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KNEE KINEMATICS DURING DAILY STANDING AND WALKING IN HEALTHY WOMEN WITH KNEE HYPEREXTENSION

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SUMMARY

Knee hyperextension, an insidious condition mainly seen in women, can result in abnormal loading patterns that can be detrimental to the integrity of the knee joint. The purpose of this study was to investigate if women with asymptomatic knee hyperextension at rest experience knee hyperextension during treadmill walking and during standing and walking outside the laboratory. Eight healthy female with asymptomatic knee hyperextension greater than 5° at rest participated in this study. After a physical assessment, participants were asked to walk on a level treadmill where 15 seconds of kinematic data was collected using 3D motion analysis system (Optotrak, NDI; Kistler). Kinematic data was calculated using Visual 3D (C-Motion). After initial testing, participants were asked to wear a conventional portable electrogoniometer with data acquisition system (Biometrics Ltd series SG150) during 6-10 hours of a typical work day. ELGON gait data was processed using Biometrics Software and Excel. All statistical testing was performed using SAS. Mean + SD knee passive range of motion was -7.6º + 0.7º (range -7° to -9°). Mean knee extension during level treadmill walking was -8.6° + 2° (range -5.4° to -11°). Mean knee extension during walking outside the laboratory was -15.1° + 4.2° (range -10.5° to -21°). The results of this study indicate that PROM and evaluations performed in a laboratory setting might not reflect the amount of hyperextension that women typically sustain.

INTRODUCTION

Abnormal knee kinematics can result in excessive loading of structures of the knee joint, such as menisci, ligaments, or cartilage. Associated change to these structures, due to the abnormal stress, can be detrimental to the integrity of the knee joint [1, 2]. Knee hyperextension (genu recurvatum), typically defined as more than 5° of extension, implies increased stress to the posterior joint capsule of the knee [3] and to the anterior cruciate ligament (ACL) [4]. Studies also point out that there is an increased contact stress on the tibial-femoral joint when the knee joint is extended [5]. Several studies have reported that compared with men, women demonstrated more knee hyperextension [6]. The purpose of this study was to investigate if women with asymptomatic knee hyperextension at rest experience knee hyperextension during treadmill walking and during standing and walking outside the laboratory.

METHODS

Healthy female, 18-39 years of age, with asymptomatic knee hyperextension greater than 5° at rest participated in this study. Participants underwent a physical evaluation to assess: knee extension passive range of motion (PROM); lower limb muscular strength; and general joint laxity using the Beighton and Horan Joint Mobility Index (BHJMI). The assessment of treadmill walking was conducted using a 3D motion analysis system (Optotrak, NDI; Kistler). Three non-collinear infrared markers were used to track each of the seven segments: feet, legs, thighs, and pelvis. Marker coordinate data was collected at 60 Hz, filtered at 6 Hz. An anatomical model was created by digitizing standard bony landmarks to define the segment coordinate system: anterior and posterior superior iliac spines, greater trochanters, lateral and medial epicondyles lateral and medial malleoli, posterior heel, second toe, and head of fifth metatarsal. Kinematic data was calculated using Visual 3D (C-Motion, Germantown, MD).

After a 5-minutes familiarization period, fifteen seconds of gait data were collected during level treadmill walking. To reduce inter subject variability, a set walking velocity (1.3 m/s) was scaled to each subject's leg length using the Froude ratio (V2/√gL) [7].

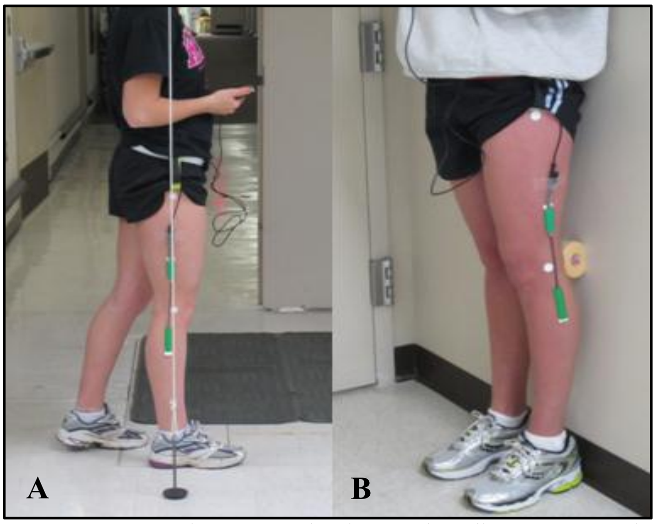

Figure 1: **A:** Device mounted using a plum line to accurately determine sagittal alignment. The plumb line was aligned to participant's greater trochanter, lateral condyle, and lateral malleolus. **B:** Initial and final positions were contrasted to assess position of device.

