CHAPTER 2

LITERATURE REVIEWS

Weightlifting is a sport in which athletes attempt to lift the maximum weight (1). It demands high levels of dynamic force using both the upper and lower extremities, and trunk musculature (1, 4). A retrospective study (six years) on Olympic elite weightlifters (4) indicated that the most injuries occur in the knees, lower back and shoulders. These injuries accounted for 64.8 %. The majority of these injuries were referred to as strains and tendinitis. Typical injuries were characterized to be overuse injuries.

In Thai national weightlifters, a recent study from Neuro-Musculoskeletal and Pain Research Unit (5) showed that the most injuries also occur in the knees and lower back. The incidence of knee and lower back injuries are equal, 39.47 %. Patellar tendinopathy is the most common pathology of knee pain with the incidence of approximately 69.23%. The remaining pathologies are patellofemoral syndrome and other knee injuries (e.g., quadriceps strain and ligament sprain), with the incidence of approximately 23.08% and 7.69%, respectively. In the present study, the main focus was on knee problems in Thai national weightlifters.

1. Knee pain in weightlifters

Anterior knee pain is the majority of knee problems in Thai national weightlifters. Pathologies of anterior knee pain include patellar tendinopathy (jumper's knee), patellofemoral syndrome, fat pad syndrome, Osgood-Schlatter syndrome, and Sinding-Larsen-Johansson syndrome. Patellar tendinopathy is the most common. Another potential knee pain for Thai national weightlifters is iliotibial band syndrome (5). It may involve bone, cartilage, bursae, muscles and tendons. Forceful and repetitive micro-trauma plays an important role for the causes of anterior knee pain (22, 23).

During lifts in the sport of weightlifting, the knee of weightlifter is exposed to very high loads. The loads that used in weightlifting may put the knee at risk of injury (4). Previous study showed that the patellar tendon during snatch, and clean and jerk is exposed to high force that up to 14.5 kN (17 times the body weight) during competitive weightlifting (10). Moreover, the training of Thai national weightlifters which is performed more than one session in a day may result in repetitive microtrauma in the knee structures. It is the main cause of knee problems in Thai national weightlifters (5).

1.1 Patellar tendinopathy

Patellar tendinopathy is an insertional tendinopathy that most commonly affects the patellar tendon origin on inferior pole of the patella (7, 10, 11, 24, 25). It occurs typically in sports characterized by high demands on speed and power of leg extensor muscles, such as volleyball, basketball, soccer and weightlifting (8, 10, 26). Repetitive quadriceps contraction leads to recurrent micro-trauma and develop tendinopathy (8, 10, 26). Histologically, this results in an increased glycoprotein matrix with consequent increased water content in the tendon, fibroblast and tenocyte proliferation, and neovascularization. This does not reflect an acute inflammatory response. In addition, the results of histological examination demonstrated a mucoid degeneration in patellar tendinopathy (10, 11, 24, 27-30). It has become clear that chronic patellar tendon is overuse syndrome, so called patellar tendinopathy. It is a degenerative condition mostly located at the posterior aspect of the proximal patellar tendon where it inserts in the inferior pole of the patella (10, 24, 30, 31).

Patellar tendinopathy associated with symptoms including pain at the inferior pole of the patella that can result in performance impairment of the athletes. The point of tenderness is located in the tendon insertion into the patella (6, 9, 11, 29). Additional physical and sport activity can aggravate the symptoms, especially activities that require high demands on speed and power for the leg extensors (9-11). Patients with patellar tendinopathy should avoid exercise that generate excessive patellar tendon load, such as vigorous jumping, squatting, stair climbing and prolonged sitting or kneeling until all symptoms are resolved (9, 11, 26).

1.2 Patellofemoral syndrome (PFS)

The patella articulates with the patellofemoral groove in the femur. Several forces act on the patella to provide stability and keep it tracking properly (23, 32). A common misconception is that the patella only moves in an up-and-down direction. In fact, it also tilts and rotates, so there are various points of contact between the undersurface of the patella and the femoral trochlea (23, 33). Repetitive contact at any of these areas, sometimes is combined with maltracking of the patella, which causes by vastus medialis oblique (VMO) muscle weakness. The result is the classic presentation of retropatellar and peripatellar pain (6, 32, 34).

