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SOCIAL SERVICES, HEALTH AND SPORTS

Preventing premature osteoarthritis in young adults with knock-knee
deformity through exercises
Scoping Literature Review

Author: Sara Ghaderi

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Author Sara Ghaderi	
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<p>The knee is the largest joint in the human body and works with the hip and ankle joints to make the flexion and extension movement function. Knock-knee or genu valgum alignment is a condition that includes excessive medial rotation of the femur relative to the tibia or excessive lateral rotation of the tibia relative to the femur. Consequently, the joint's angles rotated inside and are inclined towards each other which causes people with this condition to apply more load on the lateral side of the feet while they are walking. Non-surgical treatment of people with knock-knee is done to prevent them from developing osteoarthritis in the knee joint.</p> <p>The aim of this literature review was to find comprehensive corrective exercise programs for young adults with genu valgus deformity to prevent premature osteoarthritis. The main aim of this review is to produce brief and useful learning materials about knock-knee alignment exercises and informative video clips showing how to do the exercise correctly. The video will focus on the best exercises to use by those with knock-knee to prevent the early onset of osteoarthritis. A scoping literature review was conducted as the method of the study. Twelve (n=12) articles were systematically collected from March 2023 to August 2023 in various academic databases including Google Scholar, PubMed, Cinahl, Savonia Finna, Käypä Hoito, and Finna. fi. The data extracted from these sources were analyzed by applying inductive content analysis. This study was conducted in collaboration with Savonia University of Applied Sciences which served as the partner corporation for this thesis work.</p> <p>These findings suggest that targeted exercise regimens can effectively address knock-knee issues in young adults. These exercises included the functional corrective exercise group, high-impact kinetic and knee flexed exercises group, functional hip static training and hip abduction group, functional quadriceps static training group, Pilates mat work and core stabilization group, functional controlling valgus movement and balance control exercises group. The results of the literature review were promising, showing that the specific exercise groups that concentrated on enhancing quadriceps and hip strength demonstrated significant improvements in dynamic knee valgus.</p> <p>Since knock-knee is a well-known risk factor for premature osteoarthritis, these improvements in the dynamic knee angle may reduce the risk factors associated with the development of osteoarthritis in the knee joint. Ultimately, this could potentially delay the onset of osteoarthritis and contribute to better long-term joint health. This review underscores the importance of exercise as a preventive measure to address knee joint issues and the potential benefits it can offer in reducing the risk of osteoarthritis.</p>	
Keywords: knock-knee, genu valgum, osteoarthritis, alignment, exercises.	

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1 INTRODUCTION

The knee is the largest joint in the human body and works with the hip and ankle joints to make the flexion and extension movement function (Haghighatnejad, 2021). The knee synovial joint includes bones, cartilage, ligaments, nerves, and muscles around it that have a substantial function in the knee joint balance. Knee joint injury is one of the most common joint injuries in the human body. Impairments of the knee joint could reduce functional capacity and cause significant activity restrictions. (Lori Thein Brody, 2018.)

Knock-knee or genu valgum alignment is a condition that includes excessive medial rotation of the femur relative to the tibia or excessive lateral rotation of the tibia relative to the femur. Consequently, the joints' angle rotates inside and are inclined towards each other which causes people with this condition to apply more load on the lateral side of the feet while they are walking. (Sahrmann, 2010.)

Non-surgical treatment of people with knock-knee is done to prevent them from developing osteoarthritis in the knee joint. The treatment includes maintaining a normal body weight, increasing the strength of the muscles around the knee, and developing a plan for physical activity and physiotherapy if necessary. Surgery is recommended when the patient has a walking complication or has a risk of early onset of osteoarthritis. (Geiger, Geffner, Rozbruch, & Fragomen, 2023.) Previous research found that non-surgical methods such as exercise therapy could improve dynamic knee valgus and change the kinematics of knee angle with large effect sizes also decreasing patient pain and raising the core muscles strength (Emamvirdi, Letafatkar, & Khaleghi Tazji, 2019).

A previous 2000 case study according to Suositus (2018) has shown that in Finland clinical knee osteoarthritis is approximately 0.3% for men in the 30-44 age and 0.4% for women but its outbreak develops in men in the 55-64 age group approximately 9.1% and in women in the 65-74 age group around 18.2%. The osteoarthritis rate in elderly men in Finland is 15.6% and this amount is double for elderly women.

Consequently, the aim of this literature review is to find comprehensive corrective exercise programs for young adults with genu valgus deformity to prevent premature osteoarthritis. The main aim of this review is to produce brief and useful learning materials about knock-knee alignment exercises that can be used for young adults in order to prevent premature osteoarthritis. Findings of the study will then be presented in the form of video clips. These video clips inform the patients and other groups of audiences how to do the exercises correctly.

2 KNOCK-KNEE AND OSTEOARTHRITIS

2.1 Knock-knee

In knock-knee deformity (Figure 1), the weight-bearing line does not pass through the middle of the epiphysis of the distal femoral bone and the superior surface of the tibia bone. Therefore, the joint is deviated medially from the line. (Pretkiewicz-Abacjew, 2003.) The information about the impact of medial rotation on patella cartilage volume is noteworthy. It suggests that even small degrees of medial rotation from a neutral position can have a detrimental effect 23.4 mm³ of the overall patella cartilage amount. This information underscores the importance of maintaining proper knee alignment and rotation to protect the knee joint's cartilage and overall health. Moreover, genu valgum increases the joint pressures on the lateral part of the knee that in the long run may lead to knee osteoarthritis and other movement irritation. (Teichtahl, Wluka, & Cicuttini, 2008.)

The most common symptoms of genu valgum are pain in the lower extremities, difficulty of walking, running, or jumping, knee instability, stiff joints, and progressive knee arthritis in adults. The main causes of knock-knee (genu valgum) include physical trauma, bone infection, lack of vitamin D, genetic bone diseases, and arthritis. (Pretkiewicz-Abacjew, 2003.)

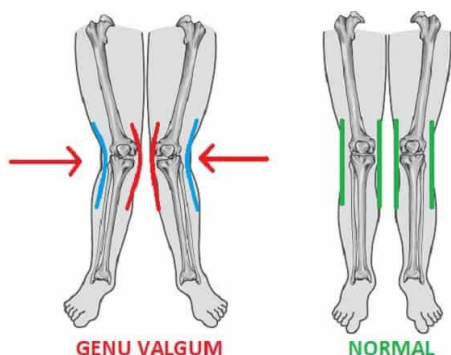


Figure 1. Knock-knee deformity (Hirschmann et al., 2019).

2.2 Osteoarthritis

Osteoarthritis (OA) is a complicated degenerative disease of the whole joint that could cause cartilage degeneration, bone dysfunction, synovial inflammation and muscle sensitivity, and changes in ligament structure (Figure 2). Osteoarthritis is indeed a significant global health concern. It is a leading cause of pain and disability, impacting the lives of over 300 million of people worldwide. As a degenerative joint disease, osteoarthritis can affect various joints in the body, with the knee being one of the commonly affected areas. (Boer et al., 2021.)

Knee osteoarthritis is the progressive degradation of the bony process (Kan et al., 2019) and the most common form of osteoarthritis in the world (Hasu & Kiiskinen 2015). Chronic dysfunction of the knee affects the vestibular system which contributes highly to the body balance. Also, it causes develop stiffness, swelling, and synovial inflammation. (Kim et al., 2011.)

The previous study in China found a global prevalence of knee OA of 16.0% in individuals aged 15 and over, which is a substantial portion of the population. Additionally, in individuals aged 40 and

over, the prevalence increased to 22.9%, indicating a higher risk as people age. The estimate that there are approximately 654.1 million individuals aged 40 and older with knee OA in 2020 worldwide is staggering. (Cui et al., 2020.)

To explain the causes of knee osteoarthritis, we could refer to factors such as obesity, diabetes, age, family history of the disease, synovitis, systematic inflammation, lower bone deformity (genu valgum and varum), joint shape, and trauma. All these factors could expedite the onset of arthritis. (Lespasio et al., 2017.) Previous studies have shown that exercise therapy is strongly useful for knee osteoarthritis. These exercises include walking, strengthening, neuromuscular practicing, aquatic training, and quadriceps set exercises. (Golightly, Allen, & Caine, 2012.)



Figure 2. The effect of OA on the knee joint space and bone structure (Haghighatnejad, 2021).

2.3 The effect of knock-knee on premature osteoarthritis

Unfortunately, osteoarthritis is not just a chronic disease that affects old people and anyone under the age of 65 with injuries, trauma background, physically demanding position, overuse of joints, obesity, and joint malalignment could suffer from osteoarthritis and become afflicted with premature osteoarthritis (Jafarzadeh, 2017).

All risk factors that increase the prevalence of OA in young adults must be identified and controlled. In case of malalignment (knee deformity such as genu varum and genu valgum), it is recommended that young patients go to the podiatrist so that the level of deformity is diagnosed and a plan is created to improve joint stability and muscle strength and to prevent joint injuries with physiotherapy and low impact exercises (Nicholson, Dickman, & Maradiegue, 2009).

