0.945 | 3.199 | 0.005 |
| Post | 0.600 | 0.754 |
| Lying in bed | Pre | 0.550 | 0.100 | 0.759 | 1.453 | 0.163 |
| Post | 0.450 | 0.605 |
| Getting in/out bath | Pre | 1.550 | 0.650 | 0.605 | 4.333 | 0.000 |
| Post | 0.900 | 0.852 |
| Sitting | Pre | 2.000 | 0.750 | 1.076 | 5.252 | 0.000 |
| Post | 1.250 | 0.910 |
| Getting on/off toilet | Pre | 2.600 | 0.700 | 0.821 | 4.273 | 0.000 |
| Post | 1.900 | 1.021 |
| Performing heavy domestic duties | Pre | 2.550 | 0.800 | 0.686 | 5.141 | 0.000 |
| Post | 1.750 | 1.020 |
| Performing light domestic duties | Pre | 1.350 | 0.750 | 0.745 | 6.097 | 0.000 |
| Post | 0.600 | 0.821 |

Fig 4.11. Mean difference between pre and post treatment pain score with each of the sixteen physical activates from control group using Bar Chart

**Table 4.10.** there is a statistical significant difference between the mean pre and post treatment pain scores with overall pain score from study group because its p-value is less than the significant level of α=0.05. In addition, the average of overall post treatment pain score (1.10) is lower than the average for pre- treatment pain scores (2.9).

**Table 4.10.** Paired Sample T Test between the mean of pre and

post treatment pain score with overall pain score from study group

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | | Mean | Mean Difference | Std. Deviation | t | p-value |
| Pain score | Pre | 2.9000 | 1.8000 | 0.3078 | 15.39 | 0.000 |
| Post | 1.1000 | 0.5525 |

**Table 4.11.** there is a statistical significant difference between the mean pre and post treatment pain scores with overall pain score from control group because its p-value is less than the significant level of α=0.05. In addition, the average of overall post treatment pain score (1.80) is lower than the average for pre- treatment pain scores (2.7).

**Table 4.11.** Paired Sample T Test between the mean pre and post treatment pain scores with overall pain score from control group

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | | Mean | Mean Difference | Std. Deviation | t | p-value |
| Pain score | Pre | 2.700 | 0.900 | 0.470 | 5.604 | 0.000 |
| Post | 1.800 | 0.951 |

**Table 4.12.** there is a statistical significant difference between the mean pre and post malalignment degree from study group because its p-value is less than the significant level of α=0.05. In addition, the average of post Malalignment score (178.20) is lower than the average for pre malalignment degree (175.845).

**Table 4.12.** Paired Sample T Test between the mean of pre and

post Malalignment degree from study group

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | | Mean | Mean Difference | Std. Deviation | t | p-value |
| Malalignment | Pre | 175.8750 | -2.3250 | 3.6342 | 4.379 | 0.000 |
| Post | 178.2000 | 1.6654 |

**Table 4.13.** there is no statistical significant difference between the mean pre and post malalignment degree from control group because its p-value is higher than the significant level of α=0.05.

**Table 4.13.** Paired Sample T Test between the mean of pre and

post Malalignment degree from control group

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | | Mean | Mean Difference | Std. Deviation | t | p-value |
| Malalignment | Pre | 176.750 | 0.000 | 1.832 | 0 | 1 |
| Post | 176.750 | 1.832 |

**4.1. Discussion**

The aim of this study was to determine the effect of biomechanical intervention on patients with knee joint osteoarthritis and compare with control group. The study group shows more affected in reducing pain within the study period, which was six months of follow up of patients with knee osteoarthritis.

This study shows that knee joint pain affects mainly older individuals, particularly those aged 50 years and over. As individuals age, there is a natural decrease in the production of synovial fluid, crucial for lubricating joints and minimizing friction between bones. Additionally, aging increases the likelihood of developing osteoarthritis, a degenerative joint disease where the protective cartilage that cushions bone ends gradually wears down, contributing to knee pain in older adults. This is in line with previous studies that have shown an increased prevalence of knee pain with advancing age (Nguyen et al., 2011). The higher percentage of female participants in this study is consistent with previous studies that have reported a higher prevalence of knee pain in women than in men (Srikanth et al., 2005), Women may have different biomechanics and movement patterns compared to men, which can affect joint loading and contribute to the development of osteoarthritis. Factors such as gait, joint laxity, and muscle strength can influence the mechanical stresses on joints. The high percentage of obese patients in this study is also consistent with previous studies that have shown a strong association between obesity and knee pain (Hayashi et al., 2012). This is likely due to the increased load placed on the knee joint in individuals who are overweight or obese, which can lead to the development of knee OA and subsequent knee pain (Blagojevic et al., 2010). The majority of patients in this study were housewives, which may be due to the fact that they are more likely to engage in activities that require prolonged standing and walking, such as household chores (Nguyen et al., 2011). This may also explain the higher percentage of patients with grade 2 of OA, as housewives may be more likely to delay seeking medical attention until their symptoms become more severe. The high percentage of patients with varus malalignment is consistent with previous studies that have shown varus malalignment to be a risk factor for the development and progression of knee OA (Naderi et al., 2014). This highlights the importance of assessing malalignment in patients with knee pain, as it may guide treatment decisions and improve outcomes.