The reasons that cause a patella to be painful remain unknown. The patella subchondral bone contains many nerve endings, and pain can come from direct stimulation of substance P and calcitonin gene-related peptide fibers or from the resultant intraosseous pressure elevation or from both (35). Patella compression during loading with high joint reaction force (JRF) would lead to patella deformation, elevated articular pressure and pain (35). An increase in JRF is the direct cause of PFS, as well as tilt, maltracking, patella alta, patella infera, weak quadriceps, excessive jumping, and poor shock absorption in a hyperpronator can cause PFS by increasing relative JRF. This theory also has the advantage of explaining why lowering JRF decreases pain (35).

PFS is clinically characterized by peripatellar pain, increased by anything that increases patellofemoral JRF, such as running, jumping, climbing, and prolonged sitting (6, 32, 34, 35). The physical examination specific for PFS is the patella compression or grind test. It has also been called the pain provocation test (35). Patients should avoid any exercise that requires excessive frequent or deep bending of the knee, such as squatting, stair climbing (especially going down stairs) as well as sitting or kneeling in the bent knee position for long periods of time until the pain eases (14, 33, 35-37).

1.3 Osgood-Schlatter syndrome (OS)

This disease belongs to the juvenile idiopathic aseptic osteonecrosis group (6). It occurs typically in the children or teenagers that are very active in running and jumping, which is consistent with an extensor mechanism traction injury (23, 35). The site of injury is the tibial tubercle apophysis and the mechanism of injury repetitive traction by the patellar tendon (6, 23, 35). Originally, the Osgood-Schlatter lesion is thought to result from an avulsion of bone or cartilage in the tibial tuberosity. However, subsequent findings have indicated that most cases of OS are caused by micro-trauma in the deep fibers of the patellar tendon at its insertion on the tibial tuberosity (6, 23, 35). Nevertheless, avulsion may be present in some cases. The only inflammation occurs with acute exacerbations of the condition when there is new swelling and possible bursitis (35). The bony bumps that are the hallmark of chronic OS are caused by widening of the physis between the tibial tubercle apophysis and the anterior tibia. OS is a common risk factor for tibial tubercle avulsion fracture (35).

The symptoms including pain, focal swelling, and localized tenderness at the tibial tuberosity are typical in OS (22). There is more likely to be an enlarged, tender tubercle if the condition has been ongoing for several months. Frequently, the quadriceps is weak in combination with tight hamstrings (22). Patients should avoid sports or exercises that require excessive running, jumping, climbing, or kneeling until all symptoms are resolved (38).

1.4 Sinding–Larsen–Johansson syndrome (SLJS)

Sinding-Larsene-Johansson syndrome (SLJS) is a juvenile osteochondrosis (6). It is classified as an apophysitis and an enthesitis (35). SLJS closely related to OS. SLJS occurs in mainly young boys and is associated with excessive running and jumping (39). It affects the distal pole of the patella at the proximal insertion of the patellar tendon (6, 23, 39). Pathogenesis is similar to that of OS (which is indeed more frequent) that is caused by repetitive micro-trauma and excessive prolonged stress occurring on a specific skeletal region which is weak in both mechanical and biological components. The symptoms start to occur when stress exceeds intrinsic resistance (35, 39).

SLJS is clinically characterized by pain localized at the distal pole of the patella, increasing during flexion combined with loading of the knee joint (6, 35, 39). Palpation shows tenderness at the distal pole of the patella but not in the fat pad area or with patella compression. Some cases also have tenderness at the tibial tubercle. Other clinical features are swelling of the infrapatellar soft tissues and functional limitation (6, 23, 35). In addition, the hamstrings and quadriceps are usually tight and frequently weak as well (6). Similar to OS, patients with SLJS should avoid exercises that require excessive running, jumping, climbing, or kneeling until all symptoms are resolved (38).

1.5 Fat pad syndrome (FPS)

Also called Hoffa's syndrome, FPS is a common occurrence. The lateral and/or medial fat pads on either side of the patellar tendon are the pain generators. Microtrauma and synovitis commonly lead to fat pad enlargement, eventually causing a soft tissue impingement in the patellofemoral joint (35). Hoffa's fat pad is an intraarticular, but extrasynovial structure, that is richly vascularized and innervated (6, 23). This tissue is extremely sensitive and failure to appreciate fat pad enlargement and pain has probably led to the majority of failed treatments for anterior knee pain (23). Any type of inflammatory process can result in fat pad synovial hypertrophy. These include trauma, infection, rheumatoid arthritis and the inflammation that occurs with cartilage degeneration (23, 35). Chronic patellofemoral syndrome probably leads to fat pad syndrome (35).

FPS associated with symptoms including tenderness and/or swelling around the bottom and under the kneecap (6, 23, 35). In some cases the bottom of the kneecap may be tilted outwards due to swelling underneath. Hoffa's test is the test specific for FPS (35). Patients with FPS should avoid activities or exercises that require rapidly kicking the knee into full or hyperextension (38).

