LOWER LIMB LOCAL OR GLOBAL ASYMMETRY IN GAIT OF PEOPLE WITHOUT IMPAIRMENTS

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INTRODUCTION

Because pathological conditions can affect gait [1-4], understanding the fundamental tasks of the lower limbs in able-bodied subjects can guide clinicians in refining their clinical evaluation or rehabilitation treatment. This gait study was undertaken to determine whether the main actions taken by the ankle, knee and hip extensors/flexors and overall lower limb muscle activity during able-bodied gait appear to be symmetrical or not.

METHODS

Sixty gait trials were obtained from 20 healthy male subjects having an average age of 25.3 ±4.1 years, height of 1.77±0.06 m and average mass was 80.6 ±13.8 kg. The model and the procedure have been explained in detail elsewhere [5]. Bilateral gait data were collected with an eight video-based camera system (90 Hz) synchronized to two AMTI force plates (360 Hz). Direct Linear Transformation software from the Motion Analysis Expert Vision system was used to reconstruct the image markers into three-dimensional coordinates. A fourth order zero-phase lag Butterworth low-pass filter was applied to reduce the noise in the video data. The cut-off frequency was 6 Hz for the body segments and 30 Hz for the force data. For averaging purposes, moments were normalized with respect to body mass. Joint moments were expressed according to the convention proposed by the International Society of Biomechanics and included in Winter [6], where the extensor and plantarflexor moments are considered positive. Kinematic and force plate data were used in an inverse dynamic approach to calculate the net sagittal muscle moments at the hip, knee and ankle of the lower limbs during the stance phase. Student's t-test for paired data with a $p<0.05$ threshold was performed on the right and left limb peak muscle moments as a primary evaluation of limb symmetry. PCA was applied to identify the main structure of the data throughout the variation in the data. To determine what each PC measures, the muscle moment having the highest correlation within each PC (called the factor loading) was used. In this instance, a factor loading higher than 0.70 was used for further biomechanical interpretation [7]. We proposed that the role of the muscles could be identified using PCA. We presumed that gait symmetry between two corresponding lower limb joints could be quantified by means of the PC curves derived from each joint or from each of the lower limbs described the same portion of the stance phase.

RESULTS AND DISCUSSION

The objective of this bilateral gait study was to determine whether the role of the sagittal plane joint moments taken appears to be symmetrical or not.

The average sagittal muscle moment curves and their standard deviation developed at the right and left ankles, knees and hips during the stance phase are presented in Table 1 and Fig 1. Muscle moment curves reported in this study were in close agreement in shape and magnitude with previously published findings [1,8,9].

Table 1: Peak muscle moments and standard deviation (SD) values calculated at the ankles, knees and hips for 20 healthy young male subjects (* $p < 0.05$)

Joint	Peak	Right		Left	
		Mean	SD	Mean	SD
Ankle	A1	-0.15	0.09	-0.12	0.02
	A2	1.53	0.30	1.46	0.10
Knee	K1	0.27	0.17	0.28	0.10
	K2	-0.40*	0.25	-0.26*	0.15
	K3	0.26	0.24	0.36	0.22
	K4	-0.31*	0.14	-0.20*	0.13
Hip	H1	-0.83	0.34	0.83	0.35
	H2	0.77*	0.32	0.40*	0.24

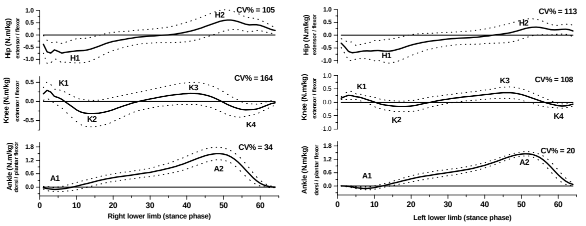

Figure 1: Average sagittal muscle moment curves and standard deviation (1SD) developed at the ankle, knee and hip joints during the stance phase of 20 able-bodied young male subjects

The two first representative curves (PC1 and PC2) accounted for the largest and an almost equal proportion of the observed variables' variance for the right (93%) and left (93%) limbs in the sagittal plane. In both PC1 and PC2, the significant loading factor values were similarly distributed over 20 to 40% and 5 to 20% of the gait cycles. These results might explain in part the idea of gait symmetry (global – Fig 3), while discrepancies were noted for group of muscles acting at each two corresponding joints (local – Fig 2). It seems that compensatory mechanisms might be the best explanation to describe global gait symmetry while different actions are taken by the joints.

Table 2: The variance extracted by each PC from the right and left lower limb muscle moment data

Joint	% Right lower limb			% Left lower limb		
	PC1	PC2	TEV	PC1	PC2	TEV
Ankle	51	21	72	40	20	60
Knee	80	11	91	73	12	85
Hip	73	15	88	82	6	88
Lower limb	64	29	93	63	30	93

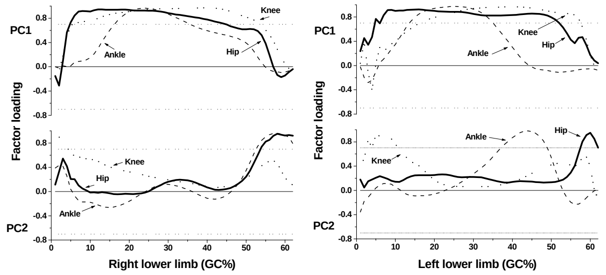

Figure 2: The first two PCs extracted from muscle moment curves calculated at the right and left ankles, knees and hips

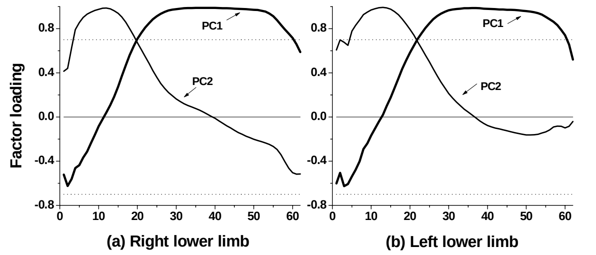

Figure 3: The first two PCs for the muscle moments developed at the lower limb during the stance phase of 20 healthy young male subjects

CONCLUSIONS

Local asymmetry in the gait of people without impairment is suggested, based on different functional tasks between the right and left hips, knees and ankles to control balance, between limb coordination and propulsion functions. The lower limbs, on the other hand, appeared to behave symmetrically when the total behavior of the limbs is considered. Compensation is recognized as an explanation for the existence of local asymmetry.

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