2.4 Normal alignment of valgus

The sagittal plane

In the sagittal plane (Figure 3), the knee structure is evaluated from the lateral side. Knee joint rotation is expressed as a knee flexion and extension angle, the angle between the tibia and femur must be perpendicular to the knee angle more or less than 0 degrees. The angle of the hip joint is evaluated by a line bisecting the femur and pelvis. (Sahrman, 2010.) The estimated normal degree is 0 and the ankle position must be straight and neutral with 0 degrees of dorsiflexion in standing position. The range of motion has differences depending on age, significantly

doesn't change for adults but muscle weakness in the rectus femoris and hamstring muscles has been shown to significantly develop joint limitations. (Sahrmann, 2010.)

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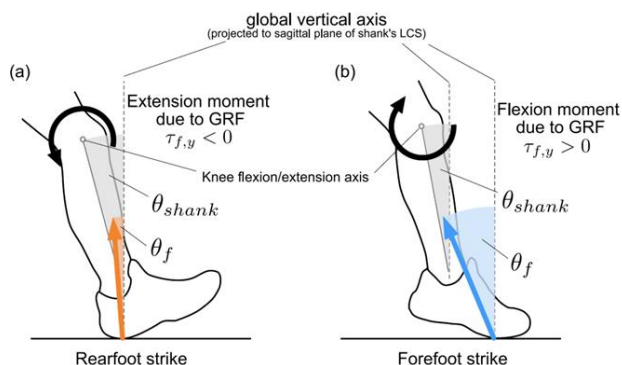


Figure 3. The normal sagittal plane of knee angle in flexion and extension posture (Uno et al., 2022).

The frontal plane

Evaluating the knee structure from anterior and posterior side, the femoral axle angles medially as a result of the angle of deviation of the proximal femur. The femoral axle diverges 10 degrees from the tibia axle. In conclusion, valgus makes an angle around 168 degrees for children and then gradually increase 2 to 7 degrees when reaches adult, the normal valgus degree for adult is nearly 175 degrees depending on the age. (Sahrmann, 2010.)

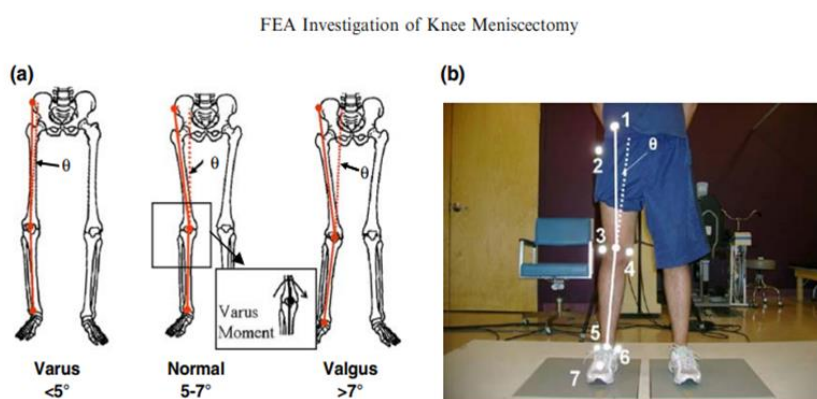


Figure 4. The frontal plane of knee angle (Yang, Nayeb-Hashemi, & Canavan, 2009).

The transverse plane

Evaluating the structure of the knee from anterior and posterior views also is possible to analyse the rotation of the femur to the hip and estimate the equal pressure on the medial and lateral aspects of the knee. With the knee flexed to 90 degrees, the total rotation is between 25 to 57

degrees and with the knee completely extended there is no specific rotation around the knee. (Sahrmann, 2010.)



Figure 5. The transverse plane of knee angle (Sahrmann, 2010).

Impairment of the frontal plane and knock-knee (genu valgum)

The observation of a specific balance control procedure in people with knock-knee deformity during childhood, especially during walking posture in the frontal plane is a significant finding. The greater hip and knee muscular work required to maintain normal alignment suggests that individuals with knock-knees may naturally attempt to increase their step width as a compensatory mechanism. This observation could have important implications for understanding gait patterns and balance control in individuals with knock-knee deformity during childhood. (Wu et al., 2021.)

2.5 Knee joint's motion

2.5.1 Knee joint's motion during walking

During the walking position (Table 1), we have 5 degrees of flexion in the heel strike at first and then the flexion increases to 10-15 degrees during the initial 15% of the walking cycle. In general, during knee movement, the primary rotational motion is typically flexion-extension, followed by internal-external rotation and abduction-adduction. (Gray et al., 2019.) Normal rotation between the tibia and femur during the walking cycle must be approximately 8 to 9 degrees, the tibia is laterally rotated about 2 to 3 degrees relative to the femur. Also, in medial observation, the tibia rotated more than the femur. (Sahrmann, 2010.)

Table 1. The gait cycle (Haghighatnejad, 2021).

Kinetics and kinematics of the walking cycle at the knee

Phase of the walking /gait cycle	Degrees	Moment	Muscle activity
Initial contact	0	Flexion	Quadriceps-Hamstrings
Loading response	Flexion 0-15	Flexion	Quadriceps
Midstance	Extends to 5 flexion	Flexion moving toward extension	quadriceps
Terminal stance	Extends to 0	Extension	Minimal
Pre swing	Flexes to 40	Flexion	Minimal
Initial swing	Flexes from 40 to 60	Flexion	Hamstring
Mid swing	Extends from 60 to 30	Extension	Mostly passive with some hamstring
Terminal swing	Extends from 30 to 0	Extension	Hamstrings-quadriceps

2.5.2 Knee joint's motion during running

Knee movement during running (Figure 6), is like walking but the knee joint's angle is more acute. The knee posture flexes up to 45 degrees as the quadriceps muscle activates completely to help shock absorption as shown in Figure 6 below. The knee posture doesn't reach the full extension during the running pattern. In mid-posture, the knee flexes around 25 degrees and maximum knee flexion of 90 degrees happens during the swing step. Also, during fast speed, it is possible to increase the knee degree up to 130. (Sahrmann, 2010.)



Figure 6. The running cycle (Garvey, 2016).

Muscles actions on the knee

a. Extensors

To move our body, we need to close and open the knee joint in the lower limb to advance. Fortunately, the strongest muscle group in our body is the quadriceps muscle group that produces the knee opening movement. This great muscular power helps us a lot in performing intense explosive movements such as jumping and running. These muscles include the external extensor muscle (vastus lateralis), which is the largest and strongest muscle, and the internal extensor muscle (vastus medialis) on both sides, the medial extensor muscle (vastus intermedius), and the rectus femoris muscle in the middle, which terminates the patellar tendon and forms

and encloses the patella of the knee and attaches to the tibial ridge from the front. By contracting these muscles, the knee is opened, the tibia is straightened, and the menisci are pulled forward. (Sahrmann, 2010.)

The vastus lateralis muscle attaches to the anterior side of the great trochanter of the thigh from above and pulls the patella out from below with great force. The vastus medialis muscle attaches to the inside of the patella and pulls the patella in. The vastus intermedius muscle is located between these two muscles and at the end it has more horizontal muscle fibres than the upper part. The rectus femoris muscle is the only biceps muscle in this muscle group that crosses the vastus intermedius and plays a greater role in flexing the thigh, helping to open the knee when the thigh is also open. The rectus femoris muscle helps to open the knee in the toe-off stage when the thigh is open when you walk or run. The maximum activity of this muscle can be seen in the first stage of shooting when it opens the knee while the knee is bent. (Sahrmann, 2010.)

b. Flexors

When you want to sit on a chair, a bending motion occurs in the knee to bring the body down. In this case, the muscles that open the knee control the lowering of the body. In all knee movements, the flexor and extensor muscles work together to control each other's action. When walking, while the foot is off the ground, the flexor muscles of the knee are very active and slow down the rapid opening of the leg by their contraction. The group of knee flexors called the hamstring group, is located at the back of the thigh. It is a two-joint muscle group that connects the upper part of the pelvis to open the thigh. The hamstring muscles include the three muscles of the biceps femoris, semitendinosus, and semimembranosus. (Straker, Exell, Farana, Hamill, & Irwin, 2022.)

These muscles also cause rotation in the knee due to the lower connection to the sides of the knee. The hamstring muscles are $\frac{1}{3}$ the strength of the quadriceps muscles and have 50% less flexural strength when the knee is open than when the knee is bent 90 degrees. The biceps femoris muscle causes the external rotation of the leg, and together with the external quadriceps, the knee joint provides stability. (Straker et al., 2022.)

The semimembranosus muscle strengthens the knee from behind the capsule prevents the tibia from moving forward and is involved in the internal rotation of the knee joint. The internal muscle of the semitendinosus, which is also part of the pes anserinus muscle group, produces 47% of the bending force and is involved in internal rotation. (Straker et al., 2022.)

The hamstring muscles work best when the thigh is bent because in this case, their length slightly increases. The sartorius muscle, which passes through the quadriceps muscles, produces 34% and the gracilis muscle 19% of the force required to bend the knee. These two muscles are also part of the pes anserinus muscles. It is also involved in flexing the gastrocnemius 2 joint muscle of the knee. In conclusion, the muscle groups of pes anserinus, semitendinosus,

semimembranosus, and gastrocnemius are involved in the internal rotation of the tibia. (Straker et al., 2022.)