1.6 Iliotibial band (ITB) syndrome

Also called ITB friction syndrome, ITB syndrome is primarily a bursitis (35). Because of ITB tightness or overuse, the bursa between the ITB and tibia becomes inflamed (6, 35, 40). Over time, there can be an ITB tendinosis. ITB overuse is thought to occur with specific activities such as running downhill or if the gluteus maximus is otherwise being overworked (35, 40). The ITB is the distal tendinous insertion of the gluteus maximus and overuse of this structural unit leads to tendinosis similar to other tendinopathies. The gluteus maximus is forced to overwork in its role as a hip stabilizer when the other hip and core muscles are inadequate (35, 40).

The symptoms of ITB syndrome are pain that localized over lateral femoral condyle and swelling of the soft tissues. Pain may radiate toward the lateral joint line and proximal tibia. Palpation of the distal ITB, especially with the Ober's test, elicits tenderness and is diagnostic (6, 35, 40). Patients should avoid any vigorous exercises that places strain onto the ITB, for example excessive and repetitive downhill running or running on uneven surface, stair climbing, squatting and cycling (41).

2. Risk factors of knee pain

Risk factors of patellar tendinopathy, PFS, OS, SLJS, FPS, and ITB syndrome are classified as intrinsic and extrinsic factors (6, 11, 22, 28, 37).

2.1 Intrinsic factors

Several intrinsic factors such as biomechanical factors have been suggested as predisposing conditions for developing overuse injury. Faulty biomechanics can arise from functional as well as anatomical abnormality (11, 27, 33, 37).

Functional abnormalities can be divided into weakness and inflexibility categories (11, 27, 33, 37). Weakness of the quadriceps muscles may adversely affect the patellofemoral mechanism (14, 23, 33, 35). Vastus medialis oblique (VMO) weakness, the most often cited area of concern, allows the patella to track too far laterally (14, 33, 42, 43). Other muscles weakness such as hamstrings, calf, hip abductors, hip adductors, hip external rotators and lower abdominal muscles leads to fatigue-induced aberrant movement patterns that may alter forces acting on the knee (27, 37). For the inflexibility, hamstring tightness lead to place more posterior force on the knee, causing pressure between the patella and femur to increase (37). A tight ITB places excessive lateral force on the patella and can also externally rotate the tibia, upsetting the balance of the patellofemoral mechanism. This problem can lead to excessive lateral tracking of the patella (33, 37). Tight calf muscles can lead to compensatory foot pronation, as well as tight hamstrings can increase the posterior force on the knee (11, 14, 37). Tightness of hip external rotators results in compensatory foot pronation. Similarly, quadriceps and gluteal muscles tightness have the potential to restrict range of motion at the knee and ankle and are likely to increase the load on the knee (33, 34).

Anatomical abnormalities such as excessive range of pronation, pes planus, rigid cavus foot, poor dorsiflexion (e.g., due to anterior impingement syndrome), patellar hypermobility, tight band between iliotibial band and patella, hyperlaxity syndrome, coxa vara, femoral anteversion, and leg length discrepancy have been suggested to be linked to anterior knee pain as well as ITB syndrome (6, 11, 14, 22, 23, 28, 32, 34, 35, 37, 40).

2.2 Extrinsic factors

Extrinsic factors include training errors and environmental conditions. Anterior knee pain as well as ITB syndrome can be caused by training errors, such as excessive mileage, increased intensity of training, improper technique, or sudden changes in training, which seems to be predominant in acute injuries. Poor environmental conditions, improper equipment selection and unforgiving training surfaces have also been associated with overuse injury (6, 11, 14, 22, 23, 28, 32, 34, 35, 37, 40).

3. Treatments of knee pain

Treatments of patellar tendinopathy, PFS, OS, SLJS, FPS, and ITB syndrome are similar (9-11, 23, 35). These treatments include conservative and surgical approaches (11, 35). Because of the exact etiology and pathophysiology of knee pain are not well known, it is difficult to prescribe a proper treatment regimen (9, 11, 14, 44). So far, the given treatments are frequently based on empirical evidence and so recommended treatment strategies by different clinicians can vary greatly (9-11, 44).

