ANALYSIS VALIDITY OF SENSORS SYSTEMS FOR GAIT PHASE DETECTION IN NORMAL GAIT

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INTRODUCTION

Gait phase detection is important for evaluating the recovering of gait ability in patients with paralysis [1] as well as for determination of stimulation in FES(Functional Electrical Stimulation) walking. In general, 3-dimensional movement analysis system is widely used in analyzing gait cycles, which is very accurate in analyzing but very expensive. Besides, it is difficult to apply this system to a patient's daily life and analyze his and her gait cycle because it can only be used inside the laboratory. The researches about simple and portable motion sensors are performed to detect gait phases more easily.

In this research, three different motion sensors were used for detection of gait events(heel strike, HS; toe off, TO) and their validity analyze using the time interval between the gait phases detected by each sensor and the standard gait phase.

METHODS

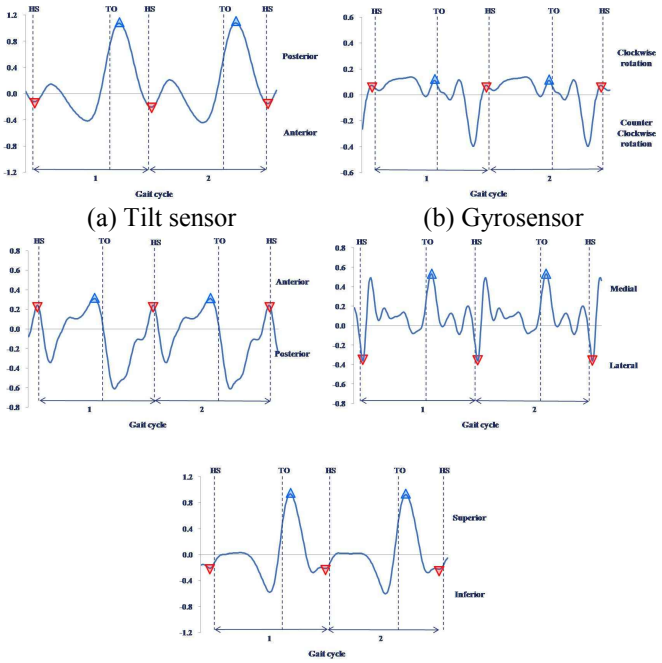
Ten normal people were volunteered for this study. Motion sensors (accelerometer, gyrosensor and tilt sensor) were attached on the shank and heel of subjects and their signals were recorded synchronized with three dimensional motion analysis system. Gait phases were determined with each sensor's signal processed to use the characteristics of sensors. Gait phase detection accuracy of each sensor was assessed using the result of FVA (Foot Velocity Algorithm) [2]. Gait phase detection using motion sensors were valid because they all have the reliability more than 95% compared with FVA.

RESULTS AND DISCUSSION

Figure 1 shows the gait phase curve of two gait cycles detected by motion sensors in normal gait. HS and TO were determined by using FVA (objective standard) and processed motion sensor signal and detection accuracy of motion sensors were assessed by calculation of time interval of HS and TO between FVA and motion sensors. Tilt sensor and gyrosensor could detect gait phase more exactly in normal subjects. Table 1 suggests the result of the validity analysis using Bland Altman plot and the time interval between the gait phases detected by each sensor and the standard gait phase. As the difference between the two methods is in the range of 95% of valid limit of each sensor, it is judged to be valid.

CONCLUSION

In this study, we could find the most applicable motion sensors to detect the gait phases in normal gait. The tilt sensor and the gyrosensor could detect gait phase more accurately about HS, TO in normal subjects, respectively. It is respected that this objective and quantitative method could help to decide the motion sensor for gait phase detection in hemiplegic patients. Further, if the signal from motion sensors in various pathologic gait should be processed customizely, more exact pathologic gait analysis could be possible by using the motion sensors.



(a) Tilt sensor (b) Gyrosensor

(c) Accelerometer (AP, ML and SI direction)

Figure 1: Gait phase detected by motion sensors and sensor output curves.

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Table 1: Validity analysis and the time interval between the gait phases detected by each sensor and FVA

Sensors		Time interval (ms)		Validity (%)	
		HS	TO	HS	TO
Tilt sensor		0.9±12.6	147.1±9.7	98.8	97.6
Gyrosensor		-18.4±19.9	-21.0±36.5	96.4	97.6
Accelerometer	Anterior-Posterior	-13.8±10.3	-77.1±18.0	100.0	98.8
	Medial-Lateral	29.4±4.6	42.4±7.5	97.6	98.8
	Superior-Inferior	-33.0±12.1	67.0±4.2	98.8	96.4