After initial testing, participants were asked to schedule a work day to wear a conventional portable electrogoniometer (ELGON) with data acquisition system (Biometrics Ltd series SG150) during 6-10 hours of a typical work day. The device was attached to participants' limb under investigation (knee with greatest amount of hyperextension) using double-sided medical adhesive tape (Biometrics Part Number T10) and mounted by the investigator using a plum line to accurately determine sagittal alignment of participants' lower extremity. The plumb line was aligned to participant's greater trochanter, lateral condyle, and lateral malleolus (Figure 1-A). The DataLog was attached to a belt to be worn on participant's waist.

Once the ELGON device was attached to the lower extremity under investigation and before detachment, participants were asked to stand against a wall and sustained this position for 30s to record device's initial and final positions to ensure it did not shift (Figure 1-B) throughout the assessment. ELGON gait data was processed using Biometrics DataLog and Excel. All statistical testing was performed using SAS 9.3 (SAS Institute Inc., Cary, NC, USA).

RESULTS AND DISCUSSION

Eight healthy women (mean $\pm$ SD age, 24 $\pm$ 4.5; mass, 65 $\pm$ 8 kg; height, 1.7 $\pm$ 0.1 m) took part in this study. Figure 2 shows mean and SD during knee passive range of motion, level treadmill walking and walking and standing outside the laboratory. Initial gait evaluation showed that four subjects had greater knee extension in their right knee. Table 1 shows individual mean and knee extension values. Figure 2 shows a significant difference ($P < .001$) between knee extension range of motion at rest and during over ground walking and standing outside the laboratory. Knee range of motion during treadmill walking was different to knee range of motion during a typical work day.

CONCLUSIONS

The results of this study indicate that the amount of knee hyperextension seen at PROM was not different from level treadmill walking (laboratory setting). However, the amount of knee extension observed outside the laboratory, during a typical day, was significantly higher than both in-lab measures. PROM and evaluations performed in a laboratory setting might not reflect the amount of hyperextension that women typically sustain. These substantial magnitudes underscore the potential for abnormal loading patterns that can be detrimental to the integrity of restraining structures, and the need for interventions.

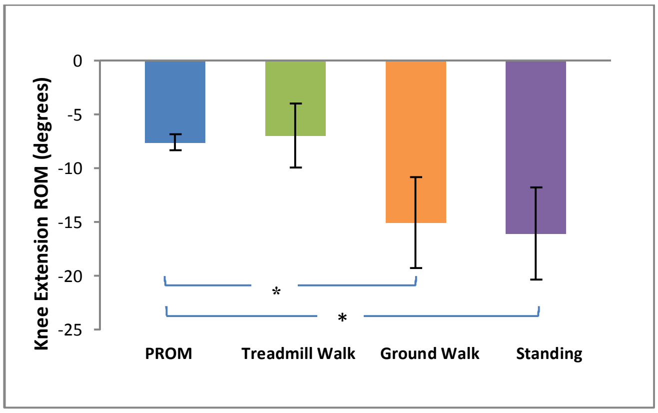

Figure 2: Mean and standard deviation SD knee extension ROM across subjects. Treadmill walking data was collected using 3D motion analysis system. Ground walking and standing data was collected using knee electrogoniometer (ELGON).

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Table 1: Mean and peak values (degrees) across eight subjects. Negative numbers mean knee extension.

			3D Motion System		Knee Electrogoniometer (ELGON)			
			Treadmill Walking		Walking		Standing	
	Side	PROM	Average (20 gait cycles)	Peak (20 gait cycles)	Average	Peak	Average	Peak
Subj.1	Rt	-7.00	-9.61	-10.66	-17.96	-19.04	-12.75	-12.83
Subj.2	Rt	-8.00	-4.88	-6.39	-11.04	-12.38	-12.66	-14.67
Subj.3	Rt	-7.00	-6.97	-8.86	-14.41	-16.43	-13.01	-13.14
Subj.4	Lt	-9.00	-3.12	-4.88	-10.50	-17.51	-16.75	-17.01
Subj.5	Lt	-8.00	-8.90	-12.07	-10.51	-13.14	-24.60	-24.84
Subj.6	Lt	-7.00	-6.70	-7.95	-15.40	-16.47	-15.35	-15.35
Subj.7	Rt	-7.00	-11.76	-12.93	-21.29	-22.86	-13.34	-13.41
Subj.8	Lt	-8.00	-3.89	-6.17	-19.52	-24.62	-20.08	-20.12
Mean		**-7.63**	**-6.98**	**-8.74**	**-15.08**	**-17.80**	**-16.07**	**-16.42**
SD		**0.74**	**2.98**	**2.93**	**4.23**	**4.28**	**4.30**	**4.17**