

GAIT STYLE AFFECTS EXTERNAL KNEE ADDUCTION MOMENT

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INTRODUCTION

The adduction moment has been shown to play an important role in the outcome of surgical treatment, such as high tibial osteotomy (HTO), for medial compartment knee osteoarthritis (Prodromos 1985). The HTO has been shown to reduce the adduction moment during walking, redistributing load from the arthritic compartment to the more normal compartment. In addition, braces have been shown to reduce the adduction moment during walking (Lindenfeld 1997).

Foot position (Wang 1990) and reduced walking speed (Stauffer 1977) have been suggested as methods to reduce the adduction moment during walking. The results of these studies suggest that a reduction in the adduction moment achieved through gait retraining could be an effective and efficient method of treatment for OA. The purpose of this study was to test the relationships between the adduction moment with walking speed and the relationship of the adduction moment with foot position (toe out angle).

MATERIALS AND METHODS

Fifteen healthy subjects (age: 33.9 ± 5.3 yrs, hgt: 171.6 ± 6.7 cm, wgt: 647.8 ± 112.7 N, 6F) were recruited for this study. All subjects signed an IRB approved informed consent. A previously described method was used to calculate kinematic and kinetic variables from gait analysis (Andriacchi 1997). Moments were normalized to percent

body weight times height ($\%BW \times Ht$)(Prodromos 1985).

The subjects performed level walking using five different gait styles: normal speed, slow speed, fast speed, normal speed with intentional toe in, and normal speed with intentional toe out. Each gait style was performed three times and the average of these three trials was used for analysis. The first and second peaks of the adduction moment, walking speed, and toe out angle in each gait style were compared with normal walking speed by using Student's paired t-test ($\alpha < 0.01$). Multiple regression analyses were used to test for an association between the toe out angle and the first peak adduction moment and between the toe out angle and the second peak adduction moment.

RESULTS

During normal walking, the average speed was 1.29 ± 0.11 m/sec, toe out angle was 19.5 ± 7.4 degree, the first peak of the adduction moment was 2.73 ± 0.64 $\%BW \times Ht$, and the second peak was 2.27 ± 0.76 $\%BW \times Ht$. When the walking speed decreased, there were no significant differences with normal speed. When the walking speed increased, the first peak of the adduction moment was increased to 3.14 ± 1.03 $\%BW \times Ht$. The walking speed was not significantly different from normal when subjects walk with toe-in and toe-out styles. The first peak of the adduction moment was significantly lower than normal ($p < 0.01$) when subjects used a toe-in style. The toe-out style showed a significantly higher first

peak adduction moment and lower second peak adduction moment than normal ($p < 0.01$) (Table 1). Figure 1 shows the correlation between toe out angle and first peak adduction moment and between toe out angle and second peak adduction moment. Although there was a significant correlation between toe out angle and first peak adduction moment ($R = 0.740$, $p < 0.01$), there was an inverse correlation between toe out angle and second peak adduction moment ($R = -0.704$, $p < 0.01$). Toe out angle at the cross point of each trend line was 12.4 degree, which is lower than normal (19.5 degree).

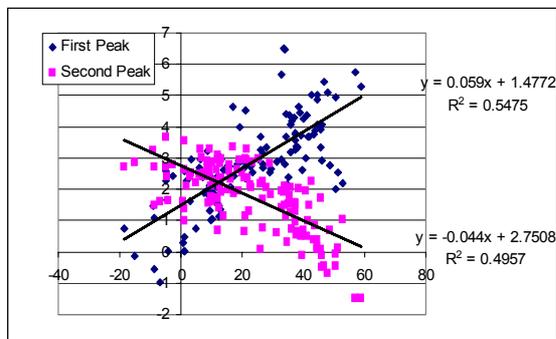


Figure 1: First peak increased but second peak decreased as toe out angle increased.

DISCUSSION

It is important for knee OA patients to reduce their adduction moment in order to slow or prevent the progression of OA. In the present study, it was shown that adduction moment was not reduced if gait speed was reduced. Some authors have

reported that adduction moment decreased as toe out angle increased (Wang 1990), with the implication that toe out gait was able to reduce adduction moment during walking. However, our present results show that first peak adduction moment increased as toe out angle increases. Therefore, if the goal is to reduce both the first and second peak of the adduction moment a slight toe in gait would be better to reduce the total adduction moment sustained during the walking cycle, since the toe out angle at which both first and second adduction moment were equally low was 12.4 degree during walking.

Reducing gait speed is not necessary to decrease adduction moment during walking. An ideal toe out angle to reduce adduction moment is 12.4 degree, which is a slightly more toed-in than normal.

REFERENCES

- Andriacchi, T.P. et al. (1997). *Basic Orthopaedic Biomechanics*, 2nd Ed., Lippincot-Raven, 37-68.
- Lindenfeld T.N. et al. (1997). *Clin Orthop*, **344**, 290-297.
- Prodromos C.C. et al. (1985). *J Bone Joint Surg [Am]*, **67**, 1188-1194.
- Stauffer R.N. et al. (1977). *Clin Orthop*, **126**, 246-255.
- Wang, J-W. et al. (1990). *J Bone Joint Surg [Am]*, **72**, 905-909.

Table 1: Values are compared with those of normal control walking ($*p < 0.01$) (Mean \pm SD).

	Walking Speed (m/sec)	Toe Out Angle (degree)	First Peak (%BW \times H)	Second Peak (%BW \times H)
Normal Control	1.29 \pm 0.11	19.5 \pm 7.4	2.73 \pm 0.64	2.27 \pm 0.76
Slow Speed	* 0.94 \pm 0.09	18.9 \pm 7.5	2.74 \pm 0.52	2.29 \pm 0.64
Fast Speed	* 1.69 \pm 0.21	19.1 \pm 6.3	* 3.14 \pm 1.03	2.25 \pm 0.81
Toe In Walking	1.24 \pm 0.14	* 4.10 \pm 8.2	* 1.57 \pm 1.00	2.29 \pm 0.67
Toe Out Walking	1.26 \pm 0.14	* 40.5 \pm 5.6	* 3.87 \pm 1.04	* 0.98 \pm 0.79