Muscles of the knee joint			
Movement	Prime Mover	Origin	Insertion
Flexion	Biceps femoris	Pelvis and femur	Tibia and fibula
	Semimembranosus	Pelvis	Tibia
	Semitendinosus	Pelvis	Tibia
	Gastrocnemius	Femur	Calcaneus
	Plantaris	Femur	Calcaneus
	Popliteus	Femur	Tibia
	Sartorius	Pelvis	Tibia
Extension	Rectus femoris	Pelvis	Patella
	Vastus lateralis	Femur	Patella
	Vastus intermedius	Femur	Patella
	Vastus medialis	femur	Patella
	Tensor fasciae latae	Pelvis	Femur
Medial rotation	Popliteus	Femur	Tibia
	Sartorius	Pelvis	Tibia
	Semimembranosus	Pelvis	Tibia
	Semitendinosus	Pelvis	Tibia
	Gracilis	Pelvis	Tibia
Lateral rotation	Biceps femoris	Pelvis and femur	Tibia and fibula

* Prime movers shaded grey are the principle muscles causing the movement.

Figure 7. The knee muscles (Sahrmann, 2010).

2.6 Key tests and signs

The standing test procedure

Single leg posture should be evaluated by comparing the lower limbs. When standing with one foot on the affected leg, the patient shows excessive internal rotation of the affected femur and excessive ankle rotation. During the single-leg position for the uninvolved leg, tibial lateral rotation is seen in the involved leg when the knee is flexed to 90 degrees. During hip and knee flexion in a semi-squat position, the patient shows femoral adduction/medial rotation and knee valgus. This movement should cause the symptoms to appear or worsen it. When the position is corrected the pain decreases and deformity is diagnosed. (Sahrmann, 2010.)

The supine test procedure

At the time of doing the two-joint hip flexor length examination, external rotation or abduction of the tibia is seen since the involved organ is lowered into the hip extent. if the patient is in pain in this position, we do the test again with fixation of the tibia to suppress observed movement. If the patient's symptoms decrease, the motion impairment of tibiofemoral deformity is supported. (Sahrmann, 2010.)

The prone tests procedure

Lateral rotation of the tibia is seen in the flexion position of the knee in the prone position. If the patient is in pain in this position, then the second test should be performed by controlling the rotation of the tibia. If the patient's symptoms improve, then the movement abnormalities are dealt with. During the internal and external rotation of the pelvis, excessive rotation of the tibia may be seen. If pelvis rotation ROM (the ranges of motion of the two movements are both 45°) is measured in this posture, to prevent the tibia from rotating relative to the femur it is possible to swell the amount of hip rotation ROM. (Sahrmann, 2010.)

The gait tests procedure

Walking is a moving pattern that is repeated, resulting in a cyclical movement called the gait cycle. During gait, inordinate medial rotation or adduction of the femur during standing or tibia lateral rotation during movement can be observed and sometimes it is possible to see the ankle's rotation. (Haghighatnejad, 2021.)

The step-up and step-down tests procedure

A step-up and step-down test could be done to evaluate the patient's movement pattern. Patients with genu valgum deformity will show femoral adduction and knee valgus doing this test. If the procedure is painful, the second test is performed by correcting the motion. (Straker et al., 2022.)

2.7 Management and alignment of knock-knee

Impairment at the knee joint can produce significant activity limitations and performance restrictions. Treatment of this class of deformities includes educating the patient on correcting postural habits and movements that contribute to the improvement of the impairment. (Sahrmann, 2010.) A corrective exercise program can be as effective as anti-inflammatory medicines in decreasing joint pain (Sengul, Yavuzer, Keles, Tunali, & Tuncer, 2022). A previous study has shown that a three-week hip abductor muscle strengthening exercise program could be useful in muscle strengthening and knee joint pain in knock-knee deformity (Ferber, Kendall, & Farr, 2011).

During alignment evaluation (Figure 8), the impairments are divided into two categories: the first one is structural impairments that are related to bony structures and are not treated with training and exercises. The other ones are acquired impairments that are usually the result of postural habits and lifestyle and can be changed with functional training and corrective movements. (Sahrmann, 2010.) The recent classification has shown that alignments only include neutral, varus, and valgus. Also, in lower limb alignment assessment, it is important to consider the femoral and tibial joint lines. (Hirschmann et al., 2019.)

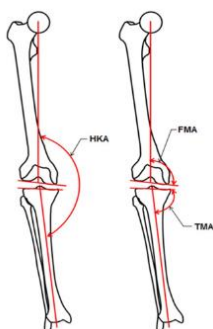


Figure 8. The measured angles: hip-knee-ankle angle (Hirschmann et al., 2019).

3 AIM OF THE STUDY AND RESEARCH QUESTION

The purpose of this literature review was to find comprehensive corrective exercise programs for young adults with genu valgus deformity in order to prevent premature osteoarthritis. The main aim of the study is to produce brief and useful learning materials about knock-knee alignment exercises like informative video clips showing how to exercise correctly. The video will focus on best practice exercises for use by those with knock-knees to prevent the early onset of osteoarthritis.

The research question is as follows:

- What specific exercises are effective in preventing patients with knock-knee problems from developing early stages of osteoarthritis?

4 METHODOLOGY

4.1 Literature review

Scoping literature review is used as a means of finding answers to research questions. (Figure 9) According to Peters (2020), "scoping reviews are usually used to clarify working definitions and conceptual boundaries of a topic". So scoping review is suitable for the academic research because it is not necessary to produce statements to guide decision-making and it is essential to produce an overview of a potentially large and diverse body of literature pertaining to a broad topic and identify gaps in the literature to make the planning for future. (Peters et al., 2020.)

To achieve that, the author has to take several steps. The first step is to identify a clear objective and write the specific question of study. The second is to clarify the objective that helps the author to investigate the topic. The next step is to apply for PCC framework by JBI to identify the main concept in the question itself, and then write the inclusion and exclusion criteria to develop a protocol. From here the next step is to conduct a series of systematic research and start charting the data. The last part is collecting and reporting the findings to the questions, to show the result of the study. (Pollock et al., 2023.)

Scoping literature review is broadly a field or area of knowledge or a sector of scientific research. The purpose of this scoping review is to collect the existing studies on a specific topic and make it understandable for the target group. A scoping review is essential because it provides the map of the body of literature on a topic area, but it needs a much larger base and sometimes makes heterogeneous results. Therefore, the author can deal with this challenge by drawing PRISMA diagram that proposes reasoned and detailed fine-grained schemes to develop and apply PRISMA. (Pollock et al., 2023.)

The main thought is to find as much material as possible with the help of previous research and studies to come to a strong and resourceful conclusion (Rovira, Codina, & Lopezosa, 2021). Healthcare professionals are required to always be up to date with the newest information, but it is impossible to read all the information, due to the vastness of the number of studies out there.

The research method was implemented by collecting theoretical and practical information about the knock-knee deformity and corrective exercises program for young adults with this deformity. The author has set one specific question. When the research question was designated, the author selected studies and extracted the essential answers to the research question. After data collection, results from the studies were presented (Figure 9).



Figure 9. Research implementation steps

Identification of research objective and question

The purpose of this literature review was to find comprehensive corrective exercise programs for young adults with genu valgus deformity to prevent premature osteoarthritis. This research has the potential to make a significant impact on public health and the well-being of individuals with knock-knee issues. The creation of informative video clips to demonstrate these exercises correctly is an effective and accessible way to disseminate this knowledge. Preventing the development of early-stage osteoarthritis in patients with knock-knee problems typically involves a combination of exercises that aim to improve knee alignment, strengthen supportive muscles, and promote joint stability.

4.2 Data collection

Defining the scope of review using PCC

The JBI recommends the PCC (population, concept, context) for formulating scoping review questions. PCC lets reviewers think of what, who, and where for the topic of interest. Regarding the first part of PCC elements, the population of this scoping literature is young adults with knock-knee alignment. The core concept includes knock-knee alignment definition, searching for corrective exercise programs for knock-knee deformity, and prevention of premature osteoarthritis. The context is the effective exercises used by young adults with knock-knee to prevent early onset of osteoarthritis worldwide and research publications within the 20 years (2003-2023) that are published in English. (Pollock et al., 2023.)

Table 2. Creation of (inclusion/exclusion) criteria

Inclusion criteria	Exclusion criteria
Published from 2003 to 2023 - to find a wide scope of literature on the research topic	Published before 2003
Literature written in English because the thesis is written in English	Written in languages other than English
Articles that focus specifically on knock-knee exercises and non-surgical methods for knock-knee treatment, because is focus on the research question	Articles explained about surgery method such as osteotomy
Peer-reviewed articles and guidelines to use reliable sources	Gray literature
Articles that explain how to do the exercises with special exercises definition	Articles did not contain enough explanation about functional activities

Conducting Systematic search

The thesis material was collected from articles, books, theses, and journals. The author started data collection in April 2022 with the help of different databases and various types of word keyboards. The author used four databases Google Scholar, PubMed, CINAHL Complete, and Käypä Hoito Finnish database. In addition, the author used three books and one previous Finnish thesis from Savonia Applied Sciences.

Google Scholar has an advanced search function, and it can link to articles and books through ECU libraries (Falagas, Pitsouni, Malietzis, & Pappas, 2008). PubMed is the standard database that is used in the healthcare profession and it can access the advanced research that the author used to collect specific exercises (Motschall & Falck-Ytter, 2005). CINAHL Complete allows us to research articles in hundreds of nursing journals and publications from the National League for Nursing (Yıldız, 2019). The Käypä Hoito is a Finnish Medical database and independent national treatment recommendations based on research evidence (suositus, 2018).

