

THE EFFECTS OF FLAT FOOT ON GROUND REACTION FORCE AND LOWER EXTREMITY JOINT ANGLES WHILE SQUATTING

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INTRODUCTION

A normal foot arch is a critical adaptation around which the human body is built to provide proper body weight distribution over the foot. The lack of a normal arch can have many adverse effects on the human body, such as anterior knee pain, intermittent low back pain [1], or postural instability [2]. Flat foot was reported in 26.2% of a population of middle-aged and older adults, affecting their normal daily activities [3]. The effects of flat foot is not well researched during exercise, such as squatting. Therefore, the purpose of this pilot study is to describe how flat foot affects the force distribution over the ground and joint angle changes while performing squats.

METHODS

A total of eight participants were recruited for this study. Participants were assigned to one of the two groups: Participants that presented flexible flat feet, defined as the disappearance of the arch upon standing, were assigned to the flat footed group (FF), while participants with a normal arch, defined as the presence of arch upon standing, were assigned to the normal arch group (N). Both group participants had 2 years of squatting experience. Participants signed an approved informed consent form before participation. Participants were asked to use spandex attire and 27 reflective markers on the lower body. Once marked, the participants were asked to perform 10 body-weight-squats. Participants were instructed to stand with a width of 1.5x hip-width and with the toes straight forward, placing one foot over each force plate (AMTI). Motion analysis data was captured using 10 infrared cameras (Qualisys motion system), and data analysis was performed using Kwon 3D 5.1 motion analysis software. Ground reaction force (GRF) and lower body joint angles in the sagittal and frontal planes were measured. GRF values were multiplied by 100 for easier reporting and interpretation.

RESULTS AND DISCUSSION

The FF group showed a reduced peak vertical force, more centralized anteroposterior force, and reduced medial force compared to the N group. Interestingly, the right foot of the N group showed a more anterior force, while the left showed a more posterior force. Unexpected differences were seen in the mediolateral force, where the FF group produced an average peak medial force of 7.8 ± 1.7 %BW for both limbs. However, in the N group, the maximum medial force produced was 8.6 ± 2.3 %BW (Figure 1).

The FF group showed increased hip abduction and knee valgus, and decreased ankle eversion. For the ankle joint, the N group showed peak eversion angle of 19.5 ± 3.9 deg, while the FF group had a maximal eversion angle of 26.8 ± 8.9 deg (Figure 2).

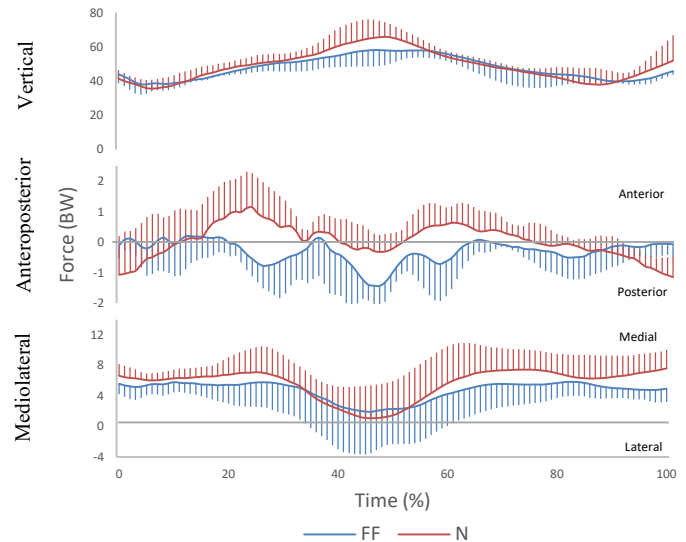


Figure 1: Normalized averaged ground reaction force of the right foot. Time is normalized to percentage of the squat motion.

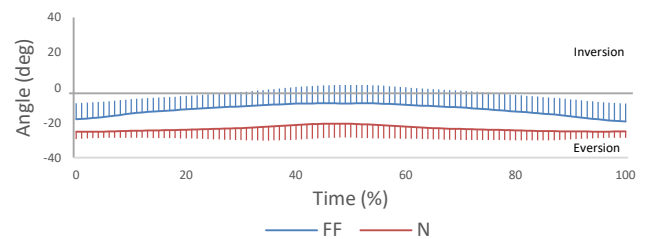


Figure 2: Average ankle eversion/inversion angles. Time is normalized to percentage of the squat motion.

Symmetry was found between limbs in relation to orientation joint angles, but in relation to forces, the N group on average exerted forces more medially than the FF group. It was expected that the foot arch in the N group would allow forces to spread more laterally and the lack of arch in the FF group would exert more medial force. What we saw is that the FF group on average maintained similar force with a more neutral exertion at the lowest position of the squat. A possible explanation for this discrepancy is that since the flat footed participants are all experienced squatters, they could have possibly overcorrected for the lack of an arch, maintaining a more neutral ankle angle in the frontal plane, but affecting joint angles of the knee and hip.

SIGNIFICANCE

This research study can help educate flat footed people who squat regularly on how their squatting motion may be altered by flat feet, in order to reduce potential injuries in this population.

REFERENCES

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