

Common Upper and Lower Limb Msds in Hcps

Shaimaa Mohamed Abd-elatif Saeed ¹, Essam Tawfeek Atwa ¹, Hala Ali Mostafa Gaballah ¹,
Sohair Ahmed Attia Hagag ², Amany Rashad Ahmed El-Najjar ¹

1 Department of Rheumatology & Rehabilitation, Faculty of Medicine, Zagazig University, Egypt.

2 Department of Public Health and Community Medicine, Faculty of Medicine, Zagazig University, Egypt

Corresponding author: Shaimaa Mohamed Abd-elatif Saeed

E-mail: Ssaeed@medicine.zu.edu.eg, shemo4587@gmail.com

Conflict of interest: None declared.

Funding: No funding sources

Abstract

Upper limb or upper extremity, refers to the part of human body extending from the shoulder to the finger tips, encompassing the arm, forearm, wrist and hand, it's involved in various activities such as ; grasping, lifting and manipulation of objects. Performing repetitive tasks such as lifting patients, or administering treatments can strain muscles and tendons, leading to overuse injuries like tendonitis and carpal tunnel syndrome. The percentage of adults with lower limb pain (LLP) increases with age, Occupations considered to be physically demanding, such as construction workers, floor layers, brick layers, fishermen, farmers and service personnel (including but not limited to salespersons, health care workers, police officers) were associated with an increased risk of the development of LL pain (40.1%- 70%) with more than 50% of the LLP cases could be attributed to work. LLP is prevalent among HCPs, in a systematic review and meta-analyse, the prevalence of LLP that lasted more than a day in the previous 12 months among HCPs ranged from 20% to 35%. Nurses, physiotherapists and surgeon had higher rates of MSD prevalence in LL than other occupations. Among health care providers (HCPs) the knee and ankle/foot regions are most commonly affected by musculoskeletal disorders (MSDs) .

Keywords: upper and Lower limb MSDs, HCPs, MSDs

*Tob Regul Sci.*TM 2022 ;8(2): 734 - 760

DOI: doi.org/10.18001/TRS.8.2.52

Introduction

Upper limb or upper extremity, refers to the part of the human body extending from the shoulder to the finger tips, encompassing the arm, forearm, wrist, and hand. It's involved in various activities such as grasping, lifting, and manipulation of objects. The bones of the hand can be divided into three distinct groups, carpal, metacarpal, and phalanges. Joints of the hand include intercarpal joints and three joints in the fingers; metacarpophalangeal joint, proximal interphalangeal joint, and distal interphalangeal joint. The muscles of the hand consist of five

groups, thenar, hypothenar, lumbricals, palmar interossei, and dorsal interossei, in addition to finger flexors and extensors [1].

Work-related upper extremity disorders (WR-UEMDs) are in the form of aches, pains, tension, and discomfort that affect the muscles, tendons, ligaments, nerves, or other soft tissues associated with the neck, shoulders, arms, hands, wrists, and fingers. These can be caused or exacerbated by the work environment. WR-UEMDs are among one of the top 10 work-related conditions and become the most pressing human health issue in the global healthcare system [2].

UEMDs showed significant rates, particularly among dentists and surgeons. This can be explained by the precision required and the constraints related to the interventions, such as unique accesses (to the mouth in particular) and the risks incurred when handling tools [3].

The most frequently identified WR-UEMDs were rotator cuff disease. Other common UEMDs include lateral and medial epicondylitis and hand OA, which have also been reported to have a negative impact on upper extremity function and activities of daily living [4].

- Common upper limb MSDs in HCPs:

Carpal tunnel syndrome (CTS)

Carpal tunnel syndrome (CTS) occurs when the median nerve is compressed as it traverses the carpal tunnel. The primary factor contributing to the onset of CTS is the elevated pressure within the carpal tunnel. The typical initial signs of CTS include pain, numbness, and paresthesias, which affect the first 3 digits and the lateral half of the fourth digit. Symptoms of CTS can exhibit variability, with pain manifesting at the wrist, involving the entire hand, and potentially radiating up the forearm or extending beyond the elbow. As the condition advances, individuals may experience hand weakness, diminished fine motor coordination, clumsiness, and eventual atrophy of the thenar muscles [5].

The incidence of CTS in the general population ranges from 1% to 5%. CTS is more prevalent in females, with a 3:1 female-to-male ratio. CTS is uncommon in children and typically manifests in adults aged 40 to 60 [6].

Occupations involving frequent computer use, exposure to vibrating equipment, or repetitive movements significantly elevate the risk of developing CTS for individuals. Obesity, genetic predisposition, diabetes, rheumatoid arthritis, hypothyroidism, and pregnancy also contribute to the risk of developing CTS [7].

The pathology associated with CTS generally results from a combination of compression and traction affecting the median nerve. The compressive element characterized by increased pressure, obstruction of overall venous outflow, localized edema buildup, and impairment of the median nerve's intraneural microcirculation. Nerve function is compromised when lesions develop on the myelin sheath and axon, causing inflammation and loss of normal physiological protective and supportive functions of surrounding connective tissues. The changes in the nerve's structural integrity worsen the dysfunctional environment. Repeated traction and wrist movements exacerbate the dysfunctional environment, leading to further nerve injury [8].

HCPs that perform tasks requiring both force and repetition or holding vibrating tools have an 80% higher rate of developing CTS, in particular dentists, physiotherapists, orthopedic doctors, and surgeons [9].

Rotator Cuff Syndrome (RCS)

Shoulder pain comprises the third-leading musculoskeletal complaint at physician office visits, following spine and knee complaints. With a lifetime prevalence rate of 67%. Shoulder pain is most commonly caused by subacromial impingement syndrome and/or rotator cuff pathologies. Rotator cuff injuries affect patient populations in an age-dependent fashion. Prevalence rates increase with the increment of age [10].

The RC is an anatomic coalescence of the muscle bellies and tendons of the supraspinatus (SS), infraspinatus (IS), teres minor (TM), and subscapularis (SubSc). RCS is inflammation of muscles and tendons around the shoulder joint leading to pain, weakness, and decrease ROM. In HCPs, it often occurs due to lifting or transferring patients.

RCS constitutes a spectrum of disease across a wide range of pathologies associated with injury or degenerative conditions affecting the RC. RCS includes subacromial impingement syndrome (SIS) and bursitis, RC tendonitis, partial-versus full-thickness RC tears (PTTs versus FTTs), and, chronically, can influence the development of glenohumeral degenerative joint disease (DJD) and rotator cuff arthropathy (RCA) [11].

Injuries to the RC range from simple contusions and tendonitis to chronic tendinopathy, partial tears, and full-thickness tears. RC pathology can affect any subset of patient populations. Similarly, RC pathology is seen across all ages [12].

Dentistry work often involves static postures, arm abductions, and repetitive overhead reaching activities that can add stress to the shoulder, predisposing them to RC injury [13].

While SIS is the most common cause of shoulder pain, RC tendonitis is often seen in association with shoulder impingement. RC tendonitis can present in the acute setting following injury or, chronically, as a result of repetitive overuse activities or sport-related demands [14]. Acute or chronic tendinopathic conditions that result from a vulnerable environment for the rotator cuff secondary to repetitive eccentric forces and predisposing anatomical/mechanical risk factors [15].

Approximately 25% of patients with rotator cuff tendinopathy reported to have depressive and anxious symptoms, and almost 90% of patients report poor sleep quality or insomnia. Overall, nine psychological factors were identified to be associated with patient-reported outcome measures in patients with rotator cuff tendinopathy including depression and anxiety or fear of pain, pain catastrophizing, emotion, distress, mental health, poor sleep-quality, expectation, and concerns [16].

Tendonitis

i. Bicipital tendinitis

The long head of the biceps (LHB) brachii tendon originates at the supraglenoid tubercle and superior glenoid labrum. Inside the joint, the tendon is extrasynovial and passes obliquely,

heading toward the bicipital groove. The LHB tendon distally joins the short head of the biceps (SHB) tendon to insert on the radial tuberosity and medial forearm fascia [17].

Biceps tendonitis describes a clinical condition of inflammatory tenosynovitis, most commonly affecting the tendinous portion of the LHB as it travels within the bicipital groove in the proximal humerus. The continuum of clinical pathology ranges from acute inflammatory tendinitis to degenerative tendinopathy [18].

The pathophysiology of LHB tendinitis/tendinopathy begins with the early stages of tenosynovitis and inflammation secondary to repetitive traction, friction, and shoulder rotation. Inflammation develops early on in the tendinous portion in the bicipital groove. The tendon increases in diameter secondary to swelling and/or associated hemorrhage, further compromising the tendon as it becomes mechanically irritated in its confined space [19].

The resultant increased pressure and specific sites of traction predispose the tendon to pathologic shear forces. In addition, the sheath of the biceps tendon is a direct extension of the synovial lining of the glenohumeral joint. Thus, concomitant or preexisting RC pathology can directly compromise the LHB tendon itself [20].

ii. Wrist and hand tendinitis

Wrist tendonitis is a relatively common overuse condition which may affect one or more wrist tendons and is characterized by tissue damage, pain, and often swelling of the affected tendons. Whilst the term wrist tendonitis technically means ‘inflammation of the wrist tendons’, recent studies have demonstrated that overuse tendon injuries have little or no inflammation present and instead are primarily characterized by collagen degeneration, fiber disorientation and thinning, scattered vascular in-growth, and increased glycosaminoglycan [21].

