Abstract

Osteoarthritis (OA) is the most common musculoskeletal disorder worldwide. Knee and hip joints are most commonly affected by OA, and their impact on public health is remarkable. The effects of OA on an individual are also considerable. The symptoms of OA, such as pain and stiffness of the joints and muscle weakness, are serious risk factors for mobility limitation and impaired quality of life. Nowadays, there is growing evidence that proper muscle function is an important factor in the aetiopathogenesis of OA. This mini-review deals with the role of muscles in hip and knee OA. Because the neuromuscular system allows finely controlled movements, provides functional joint stability and gives sensory information about limb position and movements, the role of proprioception and muscle function during locomotion is also discussed. Finally, some clinical implications are presented. Knowledge about the mechanical aspects of the aetiopathogenesis of OA could give us clues to help prevent this disease.

Keywords

Osteoarthritis, knee, hip, muscle strength, biomechanics, locomotion, postural balance

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The hip and knee are two of the joints most commonly affected by osteoarthritis (OA). The symptoms of OA, such as pain and stiffness of the joints, restrict ability to move and reduce quality of life. The exact cause of OA remains a mystery and little is known about how to prevent the disease or slow its progression. However, it has been speculated that proper muscle structure and function is beneficial in preventing the symptoms and progression of this disease.1–3 Several reviews have concluded that exercise therapy can benefit patients with OA of the knee and hip.4–7 This mini-review surveys the scientific evidence supporting the important role of muscles in hip and knee OA.

Muscle Structure

We have reported that patients with hip OA did not display a lower cross-sectional area (CSA) of pelvic and thigh muscles compared with healthy age- and sex-matched controls using magnetic resonance imaging (MRI)8 (see Figure 1). However, in OA subjects the CSA of the pelvic and thigh muscles was significantly lower (6–13%) in the more severely affected hip compared with the hip on the better side. Similarly, Grimaldi et al. stated that the lower portion of the gluteus maximus muscle demonstrated atrophy around the affected hip in subjects with advanced hip OA pathology.9 Using computed tomography (CT), Rasch et al. noted that muscle CSA values of hip extensors, flexors, adductors and knee extensors and flexors, but not hip abductors, were reduced by 11–19% in the affected hip relative to the healthy limb.10

Histological evaluations have indicated that the extent of gluteus medius muscle atrophy correlates with the pain score in hip OA.11 In hip OA, there is selective atrophy of type II muscle fibres in comparison with the situation in healthy subjects.12

There are few studies available in which the muscle composition in patients suffering from knee OA has been examined. Petterson et al. used MRI to measure lean muscle and fat CSA.13 They found that the more affected limb exhibited a smaller lean muscle CSA. Lean muscle CSA explained 41% of the variance in the contralateral limb’s maximal voluntary isometric contraction compared with 27% in the OA limb. The authors concluded that both reduced voluntary muscle activation level and lean muscle CSA contribute to muscle weakness in persons with severe knee OA.

Recently, we have shown with ultrasonography that there is a significant difference in quadriceps femoris muscle (QFm) composition between men with knee OA and healthy age-matched controls14 (see Figure 2). Although there were no significant differences between the groups in absolute muscle thickness and muscle area, the rectus femoris and vastus intermedius muscle compartments of the QFm exhibited significantly more heterogeneity in the knee OA group compared with the controls. The reduced homogeneity of muscles refers to increased fat and connective tissue content, visualised by increased echogenicity in ultrasonography.

Muscle Strength

Adequate muscle strength seems to be an important factor in the maintenance of capabilities to perform activities of daily living in hip and knee OA.15–19 Many authors have concluded that patients...
suffering from knee and hip OA exhibit decreased strength in their pelvic and QF muscles.1,8,10,20–24 Recently, we used maximal voluntary isometric knee extension and flexion tests to demonstrate that knee OA subjects have significantly lower knee extension and flexion isometric torques than corresponding age-matched healthy controls14 (see Figure 3). Knee extension or flexion torques did not diverge between knee OA severity subgroups, but the knee extension torque exhibited a significant negative linear trend as the severity of knee OA increased.

Several mechanisms have been proposed to be involved in muscle weakness in OA:

- disuse atrophy of the muscles due to joint pain25,26
- reflex inhibition of muscles moving the affected joint;8,25–27 and
- inability to fully activate the muscle resulting in the decreased force production23,28,29

Knee joint laxity is also associated with a decrease in the magnitude of the relationship between strength and physical function in knee OA.30 Assessment of weakness in the QFm has been shown to be a better determinant of pain and disability than radiographic changes in knee OA.29–32 However, the ultimate mechanism behind the muscle weakness in knee OA is not fully understood.