The books used in writing the thesis were Movement system impairment syndromes (Sahrmann, 2010).

Therapeutic Exercises (Lori Thein Brody, 2018), and Arthritis by the Numbers (Jafarzadeh, 2017). The thesis was published by (Hasu Topi, 2015) and (Haghighatnejad, 2021). For creation criteria, the author used inclusion and exclusion table to show the classification of research (Pollock et al., 2023).

In Google Scholar, a conflation of "Knock-knee and the gait", "Frontal plane knee alignment AND osteoarthritis", and "Balance Control and Knee Osteoarthritis" keywords were used. The Initial number of total articles were respectively 23 studies appeared and one (n=1) was chosen then in the next keyword 641 articles were found and four (n=4) studies were chosen. In the final keywords, 149 articles were found and two (n=2) of them randomly selected. The author

did not use criteria-setting restrictions in Google Scholar setting keywords because of the limitation of articles.

In the PubMed database, a combination of "knee valgus OR genu valgum OR tibiofemoral deformity AND exercises" and "reducing premature osteoarthritis in the adolescent" keywords were used. The initial number of total articles in the first keywords was 60 so after the criteria setting including full text and abstract availability research articles results showed 33 studies. Eleven (n=12) articles were chosen after reading. In the next keywords, 13 articles were found after criteria setting including full text and abstract availability. Research articles result showed 6 articles and three (n=3) were chosen for literature review.

In the CINAHL Complete database, a conflation of "knee valgus OR genu valgum OR tibiofemoral deformity AND exercises" and "hip exercises AND runner" keywords used. The initial number of total articles in the first keywords was 47 studies. After setting criteria including full text and abstract availability, 5 articles came out and two of them (n=2) were chosen. In the second keyword, the number of total articles was 72. After setting criteria including full text and abstract availability 11 studies appeared, and one article (n=1) was chosen.

In Savonia-Finna, the author found one preview thesis (n=1) through 84 studies and one book (n=1) from 123 options in the Savonia library. In Käypä Hoito, the Initial amount number of the total articles was 462, and one of them (n=1) was chosen. In Finna.fi, 34 books came out and one book (n=1) was chosen. After the process of screening, twelve articles (n=12) were chosen to analyze. The countries where the studies were conducted were the United States (n=3), Iran (n=3), the United Kingdom (n=1), Taiwan (n=1), Germany (n=1), Ireland (n=1), Turkey (n=1) and Canada (n=1).

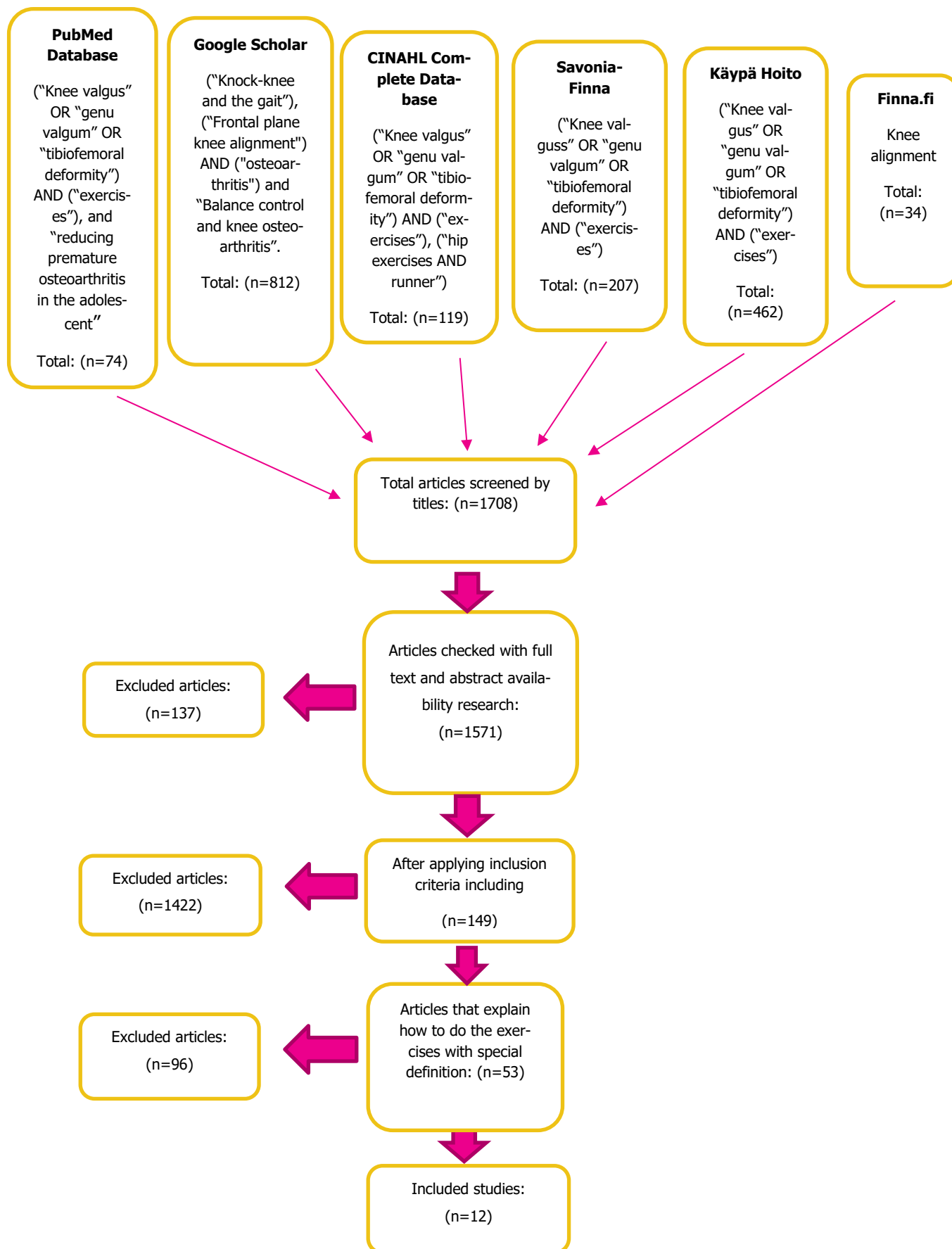


Figure 10. Study selection process (PRISMA diagram)

4.3 Content analysis

In the scoping review, the author should explain clearly how one could achieve the question's answer and how it should be presented. The result of the study must be presented as tables, diagrams, statistics, or a narrative summary so the author decided to use content analysis that is common in nursing science research. Content analysis helps the author to go through the studies deeply and achieve the aim of the research by systematically analyzing the content of text, video, and visual materials applied to various research questions and objectives and describing the subject of study. (Rovira et al., 2021.)

Researcher could explicate the data into sub-categories: inductive and deductive. The author decided to use the inductive content analysis method to investigate the data because the inductive formulation is based on the collection of the data without preconceived theories and develops theories from observation and those are analysis of progress. The first step of inductive analysis is to make detailed observations of the studied phenomenon. The author reads the previous data before starting to write the thesis. In the next step, the author looks at the data for patterns and relationships then progresses the first ideas as an original sentence so that in the final stage, the theory is developed in generic ideas to make the framework to understand the result of the study. (Rovira et al., 2021.)

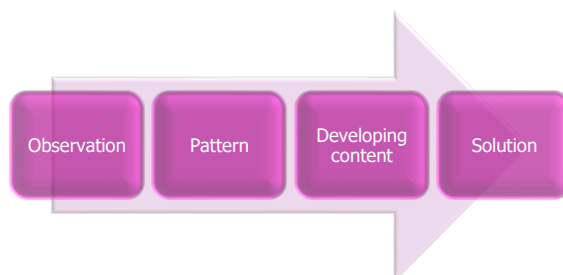


Figure 11. Inductive analysis process

Table 3. Characteristics of the most relevant research articles selected (n=12)

Authors	Country	Topic	Type of source	Database	Summary	Method
Emamvirdi	Iran, 2019	The Effect of valgus control Instruction exercises on pain, strength, and functionality in active females with patellofemoral pain syndrome.	Article	PubMed	VCL exercises could be effective in changing the valgus angle and improving knock-knee.	Controlled laboratory study
Sengul	Turkey, 2022		Article	PubMed	Quadriceps isometric exercises especially knee extension could be releasing the pain and joint stiffness and improve functional movement in patients with knee OA.	Experimental group
Ferber	Canada, 2011	Changes in knee biomechanics after a hip-abductor strengthening protocol for runners with patellofemoral pain syndrome	Article	Cinahl	The effectiveness of a 3-week hip-abductor muscle strengthening was less knee pain and improving functional movement.	Cohort study
Ekstrom	U.S, 2007	Electromyographic analysis of core trunk, hip, and thigh muscles during 9 rehabilitation exercises	Article	Cinahl	Strengthening the gluteus medius is essential for maintaining proper hip and knee alignment, reducing the risk of issues like knee valgus, and supporting lower limb function.	Prospective, single-group, repeated-measures design
Schmidt	Germany, 2023	Positive influence of neuromuscular training on knee injury risk factors during cutting and landing tasks in elite youth female handball players	Article	Google scholar	Neuromuscular training can reduce knee valgus because it strengthens the deep muscles and prevents knock-knee.	Control group
Wu	Taiwan, 2021	Balance control and lower limb joint work in children with bilateral genu valgum during level walking	Article	Google scholar	During childhood, people with knock-knee deformity appear to have a specific balance control procedure during walking motion	Experimental group

in the frontal plane.