Many muscles of the wrist and hand originate from the radius and ulnar and cross the wrist to insert into the bones of the wrist, hand, and fingers via the wrist tendons. These muscles fall into two broad groups known as the wrist and finger flexors and the wrist and finger extensors. Collectively, the muscles are responsible for gripping activity, movement of the wrist in all directions, and general activities involving the use of the wrist and fingers, such as lifting, holding, carrying, writing, typing, and pulling activities [22].

During contraction of the muscles of the wrist, tension is placed through the wrist tendons. When this tension is excessive due to too much repetition, prolonged force, or high force, damage to the wrist tendons may occur. Wrist tendonitis is a condition whereby there is damage, with subsequent degeneration, fiber disorganization/thinning, and often swelling affecting one or more of the wrist tendons. This is usually due to gradual wear and tear associated with overuse; however, it may also occur traumatically due to a specific incident [23].

A thorough subjective and objective examination from a physiotherapist may be sufficient to diagnose wrist tendonitis. Further investigations such as an X-ray, Ultrasound, MRI, or CT scan may be required to assist with diagnosis, rule out other conditions, and assess the severity of the condition [24].

There is a consistent correlation between biomechanical factors, such as awkward posture, manual therapy practices, and repeated movement, lifting heavy objects in combination with

other job risk factors, and hand/wrist tendinitis and the development of hand/wrist tendinitis [25].

Factors that have been found to have the highest predictive value for identifying an individual likely to develop wrist and hand tendonitis include mainly patient-related and few job-related factors, including age greater than 40 years, body mass index greater than 30, baseline complaints of shoulder or neck discomfort, a history of carpal tunnel syndrome, and finally, jobs with higher shoulder posture ratings. It seems increasingly clear that work-related upper extremity complaints involve a complex interaction between both physical and psychological attributes of the worker and the workplace itself [26].

Epicondylitis (Tennis/Golfer's Elbow)

Lateral epicondylitis, also commonly referred to as tennis elbow, describes an overuse injury secondary to an eccentric overload of the common extensor tendon at the origin of the extensor carpi radialis brevis tendon [27].

Tennis elbow is often an overuse injury primarily due to repetitive strain from tasks and activities that involve loaded and repeated gripping and/or wrist extension. It historically occurs in tennis players but can result from any sports or occupations that require repetitive wrist extension, radial deviation, and/or forearm supination. It is also seen in athletes who play squash and badminton, and other sports or activities that require similar movements. This condition is often precipitated by poor mechanics and technique or improper equipment in the athletic patient population [28].

Tennis elbow is the most common cause of elbow symptoms in patients presenting with elbow pain in general. The condition tends to affect men and women equally. Despite the condition being commonly referred to as tennis elbow, tennis players make up only 10% of the patient population. It is more common in individuals older than 40 years of age [29].

Smoking, obesity, repetitive movement for at least two hours daily, and vigorous activity (managing physical loads over 20 kg such as lifting and positioning of patients) are risk factors among HCPs for developing this condition. The natural course of the condition is favorable, with spontaneous recovery within one to two years in 80% to 90% of patients [30].

This condition is primarily a degenerative overuse process of the extensor carpi radialis brevis and the common extensor tendon. Aside from degenerative changes, the histological findings include granulation tissue, micro-rupture, an abundance of fibroblasts, vascular hyperplasia, unstructured collagen, and a notable lack of traditional inflammatory cells within the tissue. Ultrasound evaluation often reveals calcifications, intra-substance tears, marked irregularity of the lateral epicondyle, and thickening and heterogeneity of the common extensor tendon [31].

Lateral epicondylitis is a clinical diagnosis, and imaging is often not necessary. A provider may consider obtaining an elbow radiographic series (anteroposterior and lateral) if other injuries or conditions are suspected by history and/or physical exam. Other conditions warranting potential imaging workup include evaluating concomitant degenerative joint changes, fractures, tumors, or bursitis. If the patient is not responding to nonoperative management modalities, the provider

may consider ordering an MRI or ultrasound to evaluate for tears, stress fractures, or osteochondral defects [32].

Medial epicondylitis, also known as “golfer’s elbow” or “thrower’s elbow”, refers to the chronic tendinosis of the flexor-pronator musculature insertion on the medial epicondyle of the humerus as a result of overuse or repetitive stress. The flexor-pronator muscle group is composed of the pronator teres and the common flexor tendon, which includes tendons of the flexor digitorum superficialis, flexor carpi ulnaris, flexor carpi radialis, and palmaris longus. The flexor carpi radialis and the pronator teres are the most commonly involved tendons in medial epicondylitis [33].

Medial epicondylitis is primarily caused by repetitive strain from activities that involve frequent loaded gripping, forearm pronation, and/or wrist flexion. It most commonly occurs in golfers, tennis players, and baseball pitchers. Although it is often associated with athletes, this condition is also prevalent in the general population. Medial epicondylitis is often precipitated by poor body mechanics, improper techniques, and/or inadequate equipment or tools [34].

Musculoskeletal ultrasound (MUS) evaluation has a sensitivity and specificity, 95.2% and 92% respectively, for the diagnosis of medial epicondylitis. The most common findings on ultrasound are focal, hypoechoic changes in the common flexor tendon, thickening of the tendon sheath, partial or full-thickness tears, neovascularization using Doppler, and cortical irregularities at the medial epicondyle [35].

Thoracic Outlet Syndrome

Compression of nerves and blood vessels between the neck and shoulder, leading to pain, numbness, and weakness in the arm and hand, commonly from poor posture or repetitive overhead activities [36].

Shoulder Impingement Syndrome

Shoulder impingement is a clinical term often used nonspecifically to describe patients experiencing pain with overhead activity. Internal impingement is common in repetitive overhead activities. It occurs due to compression of the articular side rather than the bursal side of the RC tendons, between the posterior superior glenoid rim and humerus when the arm is in full external rotation, abduction, and extension [37].

External impingement, a term used synonymously with subacromial impingement syndrome. External impingement encompasses etiologies of external compressive sources (i.e. the acromion) leading to subacromial bursitis and bursal-sided injuries to the RC [38].

Muscle Strains and Sprains:

Overstretching or tearing of muscles or ligaments in the upper limb, resulting in pain, swelling, and decreased function, typically from sudden movements or lifting heavy objects [39].

De Quervain’s tenosynovitis

De Quervain’s tenosynovitis is a painful condition that affects the tendons on the lateral side of the wrist. It is caused by inflammation of the tendons that control the movement of the thumb,

specifically the abductor pollicis longus and extensor pollicis brevis. These tendons run through a narrow tunnel known as the wrist's first extensor compartment. It is a fibro-osseous sheath that becomes constricted and inflamed in De Quervain's tenosynovitis [40].

It typically affects adults, most commonly women between 30 and 50 years of age, especially those who use repetitive hand or wrist motions in their daily activities like dentists and physiotherapists. However, it can also occur in men and women of any age group who engage in activities that strain the tendons in the wrist and hand [41].

Trigger Finger

Trigger finger has been aptly described as a pathologic disproportion between the volume of the flexor tendon sheath and its contents. Although pain is the most common presenting symptom for other tendon disorders and can certainly be present in cases of trigger finger, patients mainly complain of the digit snapping, catching, or locking. Flexion deformities of the proximal interphalangeal (PIP) joint and an inability to fully flex the finger into the palm can be seen [42].

Trigger finger has a prevalence of roughly 2% in the general population and approximately 20% in multiple studies of patients with diabetes. Treatment includes rest, massage, exercise, local steroid injection, and splinting [43].

•Pathophysiology of De Quervain's tenosynovitis and Trigger Finger

The histopathologic finding of patients with both trigger finger and de Quervain's disease showed increasing disorganization or breakdown of the inner gliding layer of the pulley in the pathologic state along with the absence of inflammation. In long-standing trigger finger, the fibrocartilaginous gliding surface of the sheath is invaded by the hyperplastic outer vascular layer, ultimately replacing it with fibrotic tissue in severe cases [44].

The extensor retinaculum in patients with de Quervain's disease also demonstrated increased vascularity and deposition of dense fibrous tissue that resulted in its thickening. Tendon nodularity and fraying appear to be secondary to impingement on the degenerated and stenotic sheath. The edges of the pulleys or small-diameter retinacular sheaths through which many tendons pass, act as fulcrums. In fact, trigger finger and de Quervain's disease are primarily degenerative or reactive processes related to abnormal mechanical stress on the sheath and tendon within [45].

Subacromial bursitis of the shoulder

The subacromial bursa is bordered superiorly by the acromion, coracoid, coracoacromial ligament, and the proximal deltoid muscle fibers, and inferiorly by the fibers of the supraspinatus muscle. The height of the subacromial space ranges from approximately 1.0 to 1.5 cm [46].

Inflammation of the bursa can occur due to a variety of reasons, e.g., subacromial impingement, repetitive overhead activities/overuse, direct trauma, crystal deposition, subacromial hemorrhage, autoimmune diseases (e.g., rheumatoid arthritis), and infection, leading to the development of subacromial bursitis [47].

The lower limb (LL) refers to the part of the body below the waist from the hip to the toes. It includes the hip, thigh, knee, leg, ankle, foot, and toes, and consists of bones, muscles, tendons, ligaments, nerves, and blood vessels [48].

The percentage of adults with lower limb pain (LLP) increases with age, ranging from 21.0% for those aged (18–29) and 28.8% for those aged (30–44) to 43.4% for those aged (45–65) and 50.3% for those aged over 65 [49].

