

# Relationship between weight-bearing patterns, contact force on the patellofemoral joint, and quadriceps muscle force during walking

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## Summary

Mechanical stress, such as the contact force on a joint, is an important factor in the onset and progression of osteoarthritis (OA). The contact force of the patellofemoral (PF) joint during walking is presumed to be related to the movement of the knee joint in the sagittal plane. In this study, the contact force of the PF joint, the quadriceps muscle force, and knee joint flexion angle were measured under three conditions: normal, forefoot, and rearfoot weight-bearing walking. The results showed that the PF joint contact force and the rectus femoris muscle force during rearfoot weight-bearing walking were significantly higher than those during normal and forefoot weight-bearing walking. These results may explain the characteristics of gait form and its influence on OA-related changes in the PF joint among individuals with knee OA.

## Introduction

Mechanical stress, such as contact force on the joint, is an important factor related to the onset and progression of OA [1], and this also applies to the PF joint. The contact force in the PF joint during walking is believed to be related to knee joint movement in the sagittal plane and the muscle force of the quadriceps attached to the patella. Therefore, this study aimed to investigate the relationship between weight-bearing patterns and contact force in the PF joint, quadriceps muscle force, and knee flexion angle during walking.

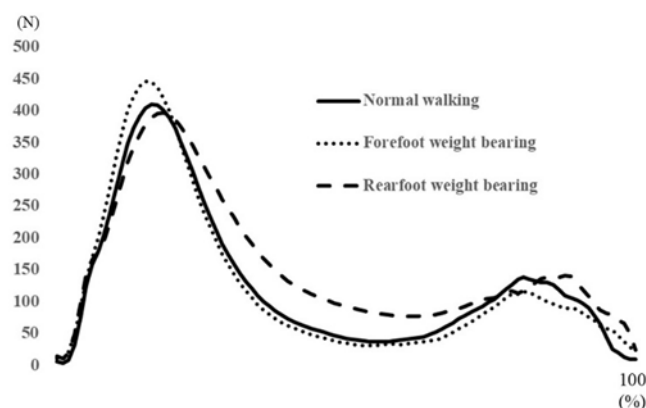
## Methods

Participants were 20 healthy individuals (mean age, 23.2±3.9 years; 14 women). The experimental task involved 10-m walking at a comfortable speed. The participants performed three tasks: normal, forefoot and rearfoot weight-bearing walking. The three conditions were applied in random order. The motion of the lower limbs during walking was measured using a three-dimensional (3D) motion analyser. The ground reaction force (GRF) was recorded using a force plate installed at the centre of the 10-m walkway. For each condition, the GRF was measured until three successful trials were completed. The contact force on the PF joint and knee joint muscle force were calculated using data obtained from the 3D motion analyser and GRF through musculoskeletal simulation analysis software (OpenSim3.3). Contact force and muscle force during the stance phase on both sides were analysed. The point at which the vertical component of the GRF exceeded 10 N was defined as heel contact. The mean contact force on the PF joint, the quadriceps muscle force, and knee flexion angle across three trials for the three conditions were calculated and compared among the three conditions

using a repeated one-way analysis of variance with a post-hoc test. A p-value of < 0.05 was considered statistically significant. This study was approved by the local ethics committee (R5-11). All participants provided written informed consent prior to participation.

## Results and Discussion

The mean contact force of the PF joint during rearfoot weight-bearing (153.4±77.9 N) was significantly higher than during forefoot weight-bearing (123.9±59.7 N) and normal walking (126.4±66.8 N) (Figure 1). Muscle force of the rectus femoris during rearfoot weight-bearing (148.4±92.1 N) was significantly larger than during forefoot weight-bearing (93.5±63.7 N) and normal walking (104.9±73.7 N).



**Figure 1:** Contact force of the patellofemoral joint during stance phase

These results provide insights into the characteristics of gait form and its influence on OA-related changes in the PF joint in individuals with knee OA. Individuals with knee OA often cannot bear weight on their forefeet [2]. Rearfoot weight-bearing may cause excessive loading on the PF joint during the stance phase in individuals with knee OA.

## Conclusions

The results of this study indicate that the contact force of the PF joint throughout the stance phase is higher during rearfoot bearing than during forefoot weight-bearing and normal walking.

## References

- [1] Felson DT. (2013). *Osteoarthritis Cartilage*, **21**: 10-15.
- [2] Saito I et al. (2013). *Arch Phys Med Rehabil*, **94**: 2502-2508.