

Effects of Asymmetric Crank Arm Adjustment on Hip Biomechanics for Patients Post Total Knee Arthroplasty

Zhang, S.¹, Menke, W.¹, Ovispo-Martinez, A.¹, Lu, T.¹, Stevens, K.², Cates, H.²

¹Biomechanics and Sports Medicine Laboratory, The University of Tennessee Knoxville, Knoxville, TN, USA

²Tennessee Orthopaedic Alliance, Knoxville, TN, USA

Email: szhang@utk.edu

Summary

Asymmetrical shortening of crank arm lengths reduced hip range of motion (ROM) for the replaced limb of patients with total knee arthroplasty (TKA) without increasing hip extension moment. This finding provides support for the potential benefits of using asymmetrically shortened crank arms in early rehabilitation for this patient group.

Introduction

During early rehabilitation, patients with TKA often face challenges in weight bearing exercises (e.g., walking) and even in stationary cycling due to pain and reduced knee range of motion (ROM) [1]. Cycling modifications with crank arm shortenings may offer a potential method to accommodate the decreased ROM and physical requirements of cycling, allowing for earlier implementation of rehabilitative exercise for the patient group. It is not clear how such modifications would impact the hip joint during cycling. Therefore, the purpose of this study was to investigate the kinematic and kinetic changes of asymmetric crank arm shortening in early-stage TKA patients in stationary cycling.

Methods

Participants (2 males, 2 females, age:65±7 yrs., BMI:35±1.16) were patients of TKA from a local orthopaedic clinic who were 1-2 months after receiving TKA surgery. Stationary cycling on an Excalibur+Sport cycle ergometer (Lode BV, Groningen, The Netherlands) was used with 3D instrumented pedals (1200Hz, Kistler) with adjustable crank arm lengths. Participants cycled in five conditions with crank arm lengths (mm) adjusted for the replaced/non-replaced limbs: C1 (140/170), C2 (155/170), C3 (170/170), C4 (155/155), C5 (140/140). Each cycling condition was performed at 70 Watts at 70 revolution per minute for 2 minutes. The last 10 seconds of each condition were recorded and truncated into 5 individual trials (crank cycles). A 13-camera Vicon system (240Hz) was used to record kinematic and pedal kinetic data

in Vicon Nexus. Data were imported into Visual 3D and relevant metrics were further processed in a custom Python program used to identify discrete events in time series data. A 2x5 (Limb x Crank Length/Condition) ANOVA within the IBM SPSS was used to identify differences of crank length, limb, and their interactions ($p < 0.05$).

Results and Discussion

A main effect of crank length was found for hip extension ROM (Table 1). Post hoc contrast showed a significant reduction in hip extension ROM in only asymmetrical reduced crank lengths of C1 and C2 compared to C3 in the replaced limb. For the symmetrical shortened crank lengths of C4 and C5, hip extension ROM was reduced in both replaced and non-replaced limbs. No main effects or interactions were observed for peak hip extension moment. These preliminary data provide support for the similar findings of the related knee joint (reported in a separate abstract) and show that asymmetrical shortening of the crank arms only affects the replaced limb's hip ROM without increasing loading to the hip.

Conclusions

Asymmetrical shortening of crank arm lengths on the replaced limb side of early post-operation patients with a TKA reduce the hip ROM requirements by accommodating their reduced knee ROM post-TKA and allow for earlier engagement in cycling during their rehabilitation journey.

Acknowledgments

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References

[1] Hummer et al., 2021. *J Biomech* **115**, 110111.

Table 1: Hip joint angles (°), ROM (°), and joint moment (Nm) across crank length conditions: Mean ± STD.

Variable	Limb	C1 (140/170)	C2 (155/170)	C3 (170/170)	C4 (155/155)	C5 (140/140)	Crank Length (p)	Limb (p)	Int. (p)
Extension ROM	NR	38.1 ^e ± 7.4	38.8 ^{d,e} ± 3.8	39.7 ^{d,e} ± 5.2	35.8 ^e ± 3.9	33.5 ± 4.5	0.004	0.717	0.225
	R	33.9 ^c ± 7.4	35.7 ^{c,e} ± 9.2	38.7 ^{d,e} ± 10.3	35.6 ^e ± 9.1	32.4 ± 8.2			
Peak Extension Angle	NR	29.9 ± 10.4	28.7 ± 11.2	28.7 ± 10.1	29.0 ± 11.4	33.1 ± 10.3	0.079	0.585	0.891
	R	33.9 ± 4.6	32.6 ± 7.5	32.6 ± 7.4	31.6 ± 8.0	36.2 ± 5.8			
Peak Extension Moment	NR	-26.8 ± 7.5	-22.1 ± 10.1	-24.6 ± 9.6	-26.2 ± 12.2	-24.7 ± 9.3	0.507	0.532	0.517
	R	-27.4 ± 7.1	-26.5 ± 3.9	-35.9 ± 14.4	-27.3 ± 8.0	-25.8 ± 14.1			

NR: Non-Replaced limb, R: Replaced limb, ^a: significantly different from C1 within limb, ^b: significantly different from C2 within limb, ^c: significantly different from C3 within limb, ^d: significantly different from C4 within limb, ^e: significantly different from C5 within limb.