Occupations considered to be physically demanding, such as construction workers, floor layers, brick layers, fishermen, farmers, and service personnel (including but not limited to salespersons, health care workers, police officers) were associated with an increased risk of the development of LL pain (40.1%– 70%) with more than 50% of the LLP cases could be attributed to work [50].

LLP is prevalent among HCPs. In a systematic review and meta-analysis, the prevalence of LLP that lasted more than a day in the previous 12 months among HCPs ranged from 20% to 35%. Nurses, physiotherapists, and surgeons had higher rates of MSD prevalence in LL than other occupations [51].

Among HCPs, the knee and ankle/foot regions are most commonly affected by MSDs. In the knee, the prevalence of MSDs ranged between 7.5% and 77%, and in the ankle between 3.2% and 100% [52].

• Hip joint and thigh MSDs in HCPs

HCPs are susceptible to various MSDs affecting the hip joint due to the physical demands of their work. Awkward postures including kneeling, sitting, stair climbing, standing, and walking with the exposure duration at least 1 h/day are the main occupational risk factors for LL-WMSDs in the hip. Among them, kneeling was the posture that had the worst side effect on the hip joint, compared to other postures and activities such as walking and standing [53].

The smaller period of kneeling less than 1 hour/day might be associated with the higher range of hip flexion: Walking is a lower extremity activity which required hip flexion ranged from –50 to 380. Meanwhile, kneeling requires higher hip flexion up to 700 [54].

Some common disorders they may encounter include:

Hip Osteoarthritis (HOA):

Hip osteoarthritis (HOA) is a degenerative joint disease that causes progressive damage to the articular cartilage in the form of erosions and thinning with subsequent joint space narrowing, and bony changes including sclerosis of subchondral bone and new bone formation [55].

The hip is the second most commonly affected joint after the knee joint. The prevalence of confirmed symptomatic hip osteoarthritis is estimated at less than 1% of the population (all ages), more common in women than in men and increasing with age [56].

Greater Trochanter Pain Syndrome (GTPS)

Greater trochanter pain syndrome (GTPS) refers to hip periartthritis and trochanteric bursitis [57]. Particularly, GTPS contains a range of causes including gluteal medius and minimus

tendinopathy and/or tears, trochanteric bursitis and external coxa saltans. The presentation in common of these conditions is prolonged, intermittent peritrochanteric pain accompanied by tenderness to palpation overlying the lateral aspect of the hip [58].

The gluteus medius tendon is composed of 2 parts: a strong main round tendon that attaches to the superoposterior facet of the greater trochanter (GT) and a thin lateral part that attaches to the lateral facet of the GT. The gluteus minimus tendon attaches to the anterior facet of the GT. A bursa is located under each of these tendons. The trochanteric bursa, the largest and most superficial bursa, is located beneath the gluteus maximus muscle and the iliotibial tract and covers the posterior and lateral facets of the GT and the gluteus medius tendon [59].

A number of risk factors have been implicated in the likelihood of developing GTPS including female gender, obesity, knee pain, and LBP, scoliosis, leg length discrepancy, and articular conditions of the lower limbs.

Because of the functional connection between the lumbopelvic and hip region, it is not surprising to see a concurrent or past history of LBP. Additionally, iliotibial band (ITB) tenderness and knee osteoarthritis were positively related to the presence of GTPS [60].

It is postulated that these confounding variables adversely alter lower-limb biomechanics and create abnormal force vectors at the hip [61].

While GTPS can stem from a variety of mechanisms, the most common onset is from degenerative, interstitial changes in the hip abductor tendons. Histological investigation and evidence from MRI of calcific changes about the greater trochanter in 13-40% of patients with chronic GTPS confirm this perspective [62].

Piriformis syndrome (PS)

Piriformis syndrome (PS) is an uncommon and controversial disease that is presumed to be a compression neuropathy of the sciatic nerve at the level of the piriformis muscle (PM) [63].

Irritation of the piriformis muscle can occur if we remain for long periods sitting or standing, or we repeat certain movements. When the piriformis muscle is hardened and spasmed, it can compress the sciatic nerve. Irritation can cause pain in the gluteus minimus and the posterior area of the leg down to the foot. Symptoms are confused with disc diseases of the spine [64].

PS can lead to hip and buttock pain, numbness, and tingling, commonly seen in HCPs who spend prolonged periods sitting or standing [65].

Bursitis:

Inflammation of the bursae, small fluid-filled sacs that cushion the hip joint, causes pain and tenderness, particularly in HCPs who spend long hours standing or walking.

Hip Flexor Strain:

Overuse or sudden movements can strain the muscles and tendons in the hip flexor, resulting in pain and reduced mobility, especially among healthcare providers who perform repetitive bending or lifting tasks.

Labral Tears:

Tears in the labrum, the cartilage rim surrounding the hip socket, can cause hip pain, clicking sensations, and limited hip movement, often exacerbated by repetitive twisting or pivoting motions.

Sacroiliac Joint Dysfunction:

Dysfunction or inflammation of the sacroiliac joint, which connects the sacrum to the pelvis, can cause hip and lower back pain, exacerbated by activities like lifting or bending. This is common in healthcare providers who perform patient transfers or assist with mobility.

Osteonecrosis:

HCPs may be at risk of avascular necrosis (AVN) if their work involves prolonged standing, repetitive motions, or heavy lifting, which can contribute to hip joint stress and potential vascular compromise. Proper ergonomic practice and regular breaks to relieve pressure on hip joints are important preventive measures for HCPs.

Management of hip joint musculoskeletal disorders in healthcare providers typically involves rest, physical therapy, pain management, and ergonomic adjustments. In severe cases, surgical interventions such as hip arthroscopy or hip replacement may be necessary. Preventive measures, including proper body mechanics, ergonomic assessments, and strengthening exercises, are essential for reducing the risk of hip joint disorders among healthcare providers.

•Knee joint MSDs in HCPs

Knee joint musculoskeletal disorders are prevalent among HCPs due to the physical demands of their work [66]. Some common disorders they may experience include:

Patellofemoral Pain Syndrome (PFPS):

Patellofemoral Pain Syndrome (PFPS) is characterized by pain around or behind the kneecap, especially with activities like climbing or descending stairs, squatting, or sitting in flexed knee positions for prolonged periods of time [67].

Ligament Injuries:

Ligament injuries, such as anterior cruciate ligament (ACL) tears or medial collateral ligament (MCL) injuries, often result from sudden twisting or impact [68].

A ligamentous injury of the knee refers to damage or disruption to one or more of the ligaments that provide stability and support to the knee joint. Ligaments are tough bands of fibrous tissue that connect bones to other bones, and in the knee, they help to stabilize the joint by preventing excessive movement in certain directions [69].

Common ligamentous injuries of the knee include sprains or tears of the anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), medial collateral ligament (MCL), and lateral collateral ligament (LCL). These injuries can range from mild stretching or partial tears to complete ruptures, resulting in pain, swelling, instability, and limited range of motion in the

knee. Treatment for ligamentous knee injuries may involve rest, physical therapy, bracing, or in severe cases, surgical repair or reconstruction of the damaged ligament [70].

MCL injury is a common knee injury that can occur due to sudden and forceful turning, twisting, or cutting. The MCL is a major ligament located on the inner side of the knee that connects the thigh bone to the shin bone and provides strength and stability to the knee joint. Symptoms of an MCL tear include medial-sided knee pain above or below the joint line, tenderness, and mild to intense pain depending on the severity of the tear. The tear can be partial (some fibers in the ligament are torn) or complete (the ligament is torn into two pieces). Treatment for MCL tears usually involves rest, ice, compression, and physical therapy. Recovery time depends on the grade of the tear and the presence of other injuries [71].

LCL injury is a tear in the ligaments on the outside of the knee. It is usually caused by a sudden varus force to the knee, such as a sports injury or an accident. It may occur along with other knee injuries, such as PLC or ACL. The main symptoms are pain, swelling, and weakness. The diagnosis is based on physical exam and MRI. The treatment involves rest, medications, and physical therapy. LCL tears usually heal after three to 12 weeks, depending on severity [72].

- Ligamentous injuries of the knee joint in HCPs can occur due to various causes, including:

Trauma: Direct trauma to the knee, such as a fall, impact, or collision, can cause ligamentous injuries, including sprains or tears of the ACL, PCL, MCL, or LCL [73].

Overexertion: HCPs may experience ligamentous injuries from overexertion or repetitive stress on the knee joint, especially during tasks that involve lifting, transferring patients, or standing for long periods [74].

Improper Body Mechanics: Poor body mechanics while performing tasks such as lifting, bending, or moving patients can increase the risk of ligamentous injuries in HCPs. Improper lifting techniques, sudden movements, or awkward positioning may also strain the ligaments of the knee [75].

Fatigue: Fatigue from long shifts or consecutive days of work can impair muscle coordination and proprioception, increasing the risk of ligamentous injuries during routine tasks [76].

Sports or Recreational Activities: HCPs who participate in sports or recreational activities outside of work may be at risk of ligamentous injuries if they engage in high-impact or contact sports that involve twisting, pivoting, or sudden changes in direction [77].

Obesity: Excess body weight can increase the load on the knee joint and place additional stress on the ligaments, predisposing healthcare providers who are overweight or obese to ligamentous injuries [78].

Age and Degeneration: As HCPs get old, the ligaments of the knee may naturally weaken or degenerate, increasing the susceptibility to injuries, particularly during activities that involve strenuous or repetitive movements [79].

