Characteristics of Intralimb Kinetic Coordination in the Lower Limbs During Gait in Patients with Hemiparesis Due to Stroke

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Yusuke Sekiguchi
Tohoku University

yusuke.sekiguchi.b2@tohoku.ac.jp*Corresponding Author*
ORCiD: https://orcid.org/0000-0002-9404-8659

Dai Owaki
Department of Robotics, Graduate School of Engineering, Tohoku University

Keita Honda
Department of Physical Medicine and Rehabilitation, Tohoku University Graduate School of Medicine

Shin-ichi Izumi
Graduate School of Biomedical Engineering, Tohoku University

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gait, ground reaction forces, hemiparesis, intralimb kinetic coordination, lower limbs

Abstract

Background: The main objective of the present study is to investigate the relationship between the principal components (PCs) of the sagittal kinetic variables in the lower limb and the ground reaction forces (GRFs) during gait in patients with hemiparesis. Methods: We recruited 21 patients with hemiparesis and 12 healthy controls. The 3-dimensional (3-D) coordinates of 33 markers were measured with a 3-D motion analysis system operating at 120 Hz and force plates as the subjects walked along a 7-meter walkway. The correlation coefficients between the over-time series of PCs, which is calculated using principle component analysis (PCA), and GRFs were compared among the left side of the controls and the paretic side (PS) and non-PS of the patients by using analysis of variance (ANOVA). Results: The correlation coefficient of the non-PS between the first PC and GRF in the anteroposterior-direction was significantly higher than that on the PS ($P < 0.05$) and that of the non-PS in the vertical-direction was lower than the PS ($P < 0.05$). Conclusions: The results indicated that intralimb kinetic coordination on the PS plays an essential role in weight support in patients with hemiparesis, whereas the kinetic coordination on the non-PS plays a role in generation of propulsion.

Full Text

Due to technical limitations, full-text HTML conversion of this manuscript could not be completed.

However, the manuscript can be downloaded and accessed as a PDF.

Tables

Table 1. Characteristics of Subjects with Hemiparesis and Control

	Hemiparesis	
N	21	
Gender	17 M / 4 F	
Age (years)	56.8 (SD 12.5)	52.8 (SD 10.1
Height (m)	166.5 (SD 8.3)	
Weight (kg)	66.6 (SD 7.3)	
Diagnosis	Cerebral hemorrhage 13 Cerebral infarction 8	
Paretic side	10 R / 11 L	
Time Since neurologic event (Month)	51.2 (SD 54.8)	
Brunnstrom stage in lower limb		
3 score	5	
4 score	4	
5 score	11	
6 score	1	
Sensory function	Touch Position	
0 score	1 2	
1 score	4 2	
2 score	11 2	
3 score	5 15	

[a] Brunnstrom stage is a six stage-evaluation tool used for patients with hemiparesis due to stroke. It has three different parts concerning three different parts concerning the upper extremity, hand and the lower extremity.

Table 2. Placement of markers on the body

Upper body	
Torso	spinous process of the 7^{th} cervical vertebrae, spinous process of the 10^{th} thoracic vertebr where the clavicles meet the sternum, xiphoid process of the sternum, the position in the right scapula
Arm	both acromions, both the upper arms between the elbow and shoulder markers, both late elbow, both styloid processes of the ulna, both styloid processes of the radius
Lower body	
Pelvis	both anterior superior iliac spines, both posterior superior iliac spines
Leg	both greater trochanters, both lateral epicondyles of knee, both lateral malleoluses, both malleoluses
Foot	both the first metatarsal heads; both fifth metatarsal heads, both calcaneouses

Table 3. The mean and standard deviation of spatialtemporal and kinetic data

	Control
Gait speed (cm/s)	53.4 (SD 0.17)
Stride time (s)	1.67 (SD 0.37)
Stride length (cm)	91.1 (SD 17.4)
Step length (cm)	44.5 (SD 8.6)
Stance time (s)	1.09 (SD 0.27)[a]
Swing time (s)	0.57 (SD 0.10)[b]
First double support time (s)	0.25 (SD 0.09)
Single support time (s)	0.57 (SD 0.09)[a]
Second double support time (s)	0.26 (SD 0.10)
Maximum hip extension moment in early stance (Nm/kg)	0.39 (SD 0.22)[b]
Maximum hip flexion moment in stance phase (Nm/kg)	0.65 (SD 0.19)
Maximum knee extension moment in early stance (Nm/kg)	0.19 (SD 0.18)
Maximum knee flexion moment in stance phase (Nm/kg)	0.28 (SD 0.14)
Maximum knee extension moment in late stance (Nm/kg)	0.27 (SD 0.09)
Maximum ankle dorsiflexion moment in early stance (Nm/kg)	0.05 (SD 0.04)
Maximum ankle plantarflexion moment in stance phase (Nm/kg)	1.06 (SD 0.16)[a]