For the conservative treatment, there are numerous treatment methods such as relative rest, electrophysical therapeutic modalities, taping and bracing or icing (9-11, 45). These treatment methods have generally been considered to be effective on minor to moderate symptoms of knee pain and add very little to the rehabilitation of chronic knee pain (13, 46). They have a role in managing knee pain when the athlete continues to train and play, however they will have a limited effect on long-term knee pain (11). Moreover, these treatments rarely offer long-term efficacy because recurrence rates are fairly high (9, 14). Rehabilitation of these knee problems is difficult and take a prolonged period of time. It requires discipline from the patient to adhere to an often long rehabilitation program (9). Therefore, rehabilitation outcome may be compromised by poor athlete compliance. Athletes can retard rehabilitation, as they may found long term compliance difficult, especially if their symptoms are mild. Similarly, slow progression in rehabilitation can limit athlete motivation (9, 14). Many researchers suggest that rehabilitation program is best achieved if patients experience the benefits attainable from exercise and patient education self-management interventions (15, 18).

4. Exercise for knee pain rehabilitation

Although difference conservative treatment approaches have been reported, exercise therapy is widely accepted and routinely applied as the main treatment method (10, 42, 43, 47). Exercise is an important factor in the prevention and rehabilitation of knee pain. Employing exercise therapy during knee pain rehabilitation has demonstrated beneficial, positive changes in pain severity, and functional disability. Moreover, it can lead to a faster return to function (8, 11, 42, 43).

Weight bearing exercises (closed kinetic chain exercise) are frequently employed during rehabilitation (11, 42, 43). They are more functional than non weight bearing exercises because they require multijoint movements, facilitating a functional pattern of muscle recruitment, and stimulate proprioceptors. Because of these advantages, clinicians often recommend weight bearing exercises in the rehabilitation for athletes with knee pain (11, 42, 43). The use of weight bearing exercises have been shown to be effective, both in short- and long-term outcomes, in decreasing anterior knee pain and enhancing functional performance (42, 43). Clinicians use these types of exercises to minimize anterior knee pain and muscle loss, strengthen hip and thigh musculature, enhance balance and stability, and minimize the risk of future recurrence (11, 14, 36, 42, 43).

There are several weight-bearing exercises are employed in rehabilitation program for patients with knee pain. Squats, lunges, and steps are commonly employed. These exercises are classified as eccentric exercise (11, 14, 36, 42, 43).

Lunges are common weight bearing exercises used by athletes to train the hip and thigh musculature. Therapists and trainers used lunges during patellofemoral rehabilitation for PFS patients to allow them to recover faster and return to function earlier (36). Like lunges, the use of step downs has been advocated in the patellofemoral rehabilitation (14, 43). It directly simulates the function of stair descent and provides excellent eccentric control training for the quadriceps (11, 14). Based on a recent study, Boling et al (43) used lunge and step downs as part of weight bearing exercises during 6 weeks of rehabilitation program for PFS patients. Patients performed the exercises 3 times a week, with 3 sets of 15 repetitions, for 6 weeks. The results indicated that this exercise program could significantly decrease pain and increase function in patients with PFS.

Squat is the eccentric exercise which has been commonly recommended in the treatment of patellar tendinopathy (46, 48). Squats can reduce pain and increase the return to sport in patients with patellar tendinopathy (8, 44). The researchers suggested that single leg decline squat exercises, which performed on a 25^{o} decline board could maximize load on the patellar tendon more than squats on a flat surface. Hence, decline squats could offer superior clinical outcomes compared to a squats on a flat surface (11). The recent studies (46-48) reported clinical improvements in athletes with patellar tendinopathy following 12 weeks of eccentric squat training performed on a 25^{o} decline board. These training programs consisted of three sets of 15 repetitions, performed twice a day, 7 days a week, for 12 weeks.

The eccentric exercise can be employed effectively using the Curwin-Stanish methods (8, 11). In this thesis study, the Curwin-Stanish protocol is introduced.

Curwin-Stanish protocol

Curwin and Stanish first proposed that eccentric exercise is an effective method of treating tendinopathy and since then there has been an increasing evidence to support the use of this approach (8, 11). The Curwin-Stanish protocol prescribed that the exercise program starts with warm-up and static stretching of the muscles such as quadriceps and hamstrings before the eccentric exercises. At the end of every training session, the same static stretch exercises as in warm-up phase are performed. Finally, the participants are instructed to use ice over the affected structures for 5 minutes at the end of each session (8).

For the other kind of exercises, the previous studies suggested that proprioceptive exercises should be included in late rehabilitation period (28). In addition, to restore maximal performance and minimize the risk of re-injury, strength as well as flexibility must be fully restored. Hence, plyometrics should be also added at the final phase of the rehabilitation (11, 28).