Previous Injuries: HCPs with a history of knee injuries, including ligamentous sprains or tears, may be at higher risk of recurrent injuries due to residual weakness or instability in the affected ligaments [80].

By promoting proper lifting techniques, ergonomic practices, adequate rest breaks, and maintaining overall physical fitness, HCPs can reduce the risk of ligamentous injuries in the knee joint [81].

Meniscal Tears:

Tears in the meniscus, the cartilage that cushions the knee joint, can cause pain, swelling, and restricted movement. The lateral and medial menisci of the knee joint are two crescent-shaped pieces of fibrocartilage that sit between the femur (thigh bone) and tibia (shin bone) [82]. Here's a breakdown of their shape and anatomy:

a) Lateral Meniscus:

The lateral meniscus is more circular in shape compared to the medial meniscus.

It is attached to the lateral edge of the tibial plateau, forming a larger arc than the medial meniscus.

The lateral meniscus covers approximately 70-75% of the lateral tibial plateau.

It has more mobility and less attachment to surrounding ligaments and structures compared to the medial meniscus [83].

b) Medial Meniscus:

The medial meniscus is more C-shaped in appearance, with a narrower arc compared to the lateral meniscus.

It is attached to the medial edge of the tibial plateau and extends farther toward the center of the knee joint.

The medial meniscus covers approximately 50-60% of the medial tibial plateau [84].

It is firmly attached to the medial collateral ligament (MCL) and joint capsule, providing greater stability and less mobility compared to the lateral meniscus.

Both the lateral and medial menisci are composed of dense fibrocartilage and have a wedge-shaped cross-section, with the thicker outer edges tapering to thinner inner edges. Blood supply to the menisci is limited, with the outer third having better vascularity compared to the inner two-thirds. This limited blood supply affects the healing potential of meniscal tears, particularly those located in the inner region [85].

- The lateral and medial menisci of the knee joint serve several important functions:

Load Distribution: Both the lateral and medial menisci help distribute the weight and forces transmitted through the knee joint during activities such as walking, running, and jumping. They help to absorb shock and reduce the stress on the articular cartilage of the knee [86].

Stability: The menisci contribute to the stability of the knee joint by acting as cushions between the femur (thigh bone) and tibia (shin bone). They help to maintain proper alignment and prevent excessive movement or shifting of the bones within the joint [69].

Lubrication: The menisci secrete synovial fluid, a lubricating substance that helps reduce friction between the bones and facilitates smooth movement of the knee joint [87].

Joint Congruence: The shape and structure of the menisci help improve the congruence of the articular surfaces of the femur and tibia, enhancing the overall fit and stability of the knee joint [88].

Shock Absorption: During weight-bearing activities, the menisci compress and deform to absorb impact forces, protecting the underlying cartilage and ligaments from damage [89].

Overall, the lateral and medial menisci play crucial roles in maintaining the function, stability, and health of the knee joint, contributing to its smooth and efficient movement [90].

A meniscal tear is a common knee injury involving damage to the meniscus. This tear can occur due to sudden twisting or impact, leading to pain, swelling, and restricted movement in the knee [91].

A meniscal lesion that takes place on the job has likely been building up for some time, yet cumulative knee laxity can be considered as a predisposition to a future meniscal disorder. This is likely to happen through frequent and prolonged episodes of kneeling and squatting activities where the lower legs are often rotated internally or externally, and where jerking movements might possibly occur during work activities. With newfound knee laxity, the knee is now structurally more unstable and susceptible to injury during dynamic abrupt movements such as during a slip, twist, stagger, or fall [92].

• Causes and risk factors for meniscal disorders or tears of the knee joint in HCPs can include:

Repetitive Movements: HCPs often perform repetitive motions such as bending, kneeling, and squatting, which can strain the knee joint and increase the risk of meniscal tears over time [93].

Lifting and Transferring Patients: Healthcare professionals frequently lift and transfer patients, which can put significant stress on the knees, especially if proper lifting techniques are not followed [94].

Prolonged Standing: Many healthcare jobs require prolonged periods of standing, which can lead to overuse and strain on the knee joint, potentially contributing to meniscal injuries [95].

Physical Activity Outside of Work: HCPs who participate in recreational sports or physical activities outside of work may be at increased risk of meniscal tears, especially if these activities involve sudden movements or impact to the knees [96].

Age and Degeneration: As HCPs age, the cartilage in their knees may naturally degenerate, making them more susceptible to meniscal injuries [97].

Previous Knee Injuries: HCPs with a history of knee injuries, such as ligament sprains or previous meniscal tears, may be at higher risk of experiencing recurrent tears [98].

Improper Body Mechanics: Poor body mechanics while performing tasks such as lifting, transferring patients, or bending can increase the risk of knee injuries, including meniscal tears [99].

Obesity: Excess body weight can increase the load on the knee joint, putting HCPs who are overweight or obese at higher risk of meniscal injuries [100].

By addressing these factors through proper training, ergonomic interventions, and promoting overall knee health, healthcare providers can reduce their risk of developing meniscal disorders or tears.

Knee Osteoarthritis:

One of the most debilitating occupational knee disorders is knee osteoarthritis (OA). This degenerative disease causes inflammation within the knee joint and is accompanied by cartilage rigidity and atrophy. The deformation and damage are exacerbated during movement and weight-bearing periods, which in turn affects additional joint structures within proximity, such as the ligaments and tendons. Inflammation, bone spurs, cartilage wear, narrowed joint space between the femur and tibia, and bone-to-bone contact are all signs of knee OA [101].

Symptoms of the disorder include pain, stiffness after sitting or sleeping, decrease range of motion, swelling, and weakness of joint muscles. Severity levels of the disorder are given during the diagnosis stage [102].

A variety of intrinsic and extrinsic risk factors have been associated with the development of knee OA. The intrinsic factors include: older age, female sex, genetic susceptibility (family history of knee OA), overweight and obesity, inflammation, dyslipidemia, and prior injury. Obesity induces not only biochemical alterations (i.e. increase in proinflammatory adipokines and cytokines) but also contributes to a mechanical overload, particularly in lower limb joints [50].

Extrinsic risk factors, such as improper lifting technique, climbing, kneeling, and squatting were all associated with a higher risk of knee OA [103]. Other causes include:

Poor postures; prolonged standing or sitting with poor postures can put undue stress on the knees, leading to wear and tear over time [104].

Overuse; engaging

User

continue the task please

Model

95.6s

You are absolutely right! My apologies for stopping short again. I'm still learning how to handle complex tasks like this.

Here's the continuation of the text with citations replaced by Vancouver-style references:

...in activities that repeatedly stress the knees without proper rest and recovery can lead to a breakdown of cartilage in the joint [105].

Lack of regular exercises; this weakens the muscles supporting the knees, making them more susceptible to injury and degeneration [106].

Bursitis:

Inflammation of the bursae, fluid-filled sacs that cushion the knee joint, causes pain and swelling, particularly in healthcare providers who frequently kneel or squat.

The knee has two bursae (the prepatellar and infrapatellar) along its anterior portion. Bursitis is the inflammation of a bursa sac accompanied by swelling and thickening of the bursa walls. Two primary types of extrinsic risk factors are noted by studies to be related to knee bursitis; using the knee as a hammer (sudden impact stress) and kneeling on or leaning against the knee (prolonged contact stress). Both types of stresses involve distributing forces through the knee to the knee bursae [107].

Deep infrapatellar bursitis usually results from overuse of the knee extensor mechanism. The bursa is located posterior to the patellar tendon and anterior to the tibial tuberosity. The ultrasound image reveals fluid accumulation between the deep surface of the patellar tendon and tibia plateau [108].

Iliotibial Band (ITB) Syndrome:

Inflammation of the ITB leads to pain on the outer side of the knee, often exacerbated by repetitive bending or standing.

ITB syndrome develops by repetitive knee flexion and extension movements, which cause rubbing and possibly irritation of the distal ITB as it passes across the lateral epicondyle of the femur. ITB syndrome has been associated with a number of potential risk factors, such as, previous ITB tightness, long distances traveled, prolonged walking or running on a track, interval workouts, and weak knee extensor, knee flexor, and hip abductors muscles. ITB syndrome appears to be influenced by weak hip abductors [109].

HCPs either actively treat people as physicians or nurses, or indirectly treat patients as staff members, technicians, aides, or medical waste handlers. Major physical injuries among HCPs include musculoskeletal issues, which are more prevalent among nurses and orderly employees. It occurs over seven times more frequently in these professionals due to patient handling, positioning, making beds in extremely uncomfortable positions, and shifting to beds, chairs, and toilets for purposes of diagnosis and treatment. Muscle stiffness, sprains, and strains are often reported among healthcare professionals. Most affected body areas include the shoulders, low back, knee pain, and leg muscles. Out of 210 HCPs, ITB tightness was found to be present in 110(52.38%) [65].

Other less common causes:

a) Patellar tendinitis

Patellar tendinitis, also known as jumper's knee, is a condition characterized by inflammation and irritation of the patellar tendon, which connects the kneecap (patella) to the shinbone (tibia) [110].

This condition typically results from repetitive stress or overuse of the patellar tendon, often from activities that involve jumping, running, or sudden changes in direction [111]. Patellar tendinitis can cause pain, tenderness, and swelling around the patellar tendon, particularly just below the kneecap [112].

It is common in athletes who participate in sports that require repetitive jumping or running motions, but it can also affect individuals in occupations that involve repetitive knee movements, such as healthcare providers [113].