[a] $p < 0.05$ as comparing the Control with the Paretic side, [b] $p < 0.05$ as comparing the Control with the Non-paretic side, [c] $p < 0.05$ as comparing the Paretic side with Non-paretic side

Table 4. The mean and standard deviation of PCA-related data

	Control
Variance explained by PC1 (%)	82 (SD 6)
Variance explained by PC2 (%)	17 (SD 6)
Variance explained by PC1 + PC2 (%)	98 (SD 1)[b]
Loadings of hip joint moment in PC1	-0.63 (SD 0.07)
Loadings of knee joint moment in PC1	0.26 (SD 0.37)
Loadings of ankle joint moment in PC1	0.63 (SD 0.09)
Loadings of hip joint moment in PC2	0.06 (SD 0.36)
Loadings of knee joint moment in PC2	0.86 (SD 0.10)[b]
Loadings of ankle joint moment in PC2	-0.28 (SD 0.23)

[a] $p < 0.05$ as comparing the Control with the Paretic side, [b] $p < 0.05$ as comparing the Control with the Non-paretic side, [c] $p < 0.05$ as comparing the Paretic side with Non-paretic side

Figures

Fig.1

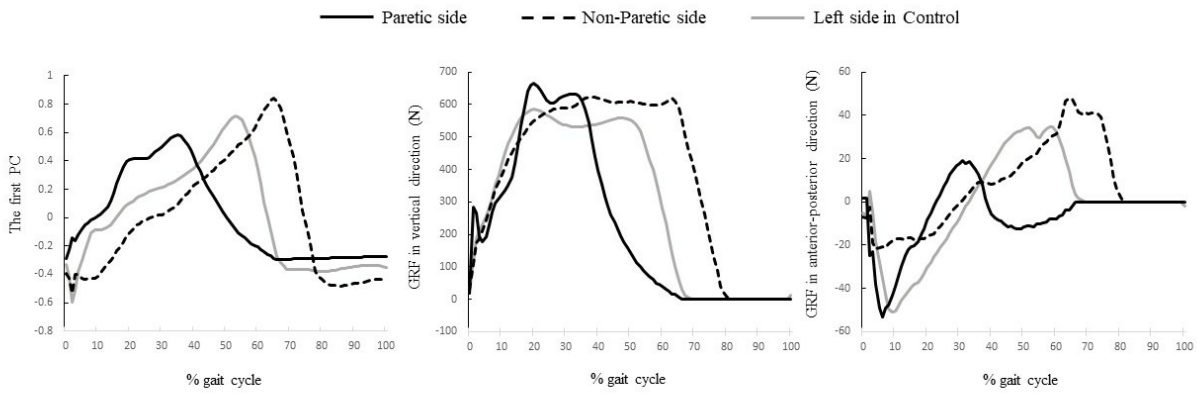

Figure 1

A typical first PC1 and GRFs in the vertical and anteroposterior directions during gait. The left, middle, and right figures indicate the PC1, the GRF in the anteroposterior direction, and the GRF in the vertical direction.

Fig.2

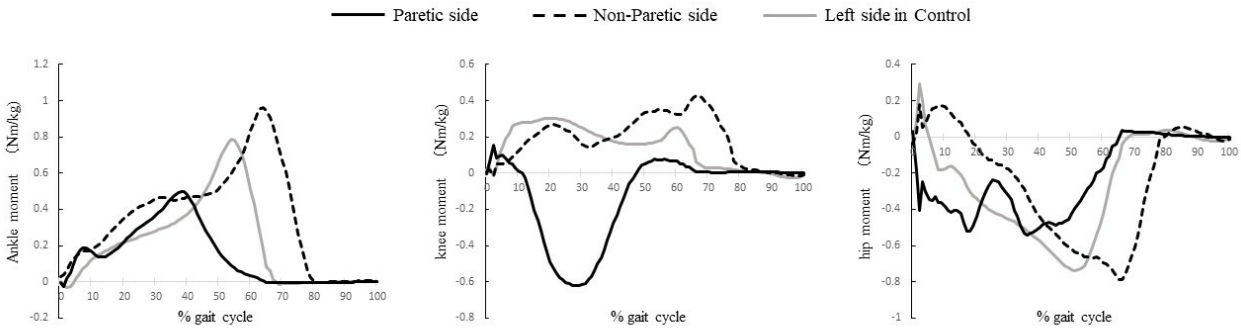

Figure 2

A typical ankle, knee, and hip moment during 1 gait cycle. The left, middle, and right figures indicate the ankle, knee, and hip moments during 1 gait cycle.