The results present a comparison of descriptive statistics for pre and post treatment pain scores between the study and control groups. In terms of pre-treatment pain scores, the study group had 5% with moderate pain and 45% with severe pain, while the control group had 15% with moderate pain and 35% with severe pain. Looking at post-treatment pain scores, the study group showed 5% with no pain, 35% with mild pain, and 10% with moderate pain. In contrast, the control group had 2.5% with no pain, 20% with mild pain, 12.5% with moderate pain, and 15% with severe pain. Comparing post-treatment pain scores, both groups had a small percentage with no pain, but the study group had a higher proportion with mild pain (35% vs. 20% ). Moderate pain distribution was similar. Notably, no patients in the study group reported severe pain, while 15% in the control group did.

The use of lateral wedge on shoes is a common intervention for patients with knee osteoarthritis (OA). These wedges (which was of 1cm height) are designed to tilt the foot slightly, with the thicker side of the wedge on the lateral (outer) edge of the sole (Rafiaee and Karimi, 2012). One of the leading causes of effectiveness of the lateral wedge is related to the reduction in knee adduction moment, this is the force that tends to push the knee inward (toward the other knee) when walking. High knee adduction moments are associated with increased joint loading and greater pain in knee OA. Lateral wedges are thought to reduce this moment by altering the alignment of the lower limb, and change the action line of the ground reaction force passing through the knee joint which may help decrease pain (Ferreira et al., 2019).

In our study, according to WOMAC pain score for each of the activities (Walking, Stair Climbing, Nocturnal, Rest, and Weight Bearing) and WOMAC physical functions. there were a statistically significant difference between the mean pre and post treatment pain scores in the study and control groups. The p-values for all activities were less than the significance level of o=0.05, (except lying in bed in control group), but the mean difference of all variables in the study group is more than the mean difference in the control group. The improvements in physical functioning for patients with knee osteoarthritis, may include increased walking speed and a reduction in knee adduction angle. Also it can lead to reductions in biomechanical factors associated with knee osteoarthritis, these factors include medial knee-joint-space load, adduction moment, and varus malalignment (Bennell et al., 2011, Huang et al., 2022).

In this study, results based on VAS showed that significantly decreased knee joint pain in the study and control groups, but in the study group the average of overall post treatment pain score (1.10) is lower than the average of pre-treatment pain score (2.9) and the mean difference is (1.8). In the control group the average of overall post treatment pain score (1.80) is lower than the average of pre-treatment pain score (2.7) and the mean difference is (0.9).

These results shows that the study group experienced a significant change in malalignment degree after the intervention, as evidenced by the lower p-value and the direction of the mean difference. However, there was no statistically significant change in malalignment degree in the control group. These findings suggest that the intervention had an effect on malalignment in the study group but not in the control group, emphasizing the potential effectiveness of the treatment or intervention (Yilmaz et al., 2016)(Fig 4.1.1, A,B).

Lateral wedges can help align the lower limb in a way that reduces the strain on the medial (inner) compartment of the knee, which is often affected by OA. By shifting the load away from the damaged part of the knee, patients may experience less pain. Also, lateral wedges are believed to redistribute the load on the knee joint. reducing the pressure on the medial compartment. This can potentially decrease the wear and tear on the joint cartilage, which is a hallmark of knee OA(Yilmaz et al.. 2016).



A: before using lateral wedge B; after using lateral wedge

It's important to note that while many studies have shown positive effects of improving the knee alignment in reducing pain in some individuals with knee OA, the effectiveness can vary from person to person. Not all patients with knee OA will experience the same degree of pain relief with this intervention. Before using lateral wedges or any treatment for knee OA, patients should consult with a healthcare professional or orthopedic specialist. Treatment plans should be personalized based on the patient's specific condition and needs. Additionally, the use of lateral wedges is just one component of a comprehensive approach to managing knee OA, which may also include exercises, physical therapy, pain medications, and lifestyle modifications (Parkser et al., 2018).