Straker	U.K, 2022	Biomechanical responses to landing strategies of female artistic gymnasts	Article	PubMed	Muscles actions on the knee	Experimental group
Mozafaripour	Iran, 2022	The effectiveness of the comprehensive corrective exercise program on kinematics and strength of lower extremities in males with dynamic knee valgus	Article	PubMed	The effect of the eight-week corrective exercise group had a substantial and positive impact on both the movement patterns (kinematics) and muscle strength in individuals with dynamic knee valgus $p < 0.05$.	Control group
Shams	Iran, 2022	Valgus control feedback and taping improves the effects of plyometric exercises in women with dynamic knee valgus	Article	Cinahl	plyometric exercises and taping can have a positive impact on proprioception and the ability to accurately sense the position of the knee valgus at 45° of knee flexion.	Controlled trial
Dolak	Boston, 2011	Hip strengthening prior to functional exercises reduces pain sooner than quadriceps strengthening in females with patellofemoral pain syndrome: a randomized clinical trial.	Article	PubMed	The comparison between the hip group and the quad group after 4 weeks is a significant finding. It shows that the hip group experienced less pain (2.4 ± 2.0) than the quad group (4.1 ± 2.5), and this difference was statistically significant ($P = 0.035$). the long-term impact is also noteworthy. In the hip group, there was a substantial 21% increase ($P < 0.001$) in hip abductor strength from baseline to 8 weeks.	Randomized clinical trial

González & Ortiz	U.S, 2023	Impact of Pilates mat-based exercises on knee kinematics during running	Article	PubMed	indicating that in the experimental group, knee valgus alignment significantly improved with the incorporation of a 12-week Pilates program.	Control group
Laws	Northern Ireland, 2017	The effect of clinical Pilates on functional movement in recreational runners	Article	PubMed	A 6-week Pilates course exercises could raise the functional ability in runner trainer.	Clinical experimental group

Table 4. Content analysis

Original expression	Reduction	Generic category	Main category
<i>In accordance to Sengul et al., "an exercise program maintains range of motion (ROM), increases muscle strength, and improves overall health. A well-planned exercise program can be as effective as nonsteroidal anti-inflammatory drugs in relieving joint pain."</i>	Exercise program can be effective as nonsteroidal medicine	Exercise program can be a valuable and effective tool for individuals with joint problems. It can provide a range of benefits, from maintaining joint mobility to relieving pain and improving overall health	Exercise can indeed be beneficial in relieving joint pain
<i>Wu et al. suggest that "children with genu valgum showed a specific balance control strategy during gait. In the frontal plane, greater hip and knee muscular work was needed to maintain balance."</i>	Balance control problem in children with knock-knee	Balance control exercises are designed to improve the ability to maintain stability. These exercises focus on strengthening the muscles responsible for balance and awareness of body position in space.	Effective balance control in physical activity program
<i>According to Straker et al., "changes in the rules that allow a more flexed landing position for both men and women reduces injury potential in artistic gymnastics."</i>	Knee flexion during landing posture	Flexed knees upon landing help to absorb impact forces and distribute them through the lower body	Flexed knees
<i>According to Emamvirdi et al., "six weeks of valgus control instruction (VCI) exercises significantly improved performance and strength and decreased pain and knee valgus angle in individuals with patella femoral pain syndrome."</i>	VCI exercises 1. Squat 2. Squat and hip lateral rotation 3. Squat on the BOSU ball 4. Balance exercise on the BOSU ball	Valgus control instruction exercises (VCI) with focus on dynamic knee valgus during exercises can positively influence the balance of torque between key muscle groups involved in knee and hip stability	Functional controlling valgus movement exercises group
<i>Ferber et al. argue that "three-week hip-abductor muscle-strengthening protocol was effective in increasing muscle strength and decreasing pain and stride-to-stride knee-joint variability in individuals with PFPS."</i>	Hip abduction strengthening	Hip abduction strengthening exercises are designed to target and strengthen the muscles responsible for moving the leg away from the centreline of the body	Hip abduction exercises group
<i>Ekstrom et al. state that "active hip abduction is effective for non-weight-bearing strength training of the gluteus medius muscles."</i>	Hip abduction exercises		

<p><i>Mozafaripour et al. highlights that "comprehensive corrective exercise program (CCEP) is one of the pioneers in showing significant improvements in DKV and related kinematics with large effect sizes ($0.14 < \eta^2$) which may be due to targeting all distal and proximal contributors to dynamic knee valgus using a comprehensive intervention attending alignment, muscle activation, and movement pattern simultaneously."</i></p>	<p>CCEP exercises</p> <ol style="list-style-type: none"> 1. Foot inversion/dorsiflexion 2. Hip external rotation 3. Oyster exercise/clamshell 4. Isometric buttocks and foot contraction 5. Modified hip adduction 6. Modified hip adduction/external rotation 7. Pelvic resisted rotation 8. Modified lunges 	<p>Comprehensive corrective exercise programs (CCEP) are designed to address various musculoskeletal issues and movement dysfunctions by incorporating a range of corrective exercises that including initial, improvement and maintenance phases</p>	<p>Functional corrective exercises group</p>
<p><i>"[Shams] suggest that short-term plyometric training can make significant positive changes in the onset of muscle activation, joint position sense, and LESS. can be trained to act as an ACL agonist during flight, helping to maintain the integrity of this ligament and surrounding structures in preparation for landing" (Shams, Hadadnezhad, Letafatkar, & Hogg, 2022).</i></p>	<p>Plyometric exercises</p> <ol style="list-style-type: none"> 1. Lateral jump 2. Jump squat 3. 180-degree squat jump 	<p>Plyometric exercises are high-intensity, explosive movements designed to improve power, speed, agility, and athletic performance. These exercises involve rapid stretching (eccentric phase) followed by a quick contraction (concentric phase) of muscles, which helps improve the body's ability to generate force quickly.</p>	<p>High-impact kinetic exercises group</p>
<p><i>According to Schmidt et al., neuromuscular exercises have positive impacts on biomechanical risk factors associated with anterior cruciate ligament injury risk (primarily reduced knee valgus moments of the dominant leg."</i></p>	<p>Neuromuscular exercises</p>	<p>Neuromuscular exercises are a group of exercises that focus on improving the communication between the nervous system and the muscles. These exercises aim to increase neuromuscular control, coordination, and stability.</p>	<p>Core stabilization exercises group</p>
<p><i>In Dolak et al. work "rehabilitation initially focusing on isolated hip strengthening would result in less pain, more strength and function, and better preparation for functional exercises than initial quadriceps strengthening. While both groups experienced similar overall increased strength and function, the hip group reported less pain than the quad group after the first 4 weeks of rehabilitation."</i></p>	<p>Hip strengthening</p> <ol style="list-style-type: none"> 1. Standing hip abduction 2. Seated hip external rotation <p>Quadriceps strengthening</p> <ol style="list-style-type: none"> 3. Short arc quads with body weight 4. Straight leg raises 	<p>Strong hip muscles, including the hip abductors, adductors, flexors, and extensors, contribute to better balance, posture, and functional movement.</p> <p>Quadriceps exercises focus on quadriceps muscles, four muscles on the front of the thigh known as the quadriceps femoris. These muscles are responsible for extending the knee and essential for various activities.</p>	<p>Functional hip static training group</p> <p>Functional quadriceps static training group</p>

<p><i>González & Ortiz determined the improvements in dynamic valgus alignment during running, during and after a 12-week Pilates mat-based exercise program in young, healthy adults. The study's initial hypothesis was that "the experimental groups' knee valgus alignment would improve significantly with the addition of a 12-week Pilates program." The result found that dynamic knee valgus improved with the Pilates intervention, showing a decrease of 5.1 cm in valgus during the running stance phase.</i></p> <p><i>According to Laws et al., "six-week course of clinical Pilates significantly improves functional movement in recreational runners, and this may lead to a reduction in the risk of running-related injuries."</i></p>	<p>Pilates</p> <ol style="list-style-type: none"> 1. Superman 2. Bridge 3. One leg bridge with ball <p>Straight leg rises with abdominal contraction</p> <ol style="list-style-type: none"> 4. Push-up for beginners 5. Stretch hamstring in sitting position 6. Plank rotation for beginners <p>Pilates group exercises</p>	<p>Pilates is a low-impact exercise that focuses on improving flexibility, strength, balance, and knee valgus alignment. Pilates exercises are useful to improving core strength, body posture, flexibility, and prevention of injuries.</p>	<p>Pilates mat work</p>
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4.4 Results of the review

The results of the review are showing that six specific exercise groups that concentrated on enhancing quadriceps and hip strength demonstrated significant improvements in dynamic knee valgus, with large effect sizes. These exercises included the functional corrective exercise group, high-impact kinetic and knee flexed exercises group, functional hip static training and hip abduction group, functional quadriceps static training group, Pilates mat-work and core stabilization, and functional controlling valgus movement and balance control exercises group.