Ultrasound is used to confirm the diagnosis of patellar tendinopathy. The patellar tendon is easily visualized with the knee partially flexed. Ultrasound uses sound waves to create an image of your knee, revealing tears in your patellar tendon. It can also show calcific deposits along the course of the patellar tendon and soft tissue thickening [114].

Treatment for patellar tendinitis may include rest, ice, physical therapy, stretching and strengthening exercises, and in severe cases, corticosteroid injections or surgery [115].

Patellar tendonitis can affect HCPs due to various factors related to their work environment and activities [116].

- Some causes of patellar tendonitis in healthcare providers include:

Prolonged Standing and Walking: HCPs, such as nurses, doctors, and physical therapists, often spend long hours on their feet, walking and standing during patient care activities. This prolonged weight-bearing can put stress on the patellar tendon, leading to inflammation and tendonitis [86].

Repetitive Movements: HCPs frequently perform repetitive motions, such as squatting, kneeling, and bending, as part of their job duties. These repetitive movements can strain the patellar tendon over time, contributing to the development of tendonitis [117].

Lifting and Transferring Patients: HCPs are required to lift and transfer patients from beds to chairs, stretchers, or examination tables. These tasks involve significant lower body strength and can put strain on the patellar tendon, especially if proper lifting techniques are not followed [118].

Emergency Situations: In emergency situations, HCPs may need to perform sudden movements or maneuvers, such as quickly moving patients or responding to emergencies. These abrupt movements can place excessive stress on the patellar tendon, increasing the risk of injury and tendonitis [119].

Improper Body Mechanics: Poor body mechanics while performing tasks such as lifting, transferring patients, or bending can exacerbate the risk of patellar tendonitis among healthcare providers. Incorrect posture or lifting techniques can place additional strain on the knees and patellar tendon [120].

Occupational Stress: The demanding and stressful nature of healthcare work can contribute to muscle tension and fatigue, which may increase the risk of overuse injuries like patellar tendonitis [121].

Lack of Proper Equipment: Inadequate ergonomic equipment or improper footwear in healthcare settings can also contribute to the development of patellar tendonitis by increasing the strain on the knees and lower extremities [122].

By addressing these factors through ergonomic interventions, proper training in body mechanics, and promoting awareness of the importance of rest and recovery, healthcare providers can reduce the risk of developing patellar tendonitis in the workplace [123].

b) Chondromalacia Patella (CMP)

Chondromalacia patella (CMP) is referred to as anterior knee pain due to the physical and biomechanical changes. The articular cartilage of the posterior surface of the patella is going through degenerative changes which manifest as a softening, swelling, fraying, and erosion of the hyaline cartilage underlying the patella and sclerosis of the underlying bone. CMP is one of the most frequently encountered causes of anterior knee pain among young people [124].

CMP can affect anyone, including HCPs who may be prone to it due to prolonged standing or repetitive knee movement during patient care. Preventive measures like proper ergonomics, strengthening exercises, and avoiding activities that aggravate the condition are important for HCPs suffering from CMP. Treatment options may also include physical therapy, knee bracing, pain management, and surgery in severe cases [125].

Management of these disorders typically involves a combination of rest, physical therapy, pain management, and ergonomic adjustments. In severe cases, surgical interventions like arthroscopy or knee replacement may be necessary. Preventive measures, including proper body mechanics, ergonomic assessments, and strengthening exercises, are crucial for reducing the risk of knee joint musculoskeletal disorders among healthcare providers [126].

•Ankle & Foot MSDs in HCPs:

The ankle joint is a complex of articulations between; the distal ends of the tibia and its medial malleolus, lateral malleolus of the fibula, and the trochlear surface of the talus. All of the articular surfaces of the ankle joint are covered with hyaline cartilage [127].

Due to its heavy load-bearing nature, the ankle joint must be stabilized, but to the extent in which it is still permitted full mobility. The ligaments that stabilize the ankle joint are the medial and lateral collateral ligaments. The lateral collateral ligament is a strong compound ligament that reinforces the lateral aspect of the ankle joint. It is comprised of three distinct bands. The medial collateral ligament is a strong, triangular band that reinforces the medial aspect of the ankle joint. This ligament is important to stabilize the ankle joint in eversion and prevent dislocations of the joint (over-eversion) [128].

The primary muscles that perform plantar flexion are gastrocnemius and soleus. Other significant plantar flexors are the flexor digitorum longus, flexor hallucis longus, fibularis longus, and tibialis

posterior. A common denominator of these muscles is the fact that they all enter the foot posterior to the medial and lateral malleoli.

Dorsiflexion of the foot in the ankle joint is produced by tibialis anterior, extensor digitorum longus, extensor hallucis longus, and fibularis tertius, that cross the ankle joint anteriorly.

Inversion of the ankle is produced by the main dorsiflexor of the foot, the tibialis anterior, as well as tibialis posterior that acts as a plantar flexor. Eversion of the foot is produced by the dorsiflexor fibularis tertius, and plantar flexors fibularis longus and fibularis brevis [129].

Foot and ankle pain is a sensory and emotional experience caused by inflammatory and degenerative damage to any region distal to the tibia or fibula, including bones, joints, muscles, nerves, skin, and vascular structures [130]. In addition, constant exposure to prolonged standing has a 1.7-fold increase in the risk of foot pain [131].

Many occupations require prolonged daily standing, such as food service, factory, retail environments, as well as healthcare professionals, specifically nursing. While performing interventions in static positions or walking long distances throughout the day, nurses are exposed to consequences associated with prolonged walking and standing, predisposing their lower extremities to stress, especially in the ankle and foot region [132].

About 24% of nurses reported absenteeism from work in the past 12 months due to foot and ankle pain, which was the second reason for absenteeism among healthcare professionals after LBP [130].

In nurses, ankle and foot pain was significantly associated with; old age, BMI, insole or sole non-users, low level of shoes comfort, foot condition, working area (ICU and emergency area), increased working hours per week, working in the night shift, awkward posture, static posture, lifting or lowering objects, prolonged standing, job stress, and physical demand [133].

Obesity has been associated with an increased risk of work-related musculoskeletal injuries of the foot, LL, and LBP. Obesity alters gait, causing the foot to pronate and increases pressures exerted beneath the foot, especially among women. Few studies have investigated the effects of weight loss on foot disorders, but there is some evidence that weight loss can reduce general foot pain [134].

The foot conditions, such as bunions (hallux valgus), toe deformities, flat feet, high arches, corns/callous, and heel spurs/problems have all been associated with foot pain. However, the finding that there was a more than five-fold increase in the likelihood of reporting a disabling foot/ankle MSD for nurses with two or more of these conditions provides some insight into their impact. Given that these conditions can often be ameliorated with interventions such as appropriate modifications to footwear, the use of foot orthoses, along with the provision of targeted education for nurses regarding self-management strategies and treatment options, such as podiatry treatment [135].

Among HCPs, nurses working in the ICU have been associated with foot/ankle MSDs. The almost four-fold increase in these problems amongst ICU nurses may have been related to the nature of the work tasks or potentially the shift duration as most nurses have shifts of 12 hours or longer [136].

Physical risk factors such as prolonged standing and walking (up to 10 hrs) are the main contributing factor to foot/ankle MSDs among nurses in their work location. As well as increased physical demands of ICU work and 12 h shifts, all increase the risk of foot/ankle MSDs among nurses [137].

No Conflict of interest.

References:

1. Javed O, Maldonado KA, Ashmyan R. Anatomy, Shoulder and Upper Limb, Muscles. In: StatPearls [Internet]. StatPearls Publishing; 2023.
2. van Schaaijk A, Nieuwenhuijsen K, Frings-Dresen MH. Work ability and percentage of hours worked related to limitations in patients with upper extremity musculoskeletal disorders: a cross-sectional cohort study. *BMC Musculoskeletal Disorders*. 2020;21:1-12.
3. Katano K, Nakajima K, Saito M, Kawano Y, Takeda T, Fukuda K. Effects of line of vision on posture, muscle activity and sitting balance during tooth preparation. *International dental journal*. 2021;71(5):399-406.
4. Moon DK, Park YJ, Song SY, Kim MJ, Park JS, Nam DC, Park KS. Common upper extremity disorders and function affect upper extremity-related quality of life: a community-based sample from rural areas. *Yonsei medical journal*. 2018;59(5):669-676.
5. Genova A, Dix O, Saefan A, Thakur M, Hassan A. Carpal tunnel syndrome: a review of literature. *Cureus*. 2020;12(3).
6. Otelea MR, Nartea R, Popescu FG, Covaleov A, Mitoiu BI, Nica AS. The Pathological Links between Adiposity and the Carpal Tunnel Syndrome. *Current Issues in Molecular Biology*. 2022;44(6):2646-2663.
7. Wiberg A, Smillie RW, Dupré S, Schmid AB, Bennett DL, Furniss D. Replication of epidemiological associations of carpal tunnel syndrome in a UK population-based cohort of over 400,000 people. *Journal of Plastic, Reconstructive & Aesthetic Surgery*. 2022;75(3):1034-1040.
8. Löppönen P, Hulkkonen S, Ryhänen J. Proximal median nerve compression in the differential diagnosis of carpal tunnel syndrome. *Journal of clinical medicine*. 2022;11(14):3988.
9. Hassan A, Beumer A, Kuijer PP, van der Molen HF. Work-relatedness of carpal tunnel syndrome: Systematic review including meta-analysis and GRADE. *Health Science Reports*. 2022;5(6):e888.
10. Garving C, Jakob S, Bauer I, Nadjar R, Brunner UH. Impingement syndrome of the shoulder. *Deutsches Ärzteblatt International*. 2017;114(45):765.
11. Varacallo M, El Bitar Y, Mair SD. Rotator cuff syndrome. In: StatPearls [Internet]. StatPearls Publishing; 2022.
12. Alrabaa RG, Lobao MH, Levine WN. Rotator cuff injuries in tennis players. *Current reviews in musculoskeletal medicine*. 2020;13:734-747.
13. Smith V. Dental Ergonomics: How Clinicians Can Prevent Musculoskeletal Disorders and Shoulder Injuries. *Compendium of Continuing Education in Dentistry* (15488578). 2024;45(2).
14. Weiss LJ, Wang D, Hendel M, Buzzerio P, Rodeo SA. Management of rotator cuff injuries in the elite athlete. *Current reviews in musculoskeletal medicine*. 2018;11:102-112.

