Evaluation of Muscle Activity just after Straight Leg Raising Exercise by using $^{18}$FDG-PET

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Background

- Knee osteoarthritis (KOA) is one of the major disorders that causes locomotive syndrome and is known to impair the motor function and decrease the movement function.
- Exercise therapy is a method that can treat and prevent the onset of KOA in a non-invasive manner.
- One of the primary types of exercise therapy includes strengthening the quadriceps femoris muscles.
- Straight leg raising (SLR) has been recommended by several reports as a home exercise method for strengthening the quadriceps femoris muscles.

Exercises for knee pain

Toning the quadriceps (the muscles at the front of the thigh)

- **Performed lying face upward**
  Lie facing upward with one knee bent at least 90 degrees. Slowly raise the foot of the other leg 10 cm off the floor with the knee straight. Hold for 5 seconds, then slowly lower it. Once it's back on the floor, rest for 2-3 seconds. Repeat with the other leg.

- **Performed sitting on a chair**
  Sit on the edge of a tall chair while holding on to the sides. Keep one foot on the floor and position the other leg with the ankle at a 90-degree angle and the knee straight. Maintaining that position, raise the heel 10 cm off the floor and hold for 5 seconds. Then slowly lower it. Once it's back on the floor, rest for 2-3 seconds. Repeat with the other leg.

Do at least two sets of twenty of either exercise per day.

SOURCE: Japanese Knee Osteoarthritis Measure (JKOM)

SLR

- SLR has been reported that the lever arm between the hip joint and the ankle is approximately twice the lever arm between the knee and the ankle.
- We hypothesized that this exercise acts primarily on the muscles surrounding the hip joint.

PET was performed after SLR to determine which muscle in the lower limb had increased glucose metabolism and increased activity due to SLR.

- FDG-PET (PET) can examine cellular glucose metabolism, several authors have used this technique to determine muscle metabolism during exercise.
- It has been reported that glucose metabolism determined through PET is correlated with the intensity of muscle activity, and that the muscle activity can be assessed by evaluating glucose metabolism in muscle.

PET was performed after SLR to determine which muscle in the lower limb had increased glucose metabolism and increased activity due to SLR.
Materials and methods

Materials

- Healthy adult male volunteers participated in this study.
- 14 lower limbs of 7 men (mean age: 31.3 ± 2.2 years) were ultimately analyzed in this study.

Methods

- Participants were placed in a recumbent resting position for 20 min before FDG injection.
- Following FDG injection, they were asked to perform SLR for 20 min.
- They rested again in a recumbent position for 30 min, and PET/CT scans were subsequently taken.
PET/CT examination was used to measure the SUVmax of each muscle in cross-sections of the trunk (superior margin of the sacrum), pelvis (superior margin of the acetabulum), thigh (midpoint between the inferior margin of the femoral lesser trochanter and femoral condyle), and lower leg (proximal third).
SUVmax was significantly greater in IL, PS, GMed, GMin, and Add compared to most of the other muscles.

The primary actions of these muscles are: hip flexion for IL and PS; hip abduction for GMed and GMin; and hip adduction for Add. This signifies that SLR may primarily be training hip flexion, abduction, and adduction.

The SUVmax of the shaded muscle was significantly greater.
Discussion

SLR has been reported that the lever arm between the hip joint and the ankle is approximately twice the lever arm between the knee and the ankle.
Wessel et al. Physiotherapy Canada. 1994

This present results also showed that the hip flexion muscles had high SUVmax values. Metabolism of the abductor and adductor muscles of the hip was also elevated, indicating that there may indeed be involvement of the lever arm.

SLR may have greater significance as a hip flexion exercise than as a quadriceps femoris muscle strengthening exercise.

Discussion

Why does SLR have a beneficial effect in patients with KOA?

Varus deformity and thrust are mechanical factors that contribute to the onset and progression of KOA. Decreased hip adductor muscle strength is associated with varus deformity in medial compartmental osteoarthritis of the knee.


Strengthening the hip abductor and adductor muscles improved symptoms in KOA patient. Hip abductor is important in gait, and strengthening the abductor has been described to improve abnormal gait and to stabilize gait.


The muscles surrounding the hip may improve thrust or varus in patients with KOA and stabilize their gait, ultimately contributing to the treatment of KOA.
Limitations

- The SUVmax of each muscle was measured in four cross-sections.
- While there are reports claiming that glucose metabolism determined through PET is correlated to the intensity of muscle activity, there are no reports that longitudinally investigated whether elevated glucose metabolism observed on PET is associated with muscle strengthening.
- The subject of this study was adult male volunteers. KOA is more common among middle-aged and elderly women.
- In this study, SLR was performed in the supine position. Other muscles might have been stimulated if SLR had been performed in a different position.
Conclusion

- Glucose metabolism was increased especially in IL, PS, GMed, GMin, and Add after SLR was performed by healthy adult male volunteers, signifying a potential increase in the activities of these muscles.

- It is therefore plausible that SLR increases the activity of muscles primarily involved in hip adduction, abduction, and flexion, thereby having a beneficial effect in the treatment of KOA.
References