1. **Functional corrective exercise group:** Comprehensive corrective exercise programs are designed to address various musculoskeletal issues and movement dysfunctions by incorporating a range of corrective exercises that including initial, improvement and maintenance phases. These exercises included: Foot inversion/dorsiflexion, Hip external rotation, Oyster exercise/clamshell, Isometric buttocks and foot contraction, Modified hip adduction, Modified hip adduction/external rotation, Pelvic resisted rotation, and Modified lunges.
2. **High-impact kinetic exercise group- flexed knees:** Plyometric exercises are high-intensity, explosive movements designed to improve power, speed, agility, and athletic performance. These exercises involve rapid stretching (eccentric phase) followed by a quick contraction (concentric phase) of muscles, which helps improve the body's ability to generate force quickly. Flexed knees upon landing help to absorb impact forces and distribute them through the lower body. These exercises included: Lateral jump, Jump squat, and 180-degree squat jump.

3. **Functional hip static training group - hip abduction:** Hip exercises including the hip abductors, adductors, flexors, and extensors, contribute to better balance, posture, and functional movement. Hip abduction strengthening exercises are designed to target and strengthen the muscles responsible for moving the leg away from the centreline of the body. These exercises included: Standing hip abduction, and Seated hip external rotation.
4. **Functional quadriceps static training group:** Quadriceps exercises focus on quadriceps muscles, four muscles on the front of the thigh known as the quadriceps femoris. These muscles responsible for extending the knee and are essential for various activities. These exercises included: Short arc quads with body weight, and Straight leg raises.
5. **Pilates-mat work – core stabilization:** Pilates is a low-impact exercise that focuses on improving flexibility, strength, balance, and knee valgus alignment that is useful to improving core strength, body posture, flexibility and prevention of injuries. Core stabilization exercises are a group of exercises that focus on improving the communication between the nervous system and the muscles. These exercises aim to increase neuromuscular control, coordination, and stability. These exercises included: Superman, bridge, One leg bridge with ball, Straight leg raises with abdominal contraction, Push up for beginners, Stretch hamstring in sitting position, and Plank rotation for beginners.
6. **Functional controlling valgus movement exercise group – balance control:** Valgus movement refers to the inward or medial collapse of a joint, and controlling it is crucial to prevent injuries, particularly in activities that involve lower body movements. Balance control exercises are designed to improve ability to maintain stability. These exercises focus on strengthening the muscles responsible for balance and awareness of body position in space. These exercises included: Squat, Squat and hip lateral rotation, Squat on the BOSU ball, and Balance exercise on the bosu ball.

Table 5. Exercises program

Functional Corrective exercise group
<ol style="list-style-type: none"> 1. Foot inversion/dorsiflexion: Tilt the sole of the foot inwards towards the midline. <div style="display: flex; justify-content: space-around; margin-top: 10px;">  </div>

2. **Hip external rotation:** In prone position, rotate the leg outwards away from the rest of the body.



3. **Oyster exercise/clamshell:** Lie on one side of the body, put the legs together, bend the knees to 90 degrees and lift the top knee until they are parallel.



4. **Isometric buttocks and foot contraction:** Lie on the stomach, face down with knees apart and bent, push your feet together by isometrically tightening contracting the buttock.



5. **Modified hip adduction:** Lie on your side of the body and lift the top leg straight with tilting of the sole of the foot in-wards toward the midline.



6. **Modified hip adduction/external rotation:** At first, keep your knees under your hips and your hands under your shoulders then raise one leg with less than 90 degrees and keep your knee far of body line.



7. **Pelvic resisted rotation:** While standing, keep the elastic band in your hand, raise one leg in suitable angle and rotate your whole body to same side of your one leg you just raised.



8. **Modified lunges:** Step forwards with one leg into a long stride and lower into a lunge, bending both knees and keeping your position upright while ensuring your knees do not travel over toes and knee and toe is in the same angle, move through your front heel to return to standing (Use elastic bands to protect the knees and focus on your deep muscles).



High-impact kinetic exercise group - flexed knees

1. **Lateral jump:** Bend your knees slightly and prepare to jump laterally over the object or line. Push off explosively with your legs, jumping sideways over the object or across the line.



2. **Jump squat:** Stand shoulder-width apart and with the toes pointing slightly outwards, it is important to keep the knees and toes in same angle. Lower your body into a squat position by bending your knees and pushing your hips back as if you are in sitting position. Pushing through the heels and jump straight up.



3. **180-degree squat jump:** Ensure that your back remains between 45 and 90 degrees to your hips (squat position) then rotate your body 180 degrees and land in squat position. Ensure that your toes and your knees are in the same angle to prevent knee injury.



Functional Hip static training group - hip abduction

1. **Standing hip abduction:** While standing up, hold onto a something like wood, chair or wall. Raise your one leg up and lift it out from the lateral of your body. Stop and return to the starting position.



2. **Seated hip external rotation:** Sit on a chair or a ball. Keep your back straight with your legs bent at a 90-degree angle and feet flat on the floor. Place the sole of the left foot on the right thigh. Put your hands on your knee and move your leg in the opposite direction to open your hip.



Functional Quadriceps static training group

1. **Short arc quads with body weight:** Take a rolled-up towel and place it underneath your knees for a target then raise one leg straight and keep it up for a few seconds then return to the starting position.



2. **Straight leg raises:** Sit on the floor and keep your legs straight. Raise one leg until you feel the stretch in the back side of leg, pause and lower the leg slowly and then return to the starting position.



Pilates mat-work – core stabilization

1. **Superman:** Lie face down on surface. Extend your arms straight overhead, and keep your legs straight then lift your legs and arms a few inches off the ground and briefly pause at the top of the movement. The position is like you are flying like a superhero.



2. **Bridge:** Lie on your back with your knees bent and your feet flat on the floor, hip-width apart. Tighten the core muscles and squeezing your glutes. Lift your hips off the ground to create the bridge shape with your body, form a straight line from your shoulders to your knees. Then keep your position for a few seconds.



3. **One leg bridge with ball:** Unilateral bridge exercise with one knee and the opposite hip extended so that the trunk is in neutral spine alignment.



4. **Straight leg raises with abdominal contraction:** Sit on the floor with your both legs straight in front of you. Raise your legs and your neck at the same time, keep it as much as you can.



5. **Push up for beginners: Begin in** prone position, Place your hands on the ground slightly wider than shoulder-width apart. Keeping the back straight with the knees touching the ground. Lower yourself until your chest is just above the ground or as far down as your strength allows. Push through your hands and straighten your arms to lift your body back to the starting position. Fully extend your arms at the top of the movement.



6. **Stretch hamstring in sitting position:** Extend both legs out in front of you with your toes pointed up. Sit up professional and tall. Keep your chest up and your spine long as you slowly lead forward and bend the hips until you feel a stretch in the back of your legs.



7. **Plank rotation for beginners:** Start inside plank position, slowly rotate your torso to one side, raising one arm toward the ceiling. Keep the knees on the ground. (Do this for both sides).



Functional controlling valgus movement exercise group - balance control

1. **Squat:** Stand with your feet shoulder-width apart and your toes pointing slightly outwards. Keep your chest up and your back straight with your shoulder relax. Bent your knees and lower your body, ensure that your knees stay in line with your feet and don't extend past your toes.



2. **Squat and hip lateral rotation:** Get in the squat position then rotate your back straight to the right and left sides.



3. **Squat on the BOSU ball:** At the first, keep your balance on the BOSU ball and then try to do the simple squat.



4. **Balance exercise on the BOSU ball:** Exercising with the BOSU ball can improve balance and stability of your body and focus on core muscles. it is so effective in protecting the knees



5 DISCUSSION

The purpose of this literature review was to find comprehensive corrective exercise programs for young adults with genu valgus deformity to prevent premature osteoarthritis. The literature review incorporates a variety of exercise methods and provides valuable insights into their effects on knee alignment and related factors.

The impact of Pilates mat-work exercises and core-stabilization on knee kinematics during the running posture, particularly the significant decrease of 5.1 cm in valgus during the running stance phase after a 12-week Pilates program, is a highly valuable finding. The substantial reduction in valgus alignment during running suggests that Pilates can be a highly effective training method for individuals seeking to improve knee alignment during dynamic activities. This has the potential to enhance knee stability and reduce the risk of injuries, particularly those related to valgus alignment. (González & Ortiz, 2023.)

According to the preliminary information, each degree of medial rotation from a neutral position result in an annual reduction of 23.4 mm³ of the universal patella cartilage amount so by changing one centimeter in the valgus angle we observe a significant reduction in knee injuries. Also, strengthening core musculature through Pilates can certainly improve knee alignment during functional movements. (Laws, Williams, & Wilson, 2017.)

The findings from Shams (2022) regarding the high-impact exercises and knee-flexed group are notable. The study showed that a short-term high-impact exercise program, conducted over a period of six weeks, had a positive impact on various key factors related to knee health and stability. This highlights the potential for relatively brief training periods to yield significant benefits. The exercise program was effective in improving muscle activation, which is crucial for providing support and stability to the knee joint. This is valuable for individuals aiming to enhance knee health and reduce the risk of injuries. The program also had a positive effect on joint position and movement control. This is important for maintaining proper alignment and reducing the risk of harmful movements, particularly during activities that involve dynamic lower body movements. The implications of these findings for injury prevention are significant. Enhanced muscle activation, improved joint position, and better movement control are essential for preventing knee injuries and enhancing performance in activities that involve dynamic lower body movements. (Shams et al., 2022.)