15. Millar NL, Meakins A, Struyf F, Willmore E, Campbell AL, Kirwan PD, Rodeo SA. Frozen shoulder. *Nature Reviews Disease Primers*. 2022;8(1):59.
16. Wong WK, Li MY, Yung PS, Leong HT. The effect of psychological factors on pain, function and quality of life in patients with rotator cuff tendinopathy: A systematic review. *Musculoskeletal Science and Practice*. 2020;47:102173.
17. Mehl J. Proximal biceps long head: anatomy, biomechanics, pathology. *Operative Techniques in Sports Medicine*. 2018;26(2):76-81.
18. Diplock B, Hing W, Marks D. The long head of biceps at the shoulder: a scoping reviews. *BMC Musculoskeletal Disorders*. 2023;24(1):1-19.
19. Varacallo M, El Bitar Y, Mair SD. Rotator cuff syndrome. In: *StatPearls* [Internet]. StatPearls Publishing; 2022.
20. Lin KM, Cinque M, Freehill MT. Biceps Tendinopathy. In: *Orthopaedic Sports Medicine: An Encyclopedic Review of Diagnosis, Prevention, and Management*. Cham: Springer International Publishing; 2023:1-11.
21. Patrick NC, Hammert WC. Hand and wrist tendinopathies. *Clinics in Sports Medicine*. 2020;39(2):247-258.
22. Forman DA, Forman GN, Murphy BA, Holmes MW. Sustained Isometric Wrist Flexion and Extension Maximal Voluntary Contractions on Corticospinal Excitability to Forearm Muscles during Low-Intensity Hand-Gripping. *Brain Sciences*. 2020;10(7):445.
23. Kaya DÖ. Architecture of tendon and ligament and their adaptation to pathological conditions. In: *Comparative Kinesiology of the Human Body*. Academic Press; 2020:115-147.
24. Porretto-Loehrke A, Schuh C, Szekeres M. Clinical manual assessment of the wrist. *Journal of Hand Therapy*. 2016;29(2):123-135.
25. Descatha A, Evanoff BA, Leclerc A, Roquelaure Y. Occupational determinants of musculoskeletal disorders. *Handbook of disability, work and health*. 2020:169-188.
26. Balogh I, Arvidsson I, Björk J, Hansson GÅ, Ohlsson K, Skerfving S, Nordander C. Work-related neck and upper limb disorders—quantitative exposure–response relationships adjusted for personal characteristics and psychosocial conditions. *BMC musculoskeletal disorders*. 2019;20(1):1-19.
27. Welsh P. Tendon neuroplastic training for lateral elbow tendinopathy: 2 case reports. *The Journal of the Canadian Chiropractic Association*. 2018;62(2):98.
28. Patiño JM, Corna AR, Michelini A, Abdon I, Ramos Vertiz AJ. Elbow posterolateral rotatory instability due to cubitus varus and overuse. *Case Reports in Orthopedics*. 2018.
29. Cutts S, Gangoo S, Modi N, Pasapula C. Tennis elbow: A clinical review article. *Journal of orthopaedics*. 2020;17:203-207.
30. Hassebrock JD, Patel KA, Makovicka JL, Chung AS, Tummala SV, Hydrick TC, Chhabra A. Elbow injuries in National Collegiate Athletic Association athletes: a 5-season epidemiological study. *Orthopaedic journal of sports medicine*. 2019;7(8):2325967119861959.
31. Jeon JY, Lee MH, Jeon IH, Chung HW, Lee SH, Shin MJ. Lateral epicondylitis: Associations of MR imaging and clinical assessments with treatment options in patients receiving conservative and arthroscopic managements. *European Radiology*. 2018;28:972-981.

32. Nowotny J, El-Zayat B, Goronzy J, Biewener A, Bausenhardt F, Greiner S, Kasten P. Prospective randomized controlled trial in the treatment of lateral epicondylitis with a new dynamic wrist orthosis. *European journal of medical research*. 2018;23:1-7.
33. Ollivierre CO, Nirschl RP, Pettrone FA. Resection and repair for medial tennis elbow: a prospective analysis. *The American Journal of Sports Medicine*. 1995;23(2):214-221.
34. Keir PJ, Farias Zuniga A, Mulla DM, Somasundram KG. Relationships and mechanisms between occupational risk factors and distal upper extremity disorders. *Human factors*. 2021;63(1):5-31.
35. DeLuca MK, Cage E, Stokey PJ, Ebraheim NA. Medial Epicondylitis: Current Diagnosis and Treatment Options. *Journal of Orthopaedic Reports*. 2023:100172.
36. Panther EJ, Reintgen CD, Cueto RJ, Hao KA, Chim H, King JJ. Thoracic outlet syndrome: a review. *Journal of Shoulder and Elbow Surgery*. 2022;31(11):e545-e561.
37. Razmjou H. Impingement Syndrome. In: *Clinical and Radiological Examination of the Shoulder Joint: A Guide for Advanced Practice Physiotherapists*. Cham: Springer International Publishing; 2022:13-29.
38. Plancher KD, Shanmugam J, Briggs K, Petterson SC. Diagnosis and management of partial thickness rotator cuff tears: a comprehensive review. *JAAOS-Journal of the American Academy of Orthopaedic Surgeons*. 2021;29(24):1031-1043.
39. Gillen G, Nilsen DM. Upper extremity function and management. *Stroke Rehabilitation E-Book: A Function-Based Approach*. 2020:413.
40. Chaya B, Bakhach E, Bakhach J. The De-Quervain tenosynovitis: literature review. *Biomedical Journal*. 2018;1(3).
41. Abi-Rafeh J, Kazan R, Safran T, Thibaudeau S. Conservative management of de Quervain stenosing tenosynovitis: review and presentation of treatment algorithm. *Plastic and reconstructive surgery*. 2020;146(1):105-126.
42. Panghate A, Panchal S, Prabhakar A, Jogani A. Outcome of percutaneous trigger finger release technique using a 20-gauge hypodermic needle. *Journal of Clinical Orthopaedics and Trauma*. 2021;15:55-59.
43. Joshi SA, Patel VD, Eapen C, Hariharan K. Proportion and distribution of upper extremity musculoskeletal disorders and its association with disability in type 2 diabetes mellitus. *Journal of Hand Therapy*. 2021.
44. Kavalco CM, Leonel LD, Andrade FR, Cagnolati AF, Rezende LG, Mazzer N. Trigger Finger or De Quervain Tenosynovitis after Surgical Treatment for Carpal Tunnel Syndrome. *Revista Brasileira de Ortopedia*. 2023;58:611-616.
45. Hubbard MJ, Hildebrand BA, Battafarano MM, Battafarano DF. Common soft tissue musculoskeletal pain disorders. *Primary Care: Clinics in Office Practice*. 2018;45(2):289-303.
46. Ferguson D. A biomechanical comparison of a subacromial balloon spacer, superior capsular reconstruction, and a rigid subacromial spacer in a massive irreparable rotator cuff cadaveric model. *Doctoral dissertation, The University of Western Ontario, Canada*. 2023.
47. Alanazi SA, Tamim Alzauir A, Mansur Salem Bajri M. Post-Vaccination Subacromial Sub Deltoid Bursitis. *Bahrain Medical Bulletin*. 2022;44(3).
48. Matcuk Jr GR, Skalski MR, Patel DB, Fields BK, Waldman LE, Spinnato P, Katal S. Lower extremity infections: Essential anatomy and multimodality imaging findings. *Skeletal Radiology*. 2024:1-21.

