JOINT CONTRIBUTIONS TO SUPPORT MOMENT DURING RUNNING AND HOPPING IN A RUNNER WITH ACHILLES TENDINOPATHY: AN INTERLIMB COMPARISON

Yu-Jen Chang, John M. Popovich, Jr., Kornelia Kulig
Jacquelin Perry Musculoskeletal Biomechanics Research Laboratory, Division of Biokinesiology and Physical Therapy, University of Southern California, Los Angeles, CA.
email: changyuj@usc.edu, web: http://pt2.usc.edu/labs/mbrl/

INTRODUCTION

The ankle is the primary contributor to support moment during running and hopping [1, 2]. We hypothesized that this contribution will be decreased in the presence of Achilles tendinopathy and that the alterations in contribution will be task dependent. This study aims to compare differences in joint contributions to support moment between the involved and non-involved leg in a subject with unilateral Achilles tendinopathy during running and hopping tasks.

METHODS

One experienced male runner (56 y/o) with chronic right side Achilles tendinopathy participated in this study. The condition was identified clinically and the pathology was confirmed using ultrasonography (Figure 1). Lower extremity kinematics (Vicon 612 motion analysis system, Oxford, UK; 250 Hz), and kinetics (AMTI force plate, Watertown, MA; 1500 Hz) were obtained during running, single-legged hopping and double-legged hopping. The running speed was controlled at 4 m/s ±5% for all trials (N=6). Single- and double- legged hopping (N=20) frequency was set at 2.2Hz using a metronome.

The vertical ground reaction force was recorded, and the sagittal plane hip, knee, and ankle joint moments were computed using standard inverse dynamics equations. The support moment was calculated by the summation of the sagittal extensor moments [3].

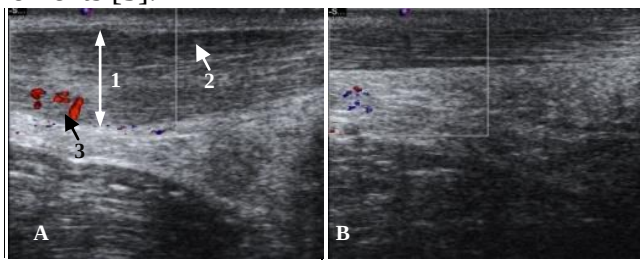

Figure 1. Ultrasound image of the involved Achilles tendon (A). Achilles tendinopathy was characterized by 1) focal thickening of the tendon; 2) hypoechoic region; and 3) neovascularization compared to uninvolved tendon (B).

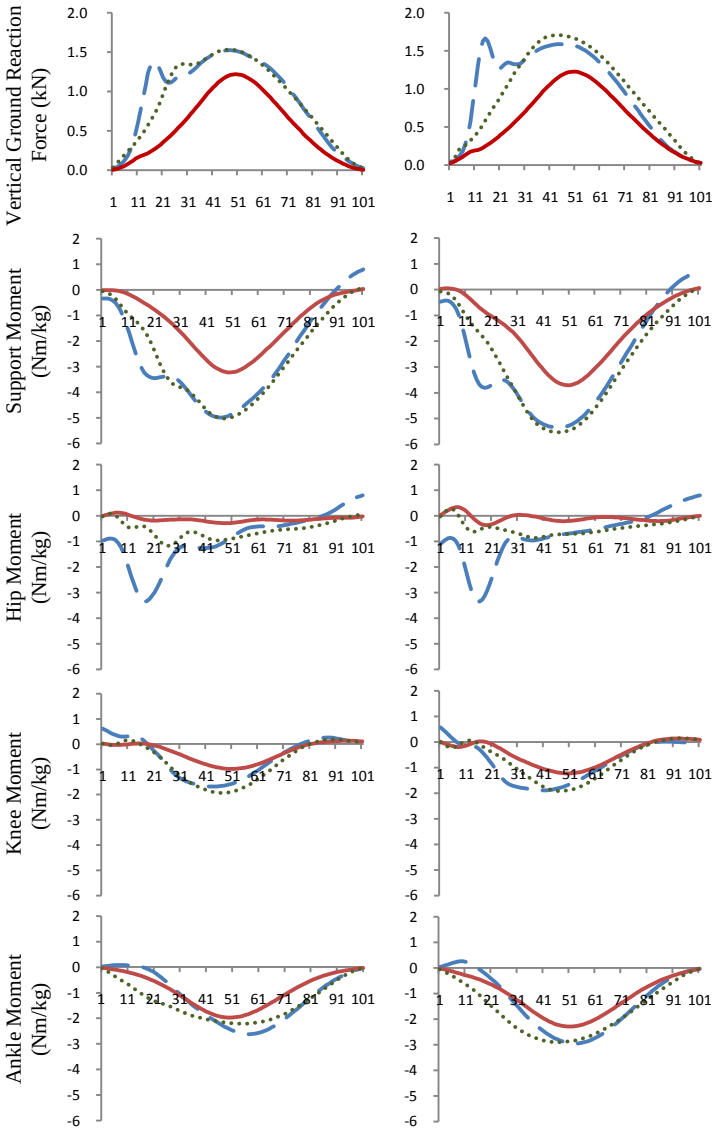

Figure 2. Vertical ground reaction force, support moment, and sagittal moments for the hip, knee, and ankle joints during running and hopping during normalized ground contact phase. Dashed-line: running; dotted-line: single-legged hopping; solid line: double-legged hopping. Negative moment denotes extensor for support moment, hip and knee, and plantarflexor for ankle.