In general, exercises that increase the stimulation of sensory signals and central mechanisms are able to reduce knee valgus by strengthening the deep muscles and preventing inwards knee rotation (Schmidt, Nolte, Terschluse, Willwacher, & Jaitner, 2023).

The findings related to initial hip strengthening versus initial quadriceps strengthening in the study have several key takeaways. Both groups experienced increased overall strength and function. This is a positive outcome as it indicates that both approaches, whether focusing on hip or quadriceps strengthening, were effective to some extent in enhancing muscle strength and functional capacity. An important observation is that the group with initial hip strengthening reported less pain com-

pared to the quadriceps group after the first 4 weeks of rehabilitation. This suggests that hip strengthening exercises may be particularly effective in alleviating pain in individuals with knee issues. Both approaches were successful in preparing individuals for functional exercises. (Dolak et al., 2011.)

The insights from Ekstrom (2007) the hip muscles a significant role in stabilizing the hip joint and controlling hip movement. When the hip muscles are weak, it can result in poor hip alignment, which, in turn, affects knee alignment. Proper alignment of the hip and knee is essential for reducing the risk of issues like knee valgus (Ekstrom, Donatelli, & Carp, 2007).

The findings regarding the eight-week corrective exercise group on the kinematics and strength of lower extremities in men with dynamic knee valgus was significant improvements in dynamic knee valgus indicated kinematics large effect sizes ($n^2 > 0.14$). This suggests that the improvements in dynamic knee valgus and related factors were substantial and had a meaningful impact on the participants' knee health. (Mozafaripour, Seidi, Minoonejad, Bayattork, & Khoshroo, 2022.)

By doing controlling valgus movement and balance control exercises group are notable there was a significant mathematical difference in knee dynamic valgus angle within the experimental group after 6 weeks of exercises. By reducing motor controls, controlling valgus movement exercises group can correct knee valgus angle suggesting that implementing such exercise protocol in the clinical setting may have a selective and positive impact on patients. This includes reducing pain, enhancing strength, and improving knee performance. This finding suggests that these exercises, which focus on controlling valgus movement and improving balance can be effective in correcting knee valgus angles according to the preliminary information. (Emamvirdi et al., 2019.)

Overall, this study provides a comprehensive overview of various exercise methods and their potential benefits to address knee deformity issues associated with knock-knee. These findings could be valuable for individuals who wish to improve their knee health and prevent premature osteoarthritis through targeted exercise programs.

5.1 Reliability and validity

The ethical principles of review and responsible conduct of review are essential aspects of any scientific study. The literature review followed the principle of integrity, which involves conducting study with honesty and transparency. The author ensured that every step of the study process was carried out diligently and without any form of manipulation or distortion of data. (Finnish Advisory Board on Research Integrity TENK 2012, 30-31.)

The study upheld the principles of meticulousness and accuracy in conducting research, recording data, presenting results, and evaluating the findings. This commitment to precision is crucial for maintaining the credibility and reliability of the review. The acquisition of study materials and sources was ethically sustainable. The author used trusted and well-known databases and literature sources, which are considered reputable and reliable in the academic community. The results of the study were communicated in an open manner, adhering to the principle of open science. This includes disclosing the research methods and how they were used, as well as presenting the results accurately and transparently. The author marked citations and references correctly, giving proper

credit to the original authors whose work was used in the study. Proper referencing is essential to give credit to the sources of information and avoid plagiarism. The study underwent plagiarism checks using the Turnitin system, demonstrating a commitment to academic honesty and originality. The review conducted in this study followed ethical principles and responsible research conduct, ensuring the integrity, accuracy, and transparency of the thesis process. These practices are essential for maintaining the credibility and trustworthiness of scientific research. The review did not incur any financial costs for the author, indicating that it was conducted efficiently within the vicinity of available resources. Signed contracts were made with the supervisor to agree on the literature review topic and thesis title, highlighting a collaborative and structured approach to the review. (Varantola, 2013.)

The completed thesis and the educational video will be made publicly accessible on platforms like Theseus.fi and YouTube, allowing for wider dissemination of the study's findings and educational content. Generally, this passage underscores the commitment to ethical and rigorous research practices and the intention to make the research publicly available for the benefit of others interested in the topic.

5.2 Limitations and recommendations

Certainly, every study project has its strengths and weaknesses. This thesis project has contributed to the development of the author's analytical skills. This is crucial for any authors as it fosters critical thinking and the ability to acquire information from various sources. One of the limitations of this literature review is the geographical bias. Most of the reviewed information came from the United States and Iran, with fewer articles available from Finland. This could potentially lead to a lack of diversity in perspectives and findings, impacting the generalizability of the results. Time limitations are a common constraint in thesis projects. As a result of time constraints, the author had to provide a condensed overview of the research. During the collection of valuable information from beneficial articles, a more in-depth analysis might have been beneficial, but author was unable to review a more extensive selection of articles and only studied a limited number of them.

The absence of a peer group to conduct review and the practical nature of the research, which required exercise and movement, presented noteworthy limitations in recording the correct exercises and collecting the data. Despite these weaknesses, this study has provided valuable insights into the topic of knee alignment and exercise. Acknowledging these limitations is a critical part of the thesis process, as it helps guide future study and ensures that findings are interpreted in a context-appropriate manner. The author has a plan to pursue quantitative study process in the future is a positive step toward addressing some of these limitations and providing robust evidence in this field.

Future study should consider conducting longitudinal studies to examine the long-term effects of specific exercises on individuals with knock-knee, tracking their progress and assessing the sustainability of results over time. The author's recommendation to individuals with knee deformity is to read the study and watch the accompanying video. It is a valuable and empowering message. It emphasizes the potential positive impact of exercise on improving the quality of life and reducing pain for those with knee deformities.

6 CONCLUSION

This study was about effective exercises to improve knock-knee or genu valgum angle in young healthy adults to prevent premature arthritis. Regarding the result, each of the exercise groups follows a common goal, which includes focusing on the hip and quadriceps muscles because they are the strongest muscle group around the knee that support it and enable the knee to have enough strength to perform intense explosive movements (Straker et al., 2022).

The results of the study show that the specific exercise groups concentrated on enhancing quadriceps and hip strength demonstrated significant improvements in dynamic knee valgus, with large effect sizes. Additionally, these exercises led to a notable positive change in muscle activation, as well as enhancements in the landing error scoring system (LESS) and joint position. These findings suggest that targeted exercise regimens can effectively address knock-knee issues in young adults. (Shams et al., 2022.)

Since knock-knee is a known risk factor for premature osteoarthritis, these improvements in the dynamic knee angle may translate into a reduction of the risk factors associated with the development of osteoarthritis in the knee joint. Ultimately, this could potentially delay the onset of osteoarthritis and contribute to a better long-term joint health. This review underscores the importance of exercise as a preventive measure for addressing knee joint issues and the potential benefits it can offer in reducing the risk of osteoarthritis. (Lespasio et al., 2017.)

The study's results demonstrate that a comprehensive exercise planning approach can produce statistically significant changes in valgus angles. These findings imply that through regular and targeted exercise, individuals may have the opportunity to reduce the risk of developing knee osteoarthritis and maintain better knee health. This statement highlights the significance of exercise in mitigating the risk of knee premature osteoarthritis and underscores the importance of proactive exercise planning for individuals with knee deformities.