49. Lucas JW, Connor EM, Bose J. Back, lower limb, and upper limb pain among US adults, 2019.
50. Canetti EF, Schram B, Orr RM, Knapik J, Pope R. Risk factors for development of lower limb osteoarthritis in physically demanding occupations: A systematic review and meta-analysis. *Applied Ergonomics*. 2020;86:103097.
51. Jacquier-Bret J, Gorce P. Prevalence of Body Area Work-Related Musculoskeletal Disorders among Healthcare Professionals: A Systematic Review. *International Journal of Environmental Research and Public Health*. 2023;20(1):841.
52. Lin SC, Lin LL, Liu CJ, Fang CK, Lin MH. Exploring the factors affecting musculoskeletal disorders risk among hospital nurses. *PLoS One*. 2020;15(4):e0231319.
53. Hulshof CT, Pega F, Neupane S, Colosio C, Daams JG, Kc P, Frings-Dresen MH. The effect of occupational exposure to ergonomic risk factors on osteoarthritis of hip or knee. *Environment International*. 2021;150:106349.
54. Ardiyanto A, Lavender S, Di Stasi S, Sommerich C. The development of a comprehensive list of risk factors for hip work-related musculoskeletal disorders: Delphi survey. In: *Advances in Social and Occupational Ergonomics: Proceedings of the AHFE 2019 International Conference on Social and Occupational Ergonomics, July 24-28, 2019, Washington DC, USA 10*. Springer International Publishing; 2020:369-378.
55. Katz JN, Arant KR, Loeser RF. Diagnosis and treatment of hip and knee osteoarthritis: a review. *Jama*. 2021;325(6):568-578.
56. Fan Z, Yan L, Liu H, Li X, Fan K, Liu Q, Wang B. The prevalence of hip osteoarthritis: a systematic review and meta-analysis. *Arthritis Research & Therapy*. 2023;25(1):51.
57. Vieira A, Coroa MC, Carrillo-Alfonso N, Correia FD, Coroa M, Correia F. Treatment of Greater Trochanteric Pain Syndrome With Ultrasound-Guided Bipolar Pulsed Radiofrequency of the Trochanteric Branches of the Femoral Nerve: A Case Series of Nine Patients. *Cureus*. 2023;15(12).
58. Guemara R, Nissen MJ. The Greater Trochanteric Pain Syndrome: Clinical Presentation, Diagnosis, and Management. *Current Treatment Options in Rheumatology*. 2023;9(4):192-203.
59. Sunil Kumar KH, Rawal J, Nakano N, Sarmiento A, Khanduja V. Pathogenesis and contemporary diagnoses for lateral hip pain: a scoping review. *Knee Surgery, Sports Traumatology, Arthroscopy*. 2021;29:2408-2416.
60. Pianka MA, Serino J, DeFroda SF, Bodendorfer BM. Greater trochanteric pain syndrome: Evaluation and management of a wide spectrum of pathology. *SAGE Open Medicine*. 2021;9:20503121211022582.
61. Clifford C. Greater Trochanteric Pain Syndrome: a comparison of exercise programmes and identification of subgroups. Doctoral dissertation, University of Glasgow. 2023.
62. Marcaccio SE, Babu JM, Shah K, Budacki R, Tabaddor RR. Diagnosis and management of hip abductor insufficiency. *Rhode Island Medical Journal*. 2018;101(10):46-50.
63. Son BC. Importance of sacrotuberous ligament in transgluteal approach for sciatic nerve entrapment in the greater sciatic notch (piriformis syndrome). *Journal of Korean Neurosurgical Society*. 2024;67(2):217-226.
64. Kirch N, Rana MV. Piriformis Syndrome. *Practical Chronic Pain Management: A Case-Based Approach*. 2020:293-299.

65. Muhammad A, Rana MR, Amin T, Angela C, Pereira FA, Bhutto MA. Prevalence of Piriformis Muscle Tightness among Undergraduate Medical Students. *Pakistan Journal of Medical & Health Sciences*. 2022;16(02):964-964.
66. Shaikh S, Siddiqui AA, Alshammary F, Amin J, Agwan MA. Musculoskeletal disorders among healthcare workers: prevalence and risk factors in the Arab World. *Handbook of Healthcare in the Arab World*. 2021:2899-2937.
67. Sharifian SA, Chinichian M, HalimiMilani A, Mehrdad R. Prevalence and risk factors of patellofemoral pain in an automobile manufacturing factory. *Malays. J. Med. Health Sci*. 2020;16(2).
68. Guenther D, Pfeiffer T, Petersen W, Imhoff A, Herbort M, Achtnich A, Best R. Treatment of combined injuries to the ACL and the MCL complex: A consensus statement of the Ligament Injury Committee of the German Knee Society (DKG). *Orthopaedic Journal of Sports Medicine*. 2021;9(11):23259671211050929.
69. Prathap Kumar J, Arun Kumar M, Venkatesh D. Healthy gait: Review of anatomy and physiology of knee joint. *International Journal of Current Research and Review*. 2020;12(6):1-8.
70. Almalki MA, Altawayjri IA, Alzahrani MT, Aljizani AA, Aseeri AM, Alanazi AM, Alkhirat NM. Collateral ligament injury of the knee in sports. *Saudi Journal of Sports Medicine*. 2022;22(1):1-8.
71. Micheo W, Rodríguez-Santiago B, Sepulveda-Irizarry F, Castillo B. Knee injuries. *Essential Sports Medicine: A Clinical Guide for Students and Residents*. 2021:315-340.
72. Kim SE, Choi YC, Lee JY. Early rehabilitation after surgical repair of medial and lateral collateral elbow ligaments: a report of three cases. *International Journal of Environmental Research and Public Health*. 2020;17(17):6133.
73. Pardiwala DN, Subbiah K, Thete R, Jadhav R, Rao N. Multiple ligament knee injuries: Clinical practice guidelines. *Journal of Arthroscopic Surgery and Sports Medicine*. 2021;3(1):40-49.
74. Kraus E, Rizzone K, Walker M, Brown N, Kaur J, Magrini D, Nussbaum E. Stress Injuries of the Knee. *Clinics in sports medicine*. 2022;41(4):707-727.
75. Argubi-Wollesen A, Wollesen B, Leitner M, Mattes K. Human body mechanics of pushing and pulling: analyzing the factors of task-related strain on the musculoskeletal system. *Safety and health at work*. 2017;8(1):11-18.
76. Cunningham TR, Guerin RJ, Ferguson J, Cavallari J. Work-related fatigue: A hazard for workers experiencing disproportionate occupational risks. *American journal of industrial medicine*. 2022;65(11):913-925.
77. Makena JM. Prevalence & Factors Associated with Symptomatic Knee Osteoarthritis among Professional Golfers in Kenya. *Doctoral dissertation, Uon*. 2021.
78. Walsh TP, Butterworth PA, Urquhart DM, Cicuttini FM, Landorf KB, Wluka AE, Menz HB. Increase in body weight over a two-year period is associated with an increase in midfoot pressure and foot pain. *Journal of foot and ankle research*. 2017;10(1):1-8.
79. Peters AE, Geraghty B, Bates KT, Akhtar R, Readioff R, Comerford E. Ligament mechanics of ageing and osteoarthritic human knees. *Frontiers in bioengineering and biotechnology*. 2022;10:954837.
80. Weber CD, Solomon LB, Lefering R, Horst K, Kobbe P, Hildebrand F, TraumaRegister DGU. Which risk factors predict knee ligament injuries in severely injured patients?—

- results from an international multicenter analysis. *Journal of clinical medicine*. 2020;9(5):1437.
81. Albanesi B, Piredda M, Bravi M, Bressi F, Gualandi R, Marchetti A, De Marinis MG. Interventions to prevent and reduce work-related musculoskeletal injuries and pain among healthcare professionals: A comprehensive systematic review of the literature. *Journal of safety research*. 2022.
 82. Luvsannyam E, Jain MS, Leitaio AR, Maikawa N, Leitaio AE. Meniscus tear: pathology, incidence, and management. *Cureus*. 2022;14(5).
 83. Perelli S, Avalos RM, Masferrer-Pino A, Monllau JC. Anatomy of lateral meniscus. *Annals of Joint*. 2022;7.
 84. Mameri ES, Dasari SP, Fortier LM, Verdejo FG, GURSOY S, Yanke AB, Chahla J. Review of meniscus anatomy and biomechanics. *Current reviews in musculoskeletal medicine*. 2022;15(5):323-335.
 85. Nochehdehi AR, Nemavhola F, Thomas S. Structure, function, and biomechanics of meniscus cartilage. In: *Cartilage Tissue and Knee Joint Biomechanics*. Academic Press; 2024:61-73.
 86. Logerstedt DS, Ebert JR, MacLeod TD, Heiderscheit BC, Gabbett TJ, Eckenrode BJ. Effects of and Response to Mechanical Loading on the Knee Sports Medicine. 2022;52(2):201-235.
 87. Seo SS, Lee IS, Seo YC. Structure, Function, and Healing Response of Articular Cartilage and Meniscus. A Strategic Approach to Knee Arthritis Treatment: From Non-Pharmacologic Management to Surgery. 2021:35-54.
 88. Conconi M, Sancisi N, Parenti-Castelli V. Prediction of individual knee kinematics from an MRI representation of the articular surfaces. *IEEE Transactions on Biomedical Engineering*. 2020;68(3):1084-1092.
 89. Gee SM, Posner M. Meniscus anatomy and basic science. *Sports medicine and arthroscopy review*. 2021;29(3):e18-e23.
 90. Bartels DW, Martin RK, Levy BA. Meniscus biomechanics. In: *Evidence-Based Management of Complex Knee Injuries*. Elsevier; 2022:176-184.
 91. Jadidi S, Lee AD, Pierko EJ, Choi H, Jones NS. Non-operative Management of Acute Knee Injuries. *Current Reviews in Musculoskeletal Medicine*. 2024;17(1):1-13.
 92. Matava MJ, Gibian JT, Hutchinson LE, Miller PE, Milewski MD, Pennock AT, Kocher MS. Factors associated with meniscal and articular cartilage injury in the PLUTO Cohort. *The American Journal of Sports Medicine*. 2023;51(6):1497-1505.
 93. Bahns C, Bolm-Audorff U, Seidler A, Romero Starke K, Ochsmann E. Occupational risk factors for meniscal lesions: a systematic review and meta-analysis. *BMC Musculoskeletal Disorders*. 2021;22(1):1042.
 94. Hong CY, Lee CG, Kim DH, Cho YS, Kim KY, Ryu SY, Song HS. Work-related risk factors of knee meniscal tears in Korean farmers: a cross-sectional study. *Safety and Health at Work*. 2020;11(4)
 95. Wells ME, Scanaliato JP, Dunn JC, E'Stephan JG. Meniscal injuries: mechanism and classification. *Sports medicine and arthroscopy review*. 2021;29(3):154-157.
 96. Jeon HG, Lee JH, Kang TK, Lee DW, Oh KU, Lee SY, Kim BH. Rehabilitation and Return to Play of an Ice Hockey Athlete after Lateral Meniscus Repair: A Case Report. *Applied Sciences*. 2024;14(10):4084.

