Knee Flexion/Extension Moment during Slope Walking in Unilateral Knee Osteoarthritis Patients

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Introduction

Knee osteoarthritis (KOA) is a disease that affects the entire articular tissue and is one of the major causes of chronic pain and disability in the elderly. Patients suffer from pain, stiffness, reduced joint movement, muscle weakness, and gait dysfunction. Slopes are one of the most significant environmental barriers for KOA patients [1], but they are also recommended as a part of rehabilitation approaches [2]. Therefore, research on gait adaptation in KOA patients during slope walking will provide new insights into locomotion control and rehabilitation strategies.

Methods

The slope environment was constructed using aluminum profiles with wooden boards on the surface of the walkway for walking. A force plate was mounted horizontally at the center of the 3.8 m walkway [3]. Nineteen retroreflective markers were placed on the lower limbs according to the modified Helen Hayes Marker Set. Subjects were asked to walk on the walkway for five practice trials and three self-paced walking trials on a level (0°) walkway. Then, the remaining six gradients (+9°, +6°, +3°, -3°, -6°, -9°) were tested in a block-randomized order.

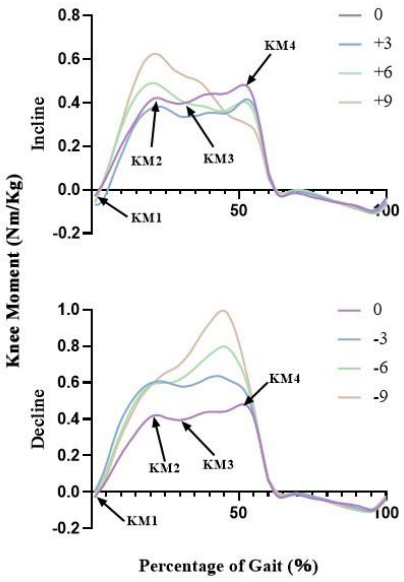

Figure 1: Standardized knee joint moment curve with different slope angles in one gait cycle.

Kinematic and kinetic data were recorded using six motion cameras and a force plate at Beijing Luhe Hospital. Joint moments were calculated and normalized to body mass. Points of interest (POI) were defined as follows: KM1/2, KM3, KM4 (Maximum knee flexion/extension moment at the beginning of the support phase, Moment at 50% of the support phase of the knee joint, Maximum knee extension moment at the end of the support phase). A repeated-measures one-way ANOVA ($p \leqslant 0.05$) was used to determine if the measures were affected by the slope manipulation. Pairwise comparisons were conducted using Dunnett's post hoc test.

Results and Discussion

The results for the knee joint are shown in Table 1 and Figure 1. Slope angles significantly affected the moments at KM1, KM2, KM3, and KM4 ($p<0.01$).

Table1: Means (SD) of POI of knee joint with different slope angles, bold indicated significant difference compared to level.

KM	Gradient (degree)						
	-9	-6	-3	0	**3**	6	9
1	-0.009	-0.006	-0.001	-0.036	**-0.079**	-0.059	-0.065
	(0.046)	(0.047)	(0.061)	(0.037)	(0.041)	(0.039)	(0.056)
2	0.607	**0.606**	**0.619**	0.430	0.402	0.508	**0.641**
	(0.238)	(0.186)	(0.131)	(0.169)	(0.180)	(0.158)	(0.266)
3	0.629	**0.599**	**0.608**	0.421	0.381	0.479	0.618
	(0.246)	(0.196)	(0.134)	(0.175)	(0.206)	(0.153)	(0.266)
4	**1.076**	**0.876**	0.744	0.625	0.571	0.554	0.622
	(0.218)	(0.171)	(0.153)	(0.149)	(0.229)	(0.183)	(0.237)

When incline walking, KM2, KM3, and KM4 tended to decrease until the slope reached 9 °, KM2 increased significantly, indicated that incline uphill at moderate slopes requires less knee moment. When decline walking, each gradient leads to increasing knee moment. Tibio-Femoral Contact Force is proportional to the net external moment. Therefore, our results recommend avoiding steep inclines or decline walking in patients' rehabilitation and daily activities. Further study of contact force by finite element method will clarify the application of slope to rehabilitation for KOA patients.

Conclusions

Patients with KOA should avoid steep inclines or decline walking during rehabilitation and in daily activities.

References

[1] Merja R et al. (2017) *BMJ open* , **7(6)**: e012826.
[2] Whitney M (2008). *J Orthop Sports Phys Ther*, **38(5)**: 246-256.
[3] Zihan Y (2019). *J BIOMECH*, **92**: 35-44.