REFERENCES

- Boer, C. G., Hatzikotoulas, K., Southam, L., Stefánsdóttir, L., Zhang, Y., Coutinho de Almeida, R., . . . Zeggini, E. (2021). Deciphering osteoarthritis genetics across 826,690 individuals from 9 populations. *Cell*, *184*(18), 4784-4818.e4717. doi:10.1016/j.cell.2021.07.038
- Cui, A., Li, H., Wang, D., Zhong, J., Chen, Y., & Lu, H. (2020). Global, regional prevalence, incidence and risk factors of knee osteoarthritis in population-based studies. *EClinicalMedicine*, *29-30*, 100587. doi:10.1016/j.eclinm.2020.100587
- Dolak, K. L., Silkman, C., Medina McKeon, J., Hosey, R. G., Lattermann, C., & Uhl, T. L. (2011). Hip strengthening prior to functional exercises reduces pain sooner than quadriceps strengthening in females with patellofemoral pain syndrome: a randomized clinical trial. *J Orthop Sports Phys Ther*, *41*(8), 560-570. doi:10.2519/jospt.2011.3499
- Ekstrom, R. A., Donatelli, R. A., & Carp, K. C. (2007). Electromyographic analysis of core trunk, hip, and thigh muscles during 9 rehabilitation exercises. *J Orthop Sports Phys Ther*, *37*(12), 754-762. doi:10.2519/jospt.2007.2471
- Emamvirdi, M., Letafatkar, A., & Khaleghi Tazji, M. (2019). The Effect of Valgus Control Instruction Exercises on Pain, Strength, and Functionality in Active Females With Patellofemoral Pain Syndrome. *Sports Health*, *11*(3), 223-237. doi:10.1177/1941738119837622
- Falagas, M. E., Pitsouni, E. I., Malietzis, G. A., & Pappas, G. (2008). Comparison of PubMed, Scopus, Web of Science, and Google Scholar: strengths and weaknesses. *Faseb j*, *22*(2), 338-342. doi:10.1096/fj.07-9492LSF
- Ferber, R., Kendall, K. D., & Farr, L. (2011). Changes in knee biomechanics after a hip-abductor strengthening protocol for runners with patellofemoral pain syndrome. *J Athl Train*, *46*(2), 142-149. doi:10.4085/1062-6050-46.2.142
- Garvey, J. (2016). [Runcycle_full_500x118]. Retrieved from https://www.physio-pedia.com/File:Runcycle_full_500x118.jpg
- Geiger, E. J., Geffner, A. D., Rozbruch, S. R., & Fragomen, A. T. (2023). Management of Segmental Tibia Bone Defects with the Magnetic Motorized Intramedullary Transport Nail: A Case Series. *J Orthop Trauma*. doi:10.1097/bot.0000000000002574
- Golightly, Y. M., Allen, K. D., & Caine, D. J. (2012). A comprehensive review of the effectiveness of different exercise programs for patients with osteoarthritis. *Phys Sportsmed*, *40*(4), 52-65. doi:10.3810/psm.2012.11.1988
- González, J., & Ortiz, A. (2023). Impact of Pilates mat-based exercises on knee kinematics during running. *J Bodyw Mov Ther*, *33*, 8-13. doi:10.1016/j.jbmt.2022.09.005
- Gray, H. A., Guan, S., Thomeer, L. T., Schache, A. G., de Steiger, R., & Pandy, M. G. (2019). Three-dimensional motion of the knee-joint complex during normal walking revealed by mobile biplane x-ray imaging. *J Orthop Res*, *37*(3), 615-630. doi:10.1002/jor.24226
- Haghighatnejad, M. (2021). Effect of torso posture on knee joint biomechanics during walking. *University of Eastern Finland-Faculty of Science and Forestry-Department of Applied Physics*.
- Hasu Topi, K. S. (2015). Kotona tapahtuvan lihasvoimaharjoittelun opas polven alkavaan nivelrikkoon työkäisillä. Retrieved from <https://urn.fi/URN:NBN:fi:amk-201601081154>
- Hirschmann, M. T., Moser, L. B., Amsler, F., Behrend, H., Leclerq, V., & Hess, S. (2019). Functional knee phenotypes: a novel classification for phenotyping the coronal lower limb alignment based on

- the native alignment in young non-osteoarthritic patients. *Knee Surg Sports Traumatol Arthrosc*, 27(5), 1394-1402. doi:10.1007/s00167-019-05509-z
- Jafarzadeh. (2017). *Arthritis Foundation*.
- Kan, H. S., Chan, P. K., Chiu, K. Y., Yan, C. H., Yeung, S. S., Ng, Y. L., . . . Ho, T. (2019). Non-surgical treatment of knee osteoarthritis. *Hong Kong Med J*, 25(2), 127-133. doi:10.12809/hkmj187600
- Kim, H. S., Yun, D. H., Yoo, S. D., Kim, D. H., Jeong, Y. S., Yun, J. S., . . . Choi, S. H. (2011). Balance control and knee osteoarthritis severity. *Ann Rehabil Med*, 35(5), 701-709. doi:10.5535/arm.2011.35.5.701
- Laws, A., Williams, S., & Wilson, C. (2017). The Effect of Clinical Pilates on Functional Movement in Recreational Runners. *Int J Sports Med*, 38(10), 776-780. doi:10.1055/s-0043-111893
- Lespasio, M. J., Piuze, N. S., Husni, M. E., Muschler, G. F., Guarino, A., & Mont, M. A. (2017). Knee Osteoarthritis: A Primer. *Perm J*, 21, 16-183. doi:10.7812/tpp/16-183
- Lori Thein Brody, C. M. H. (2018). *THERAPEUTIC EXERCISE*. Lippincott Williams & Wilkins, a Wolters Kluwer business.
- Motschall, E., & Falck-Ytter, Y. (2005). Searching the MEDLINE literature database through PubMed: a short guide. *Onkologie*, 28(10), 517-522. doi:10.1159/000087186
- Mozafaripour, E., Seidi, F., Minoonejad, H., Bayattork, M., & Khoshroo, F. (2022). The effectiveness of the comprehensive corrective exercise program on kinematics and strength of lower extremities in males with dynamic knee valgus: a parallel-group randomized wait-list controlled trial. *BMC Musculoskeletal Disord*, 23(1), 700. doi:10.1186/s12891-022-05652-8
- Nicholson, S., Dickman, K., & Maradiegue, A. (2009). Reducing premature osteoarthritis in the adolescent through appropriate screening. *J Pediatr Nurs*, 24(1), 69-74. doi:10.1016/j.pedn.2008.03.009
- Peters, M. D. J., Marnie, C., Tricco, A. C., Pollock, D., Munn, Z., Alexander, L., . . . Khalil, H. (2020). Updated methodological guidance for the conduct of scoping reviews. *JBIM Evid Synth*, 18(10), 2119-2126. doi:10.11124/jbies-20-00167
- Pollock, D., Peters, M. D. J., Khalil, H., McInerney, P., Alexander, L., Tricco, A. C., . . . Munn, Z. (2023). Recommendations for the extraction, analysis, and presentation of results in scoping reviews. *JBIM Evid Synth*, 21(3), 520-532. doi:10.11124/jbies-22-00123
- Pretkiewicz-Abacjew, E. (2003). Knock knee and the gait of six-year-old children. *J Sports Med Phys Fitness*, 43(2), 156-164.
- Rovira, C., Codina, L., & Lopezosa, C. (2021). Language Bias in the Google Scholar Ranking Algorithm. *Future Internet*, 13(2), 31. Retrieved from <https://www.mdpi.com/1999-5903/13/2/31>
- Sahrmann, S. (2010). *Movement System Impairment Syndromes of the Extremities, Cervical and Thoracic Spines*. Elsevier Health Sciences.
- Schmidt, M., Nolte, K., Terschluse, B., Willwacher, S., & Jaitner, T. (2023). Positive influence of neuromuscular training on knee injury risk factors during cutting and landing tasks in elite youth female handball players. *German Journal of Exercise and Sport Research*, 53(1), 19-29. doi:10.1007/s12662-022-00851-w
- Sengul, A., Yavuzer, M. G., Keles, O., Tunali, A. N., & Tuncer, D. (2022). Isometric Quadriceps Exercises for Patients with Knee Osteoarthritis: A Randomized Controlled Trial Comparing Knee Joint Position Flexion versus Extension. *Rehabil Res Pract*, 2022, 2690871. doi:10.1155/2022/2690871

Shams, F., Hadadnezhad, M., Letafatkar, A., & Hogg, J. (2022). Valgus Control Feedback and Taping Improves the Effects of Plyometric Exercises in Women With Dynamic Knee Valgus. *Sports Health, 14*(5), 747-757. doi:10.1177/19417381211049805

Straker, R., Exell, T. A., Farana, R., Hamill, J., & Irwin, G. (2022). Biomechanical responses to landing strategies of female artistic gymnasts. *Eur J Sport Sci, 22*(11), 1678-1685. doi:10.1080/17461391.2021.1976842

suositus, K. h. (2018, 2016). Polvi- ja lonkkanivelrikko. Retrieved from <https://www.kaypahoito.fi/hoi50054?tab=suositus>

Teichtahl, A. J., Wluka, A. E., & Cicuttini, F. M. (2008). Frontal plane knee alignment is associated with a longitudinal reduction in patella cartilage volume in people with knee osteoarthritis. *Osteoarthritis Cartilage, 16*(7), 851-854. doi:10.1016/j.joca.2007.12.002

Uno, Y., Ogasawara, I., Konda, S., Yoshida, N., Otsuka, N., Kikukawa, Y., . . . Nakata, K. (2022). Validity of Spatio-Temporal Gait Parameters in Healthy Young Adults Using a Motion-Sensor-Based Gait Analysis System (ORPHE ANALYTICS) during Walking and Running. *Sensors (Basel), 23*(1). doi:10.3390/s23010331

Varantola, K. (2013). *Hyvä tieteellinen käytäntö ja sen loukkausepäilyjen käsitteleminen Suomessa : Tutkimuseettisen neuvottelukunnan ohje 2012 = God vetenskaplig praxis och handläggning av misstankar om avvikelser från den i Finland : Forskningsetiska delegationens anvisningar 2012 = Responsible conduct of research and procedures for handling allegations of misconduct in Finland : guidelines of the Finnish advisory board on research integrity 2012*. Helsinki: Tutkimuseettinen neuvottelukunta.

Wu, K. W., Lee, W. C., Ho, Y. T., Wang, T. M., Kuo, K. N., & Lu, T. W. (2021). Balance control and lower limb joint work in children with bilateral genu valgum during level walking. *Gait Posture, 90*, 313-319. doi:10.1016/j.gaitpost.2021.09.187

Yang, N., Nayeb-Hashemi, H., & Canavan, P. K. (2009). The combined effect of frontal plane tibio-femoral knee angle and meniscectomy on the cartilage contact stresses and strains. *Ann Biomed Eng, 37*(11), 2360-2372. doi:10.1007/s10439-009-9781-3

Yıldız, E. (2019). Ethics in nursing: A systematic review of the framework of evidence perspective. *Nurs Ethics, 26*(4), 1128-1148. doi:10.1177/0969733017734412

APPENDIX : VIDEO