Plyometric exercise

Plyometrics refers to exercise that enables a muscle to reach maximum force in the shortest possible time (49). The muscle is loaded with an eccentric (lengthening) action, followed immediately by a concentric (shortening) action of the muscle and connective tissue (50, 51). Plyometric exercise includes activities such as jumping, landing, hopping, leaping, skipping, bounding, and galloping (51). Athlete trainers use plyometric training for developing the explosive power or speed-strength and ultimately improving performance. Previous studies showed that these exercises could improve leg strength, muscular power, joint awareness, and overall proprioception (49, 51, 52).

There are three phases that must be executed during performing plyometric exercise (52, 53). The first phase is the landing or eccentric phase. This phase consists of a rapid stretch that stimulates muscle spindles for the purpose of generating additional muscle contractions. Elastic energy is generated and stored in this phase. The second phase is the period of time from the beginning of the eccentric action to the beginning of the concentric action. This brief transition period from stretching to contracting is known as the amortization phase. This phase is the most important phase and must be kept in short duration. The longer the amortization phase the greater the loss of stored elastic energy. Hence, the subsequent muscle contraction will be more powerful if this phase is shorter. Likewise, the subsequent muscle contraction will be less powerful if this phase is longer. The last phase is the take off or concentric phase, which follows the eccentric phase. The stored elastic energy is used to increase jump height and explosive power during this phase. This sequence of three phases is called the stretch-shortening cycle (SSC) (51, 52, 54).

As weightlifting requires explosive movement in the execution of all lifts, especially in the legs and hips, plyometric training is also an important tool (51, 52). Similar to other athletes, exercises included in a plyometric training program for weightlifters should reflect the concept of specificity. This includes both velocity and direction of movement, and specific muscle groups (51). The plyometric drills that are classified as closed kinetic chain exercises category such as squat jump, single and double-leg hop, box jump, and skipping should be considered (49-51, 55).

5. Knee educational program

'Knee educational program' or 'knee school program' is an educational program for individuals with knee pain (15, 16, 18-20). In this thesis study as well as the previous studies, the operational definition of 'the knee educational program' is a combination of both theoretical and practical lessons, as well as exercises training and self-management program (15, 16, 20). Lessons are given to groups of participants or individual person and are led by the physiotherapist or health professions. Lessons may last for many minutes, a few hours on one day, or several hours over a period of months (15, 16, 20). It is designed to assist patient to effectively manage their condition, by teaching them how to cope with their symptoms, including the physical and psychological consequences of living with their conditions (15, 16, 18-20). In osteoarthritis condition, various models of knee educational program have been employed. Thus, the contents of knee educational program can vary widely. However, the concepts of knee educational program are similar. It includes education, self management and exercise program (15, 16, 18-20). The goals of the program are to reduce pain, improve physical function and increase general well-being (15, 16, 18-20). A psychosocial theory approach incorporating goal setting, problem solving and cognitive techniques was adopted to improve self-efficacy and facilitate long-term change in behavior (15, 16, 18). Participants were encouraged to include exercise and effective pain management as well as specific information learned during the sessions. The physiotherapists can provide support and specific feedback for any problems that were encountered (15).

There are little studies that investigated the effectiveness of knee educational program especially for athlete populations. Moreover, these studies are only limited in the osteoarthritis of the knees. Based on a few recent studies (15, 18), the literatures indicated that knee educational program could lead to the improvement in pain and physical function, and health status in patients with osteoarthritis of the knee. Hurley et al (18) investigated effectiveness of knee educational program for patients with chronic knee pain such as osteoarthritis of knee. The knee educational program that was added to the usual primary care consists of progressive exercise regimen, patient education, self-management, and active coping strategies. Participants attended 12 supervised sessions (twice weekly for 6 weeks) of knee educational program. The result showed that knee educational program could improve functioning, pain and health status for up to 6 months. Similarly, Colemen et al (15) studied the effectiveness of knee educational program for individuals with osteoarthritis of knee. Groups of 8–10 participants attended 6 education sessions (one 2.5-hour session per week). The results showed that improvements in pain, physical function and mental health were demonstrated from baseline to 12 months. In summary, the results of these studies indicated that knee educational program can lead to the improvement in pain, physical functional and health status in patients with osteoarthritis of the knee.

To date, there has no research evidence determining the effects of knee educational program for management of knee pain in athletes, especially in high risk population such as weightlifters. The present study was planned to develop and evaluate a potential knee educational program which could be part of management program for Thai national weightlifters with knee pain. Furthermore, this developed knee educational program would be able to apply to junior weightlifters and other athletes, who encountered with knee pain.