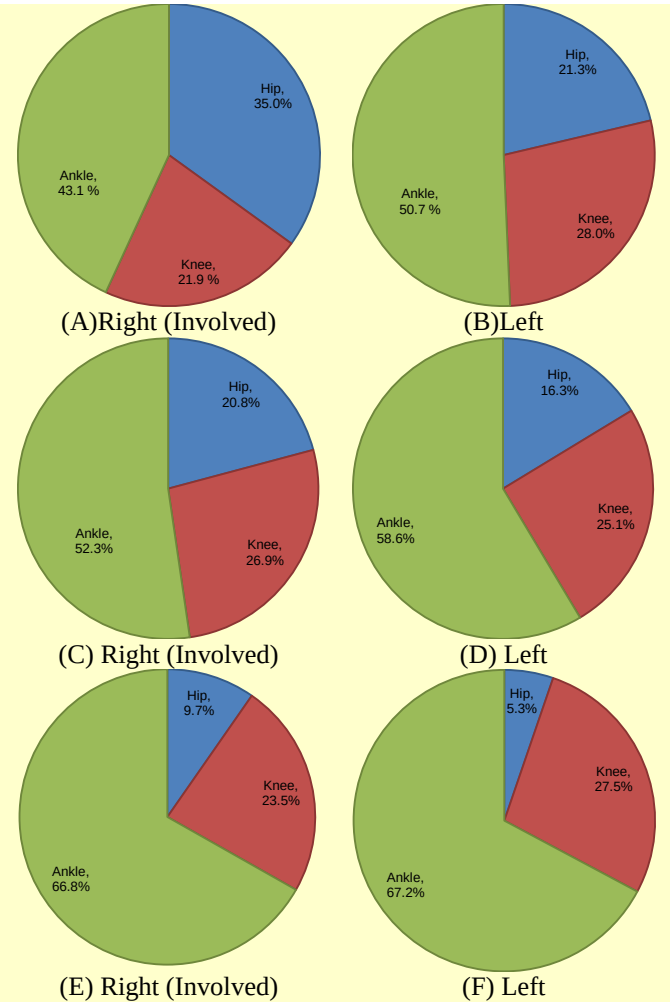

Figure 3. Percent contribution to support moment during ground contact phase of running (A, B); single-legged hopping (C, D); and double-legged hopping (E, F).

The averaged percent contribution to support moment for each joint was calculated by dividing the net sagittal joint moment by the support moment, respectively.

RESULTS AND DISCUSSION

The peak vertical ground reaction force (active peak) was lower for the involved leg during running and single-legged hopping, but there were no differences between sides during the double-legged hopping task (Table 1). The peak support moment exhibited a similar pattern; the results showed a lower peak support moment on the involved side for all three movement tasks, which might be driven by the ankle joint as its joint moments were consistently lower on the involved side among task (Table 1, Figure 2).

The ankle joint is the primary contributor to support moment across tasks (Figure 3). Although, when the ankle contribution during running was diminished on the involved side, other joints, especially the hip, increased their contribution to support moment. This phenomenon of re-distributing the ankle joint's contribution was also observed, though to a lesser extent, during single-legged hopping (Figure 3-C, D), but this was not obvious during the double-legged hopping (Figure 3-E, F).

Following injury, the mechanical properties of soft tissues are altered [4]. A degenerated tendon is more compliant than a healthy tendon, which might lead to a more compliant joint and result in lesser contribution to support moment. This study observed that the involved ankle joint contributed less to the support moment during the ground contact phase of habitual running, as well as during un-practiced hopping, though the contribution pattern was less pronounced. Yet, this finding was not observed when a synchronous double limb activity was performed. This implies that the involved joint was capable of contributing to the support moment, but either the additional moment demands of unipedal support or adaptive learned movement strategies resulted in altered joint contributions to support moment in the presence of long standing pathology.

REFERENCES

1. Günther M & Blickhan R. *J Biomech* **35**, 1459-1474, 2002.
2. Farley CT & Morgenroth DC. *J Biomech* **32**, 267-273, 1999.
3. Winter DA, *J Biomech* **13**, 923-927, 1980.
4. Arya S & Kulig K. *J Appl Physiol* In review.

Table 1. Averaged peak vertical ground reaction force, support moment, and hip, knee, and ankle joint moment values for three tasks.

	Right (Involved)			Left		
	Running	Single Leg Hopping	Double Leg Hopping	Running	Single Leg Hopping	Double Leg Hopping
Vertical Ground Reaction Force (kN)	1.53	1.54	1.23	1.58	1.73	1.23
Support Moment (Nm/kg)	4.99	5.04	3.24	5.36	5.59	3.72
Hip Moment (Nm/kg)	3.36	1.35	0.31	3.36	0.94	0.39
Knee Moment (Nm/kg)	1.68	1.95	0.98	1.89	1.93	1.23
Ankle Moment (Nm/kg)	2.62	2.22	1.98	2.96	2.91	2.29