**5. Conclusion and Recommendation**

**5.1. Conclusion**

According to the results, the study group was used the lateral wedge outsole as a biomechanical intervention to realign the weight bearing line going through the knee joint, had a positive effect on decreasing pain levels and improving physical functions more than the control group. It also delays the need for a surgical intervention

**5.2. Recommendations for future works**

**1.** We recommend further studies on the effect of the foot wear itself on the OA conditions to be conducted.

**2.** We recommend further studies to decide the most suitable height to be used as lateral wedge outsole to realign the knee joint malalignment.



**ڕۆڵی ڕێکخستنی بایۆمیکانیکی لەسەر چارەسەرکردنی داخورانی جومگەی ئەژنۆ**

**نامەیەکە**

پێشکەشی ئەنجومەنی کۆلێژی تەکنیکی تەندروستی پزیشکی هەولێر کراوە لە زانکۆی پۆلیتەکنیکی هەولێروەکو بەشێک لە پێداویستیەکانی بۆبەدەست هێنانی بڕوانامەی باڵا لە ماستەری لە چارەسەری سروشتی

لەلایەن

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بەفرانبار ٢٧٢٣

**پوختە**

هەوکردنی جومگەی ئەژنۆ حاڵەتێكی درێژخایەنی جومگەكانە و بەهۆی داخورانی كڕكڕاگەی كۆتایی ئێسكەكان روودەدات، ئەم حاڵەتە کاریگەری لەسەر ژمارەیەکی زۆر لە تاکەکان هەیە لە ئاستی جیهانیدا و دەتوانێت ببێتە هۆی ئازارێکی بەرچاو، سنووردارکردنی چالاکی و گۆڕانکاری لە پێکهاتەی جومگەکاندا.

**ئامانجی توێژینەوەکە:** هەڵسەنگاندنی کاریگەری ڕێکخستنی بایۆمیکانیکی بۆ ئەو نەخۆشانەی کە داخورانی جومگەی ئەژنۆیان هەیە.

**کەرەستە و شێوازەکان:** لەم توێژینەوەیەدا ٤٠ نەخۆش بەشدارییان کردووە، تەمەنیان لە نێوان ٣٠-٨٠ ساڵدایە، بە هەردوو رەگەزی مێ و نێر. نەخۆشەکان لەلایەن پزیشکانی ڕۆماتیزم و ئێسک دەستنیشانی ئازاری ئەژنۆیان کراوە. بەشداربووان دابەشکراون بەسەر دوو گروپدا: گروپی پێکدێت لە ٢٠ نەخۆش کە چارەسەری بایۆمیکانیکیان کردووە، گرووپی گرووپی کۆنتڕۆڵە پێکدێت لە ٢٠ نەخۆش کە چارەسەری سروشتی و دەرمانیان وەرگرتووە. داتاکان لە نەخۆشخانەی فێرکاری ڕزگاری و نەخۆشخانەی فێرکاری هەولێر لە ماوەی مانگی کانوونی دووەمی ٢٠٢١ تا تەمموزی ٢٠٢٣ کۆکراونەتەوە.

B

A

**دەرەنجامەکان:** ئەنجامەکان دەریانخست کە هەردوو گروپەکە کاریگەر بوون لە کەمکردنەوەی ئازار و باشترکردنی ئەرکە جەستەییەکان، لە گروپی توێژینەوەکەدا تێکڕای نمرەی گشتی دوای ئازار (١،١٠) کەمترە لە تێکڕای نمرەی پێش ئازار (٢،٩) و تێکرای جیاوازی بریتییە لە (١،٨). لە گروپی کۆنترۆڵدا تێکڕای نمرەی گشتی دوای ئازار (١،٨٠) کەمترە لە تێکڕای نمرەی پێش ئازار (٢،٧) و تێکرای جیاوازی (٠،٩) یە. واتە گروپی توێژینەوەکە بە شێوەیەکی کاریگەرتر چارەسەر دەکرێت لە گروپی کۆنترۆڵ.

**دەرەنجام:** کەمبوونەوەی ئازاری جومگەی ئەژنۆ، باشترکردنی چالاکییە جەستەییەکان و ڕێکخستنەوەی ناڕێکی جومگەی ئەژنۆ دوای بەکارهێنانی کەفەی دەرەوە.



دور المحاذاة الميكانيكية الحيوية في علاج التهاب مفاصل الركبة

الاطروحة

مقدمة إلى مجلس كلية التقييه الصحيه الطبية في جامعة اربيل التقنيه وهي جزء من متطلبات نيل شهادة الماجستير في اختصاص العلاج الطبيعي

من قبل

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