It has been claimed that a strong muscular system may prevent the initiation and progression of OA, because it has been shown that reduced quadriceps strength relative to bodyweight may be a risk factor for knee OA in women.1,2 However, QFm strength may be a significant risk factor for radiographic progression of knee OA in malaligned and lax knees; in other words, strength training may evoke damage in at-risk OA knee joints.34

**Figure 1: Magnetic Resonance Image Assessment of the Cross-sectional Area of the Pelvic and Thigh Muscles**

**Figure 2: A Method for Determining Muscle Thickness and Echogenicity from the Rectus Femoris and Vastus Intermedius of the Quadriceps Femoris Muscle**

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**Proprioception and Standing Balance**

The neuromuscular system (NMS) allows finely controlled movements, provides functional joint stability and gives sensory information about limb position and movements, which constitute the neuromuscular protective mechanisms that minimise adverse loading during locomotion and prevent joint damage. The sensorimotor dysfunction that may occur due to ageing could play a significant role in the pathogenesis and/or progression of hip and knee OA through the impairment in NMS-protective mechanisms, although there is a general assumption that joint damage precedes pain, disability and muscle weakness.35

Muscle spindles, joint receptors and Golgi tendon organs are proprioceptors, providing information about the position and movement of the joint. If the sensitivity of proprioceptors is diminished, their ability to detect and transfer information to the central nervous system (CNS) will be impaired. As a consequence, the
The precision of the proprioceptive system declines. Muscle fatigue, ageing, knee joint hypermobility and effusion have all been reported to affect the optimal function of the proprioceptive system. Furthermore, the function of the proprioceptive system may have become impaired in patients with knee OA.

Joint reposition sense could also be diminished in the asymptomatic limb. This could partially explain why patients with unilateral knee OA usually develop bilateral joint degeneration. However, there are too few studies available to draw any firm conclusions about whether the impaired proprioceptive system is the cause and/or a consequence of the pathogenesis in knee OA.

Degenerative changes in the knee joint are also thought to increase postural sway. According to most previous clinical studies, patients with knee OA have impaired postural control. Hassan et al. concluded that the severity of knee pain is one explanatory factor for the variation in sway in knee OA patients. Masui et al. in turn reported that the grade of radiographic knee OA plays a significant role in increasing postural sway, but that joint pain has no effect on the extent of postural sway.

However, in contrast to the above-mentioned studies, Arokoski et al. found that there is no significant difference in postural stability between those patients suffering from hip OA and their healthy controls.

Muscle Activity During Locomotion

Motor and sensory functions are not separate but, in fact, are closely interlinked. For example, at heel strike during walking, the proprioceptive system gives information about lower-limb movement, position and loading. Through a complex system of voluntary contractions and reflexes, the muscle not only ensures appropriate movements but also provides joint stability and shock absorption. In particular, the proper function of the QFm may protect the knee joint from potentially adverse impulsive loading.

The activity of the muscles can be studied directly by surface electromyography (EMG). EMG has been widely utilised in the investigation of normal and pathological walking and it is an important part of movement analysis, because joint movement analysis does not reveal the active muscles taking part in force production during the gait cycle. Figure 4 illustrates the typical QFm activation pattern occurring during the gait cycle.

There seem to be different muscle activity patterns in knee OA and healthy subjects. Childs et al. showed that the muscle activity of the vastus lateralis, medial hamstrings, tibialis anterior and medial gastrocnemius were approximately 1.5 times longer than the same muscles in control subjects. On the other hand, subjects with knee OA exhibited delayed onset of vastus lateralis activity during stair descent. The changes in the patterns of muscle activity seem to be also associated with differences in the severity of knee OA.

Clinical Implications

The goals of OA treatment with exercise are to reduce pain, to increase walking distance and to improve functional status, i.e.
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to maintain or increase joint mobility and muscle strength and to improve general physical fitness. The above results highlight the effects of muscle strength and correct neuromuscular function when considering the appropriate knee and hip OA treatment policy. However, no optimal exercise regimen (intensity, frequency, progression) has yet been determined and no clear differences have been detected between different types of exercise programmes in OA, this is a subject that requires further research.