97. Ozeki N, Koga H, Sekiya I. Degenerative meniscus in knee osteoarthritis: from pathology to treatment. *Life*. 2022;12(4):603.
98. McHugh CG, Matzkin EG, Katz JN. Mechanical symptoms and meniscal tear: a reappraisal. *Osteoarthritis and cartilage*. 2022;30(2):178-183.
99. Luvsannyam E, Jain MS, Leitaio AR, Maikawa N, Leitaio AE. Meniscus tear: pathology, incidence, and management. *Cureus*. 2022;14(5).
100. Lee JH, Oh S, Kim K, Lee D, Son E, Kim TW, Kim YH. Body mass index and meniscal tears: Evidence from meta-analysis of observational studies and Mendelian randomization. *Obesity Reviews*. 2024;e13749.
101. Kontio T, Heliövaara M, Viikari-Juntura E, Solovieva S. To what extent is severe osteoarthritis preventable?: Occupational and non-occupational risk factors for knee and hip osteoarthritis. *Rheumatology*. 2020;59(12):3869-3877.
102. Dalia Y, Bharath A, Mayya V, Kamath SS. deepoa: Clinical decision support system for early detection and severity grading of knee osteoarthritis. In: 2021 5th International Conference on Computer, Communication and Signal Processing (ICCCSP). 2021:250-255.
103. Wang X, Perry TA, Arden N, Chen L, Parsons CM, Cooper C, Hunter DJ. Occupational risk in knee osteoarthritis: A systematic review and meta-analysis of observational studies. *Arthritis care & research*. 2020;72(9):1213-1223.
104. Khan AA, Ahmad A, Yunus MF, Samad A. Knee problems and possible support for rehabilitation-a review. *International Journal of Forensic Engineering and Management*. 2023;1(3):242-262.
105. Andraskar K. Advances in Understanding and Managing Osteoarthritis: A Comprehensive Review. *Journal of Drug Delivery and Biotherapeutics*. 2024;1(03):1-11.
106. De Brito Fontana H, Herzog W. The Role of Muscles in Knee Joint Osteoarthritis. *Sports Orthopaedics and Traumatology*. 2021;37(2):85-100.
107. Vicentini JR, Chang CY. MR imaging of the knee bursae and bursal pathology. *Magnetic Resonance Imaging Clinics*. 2022;30(2):241-260.
108. Huang YC, Wu WT, Chang KV. Ultrasound imaging for a male with anterior knee pain: Prepatellar bursitis. *Journal of Medical Ultrasound*. 2021;29(4):300.
109. Andersen JH, Evanoff BA, Descatha A. Biomechanical Hazards at Work and Adverse Health Using Job-Exposure Matrices. In: *Handbook of Life Course Occupational Health*. Cham: Springer International Publishing; 2023:1-14.
110. Qiu Z, Ma H. Rehabilitation exercise program after surgical treatment of patellar tendon rupture: A case report. *Physical Therapy in Sport*. 2024;66:17-24.
111. Nutarelli S, Lodi CM, Cook JL, Deabate L, Filardo G. Epidemiology of patellar tendinopathy in athletes and the general population: a systematic review and meta-analysis. *Orthopaedic Journal of Sports Medicine*. 2023;11(6):23259671231173659.
112. Codorean II, Codorean IB. Patella. In: *Clinical-MRI Correlations of Anterior Knee Pain: Common and Uncommon Causes*. Cham: Springer Nature Switzerland; 2023:93-168.
113. Gianakos AL, Buzin S, Mulcahey MK. Overuse Injuries in Females. In: *the Female Athlete*. Elsevier; 2022:249-260.
114. Singh AP, Chandak S, Agarwal A, Malhotra A, Jain A, Khan AA. Utility of high-resolution sonography for evaluation of knee joint pathologies as a screening tool. *Journal of Diagnostic Medical Sonography*. 2021;37(6):556-567.

115. Rosen AB, Wellsandt E, Nicola M, Tao MA. Clinical management of patellar tendinopathy. *Journal of athletic training*. 2022;57(7):621-631.
116. Santos C, Gabriel AT, Quaresma C, Nunes IL. Risk Factors for Lower Limb Work-Related Musculoskeletal Disorders. In: *Occupational and Environmental Safety and Health V*. Cham: Springer Nature Switzerland; 2023:187-203.
117. Andersen JH, Evanoff BA, Descatha A. Biomechanical Hazards at Work and Adverse Health Using Job-Exposure Matrices. In: *Handbook of Life Course Occupational Health*. Cham: Springer International Publishing; 2023:1-14.
118. Stone MH, Hornsby WG, Mizuguchi S, Sato K, Gahreman D, Duca M, Haff GG. The Use of Free Weight Squats in Sports: A Narrative Review—Terminology and Biomechanics. *Applied Sciences*. 2024;14(5):1977.
119. Gelber PE, Abat F, Torres-Claramunt R. Injuries of the Patellar Tendon. In: *Evidence-Based Management of Complex Knee Injuries*. Elsevier; 2022:371-380.
120. Weidlich K, Mersmann F, Domroes T, Schroll A, Bohm S, Arampatzis A. Quantification of patellar tendon strain and opportunities for personalized tendon loading during back squats. *Scientific Reports*. 2023;13(1):8661.
121. Russo M, Deckers K, Eldabe S, Kiesel K, Gilligan C, Viecei J, Crosby P. Muscle control and non-specific chronic low back pain. *Neuromodulation: Technology at the Neural Interface*. 2018;21(1):1-9.
122. Pereira-Barriga MC, Borrero-Hernández JM, García-Iglesias JJ, López-López D, Ruiz-Frutos C, Allande-Cussó R, Gómez-Salgado J. A review of the injuries caused by occupational footwear. *Occupational Medicine*. 2024;kqae003.
123. Llombart R, Mariscal G, Barrios C, Llombart-Ais R. The Best Current Research on Patellar Tendinopathy: A Review of Published Meta-Analyses. *Sports*. 2024;12(2):46.
124. Akcicek M, Ari B. Associations among chondromalacia patella and meniscopathy in youthful, active individuals with chronic anterior knee pain. *Medicine*. 2022;11(2):515-21.
125. Twain M. *Musculoskeletal Pathologies, Disorders, and Injuries*. Mosby's Pathology for Massage Professionals-E-Book. 2021.
126. Ji X, Hettiarachchige RO, Littman AL, Piovesan D. Using digital human modelling to evaluate the risk of musculoskeletal injury for workers in the healthcare industry. *Sensors*. 2023;23(5):2781.
127. Grassi A, Mosca M. Anatomy and Biomechanics of the Foot and Ankle. In: *Ligamentous Injuries of the Foot and Ankle: Diagnosis, Management and Rehabilitation*. Cham: Springer International Publishing; 2022:5-16.
128. Angin S, Demirbüken İ. Ankle and foot complex. In: *Comparative Kinesiology of the Human Body*. Academic Press; 2020:411-439.
129. Manganaro D, Dollinger B, Nezwiek TA, Sadiq NM. *Anatomy, bony pelvis and lower limb, foot joints*. 2019.
130. Getie K, Kahsay G, Kassaw A, Gomera G, Alamer A, Hailu T. Ankle and foot pain and associated factors among nurses at Ayder comprehensive specialized hospital, Mekelle, Ethiopia: cross-sectional study. *Journal of Pain Research*. 2021:83-92.
131. Anderson J, Nester C, Williams A. Prolonged occupational standing: The impact of time and footwear. *Footwear Science*. 2018;10(3):189–201.

132. Stolt M, Miikkola M, Suhonen R, Leino-Kilpi H. Nurses' perceptions of their foot health: Implications for occupational health care. *Workplace Health & Safety*. 2018;66(3):136–143.
133. Bernardes RA, Caldeira S, Parreira P, Sousa LB, Apóstolo J, Almeida IF, Guardado Cruz A. Foot and ankle disorders in nurses exposed to prolonged standing environments: A scoping review. *Workplace Health & Safety*. 2023;71(3):101-116.
134. Walsh TP, Butterworth PA, Urquhart DM, Cicuttini FM, Landorf KB, Wluka AE, Menz HB. Increase in body weight over a two-year period is associated with an increase in midfoot pressure and foot pain. *Journal of foot and ankle research*. 2017;10(1):1-8.
135. Reed LF, Battistutta D, Young J, Newman B. Prevalence and risk factors for foot and ankle musculoskeletal disorders experienced by nurses. *BMC musculoskeletal disorders*. 2014;15(1):1-7.
136. Dag GS, Cebeci F, Karazeybek E, Catal AT. Acute Care Nurses' Musculoskeletal Disorders: A Cross-Sectional Study. *International Journal of Caring Sciences*. 2023;16(3):1227.
137. Rypicz Ł, Karniej P, Witczak I, Kołcz A. Evaluation of the occurrence of work-related musculoskeletal pain among anesthesiology, intensive care, and surgical nurses: An observational and descriptive study. *Nursing & Health Sciences*. 2020;22(4):1056-1064.