Relationship between lower-extremity muscle co-contraction and lower-leg jerk during gait.

Toshinori Miyashita [1,2], Kengo Kawanishi[1], Shintarou Kudo[1,2,3]

1 Inclusive medical science research institute, Morinomiya University of Medical Sciences, Osaka, Japan.

2 Osaka Bay Clinic, Morinomiya University of Medical Sciences, Osaka, Japan.

3 AR-Ex medical research center, Tokyo, Japan.

Email: kudo@morinomiya-u.ac.jp

Summary

This study aimed to examine the relationship between jerk of lower-leg and lower-extremity co-contraction (CC) during gait in middle-aged and elderly. A significant negative correlation was observed between jerk and thigh-shank part CC during gait. Multiple regression analysis using thigh-shank part CC as the dependent variable revealed that the jerk, age, and gait speed were highly significant partial regression coefficients. The estimated CC can be calculated from the jerk during gait obtained using the multiple regression equation.

Introduction

The elderly increase their CC during gait and the loss of smooth movement [1]. Excessive CC interferes with smooth joint movement [2]. The jerk, a derivative of acceleration, has been used to quantitatively smoothness. This study aimed to examine the relationship between lower-leg jerk and lower-extremity CC during gait in healthy middle-aged and elderly.

Methods

Participants were 30 healthy middle-aged and elderly (66.0±12.0 years, 159.9±9.8 cm, 61.5±10.8 kg). Surface electromyography (Cometa, Milano, Italia, 2000Hz) was measured from the anterior tibialis (TA), lateral gastrocnemius (GL), vastus lateralis (VL), and biceps femoris (BF). After waveform processing, the integral value of each muscle activity was calculated. The percent CC index (CCI) was calculated in the shank part (TAGL), the thigh part (VLBF), and the thigh-shank part (VLGL) [2]. Each CCI was obtained and defined as the entire stance phase (Gait cycle: 0-62%), the first half of the stance phase (Gait cycle: 0-31%), and the second half of the stance phase (Gait cycle: 32-62%). An IMU (143Hz) was attached to the lower leg (three axes; Ax: vertical, Ay: anterior-posterior, Az: mediolateral axes). The calculated jerk in each direction was adjusted by dividing it by the gait speed. The difference value between the minimum and maximum values of each three axes jerk were calculated for each stance phase, respectively. The correlation coefficient were used to examine the correlation between three parts of CCI (entire stance phase, first half of the stance phase, and second half of the stance phase), and three-axes jerk (first half of the stance phase and second half of the stance phase). The part with the highest correlation between jerk and CC during gait was used as the dependent variable, and a multiple regression analysis was performed using a stepwise method to obtain the estimated CC values ($p < 0.05$).

Results and Discussion

A significantly correlation was observed between VLGL and jerk, gait speed and age (Table 1). Multiple regression analysis revealed that the jerk (second half of the stance phase), age, and gait speed were highly significant partial regression coefficients (adjusted $R^2 = 0.53$). The obtained using the following multiple regression equation for the estimation of CCI of VLGL. (1).

$$Estimated\ CCI\ of\ VLGL\ (second\ half\ of\ stance) = 39.51 + (27.105 \times Second\ half\ of\ stance\ Ax\ jerk\ ) + (0.343 \times Age) + (-17.511 \times gait\ speed) \tag{1}$$

Lower-leg jerk was the relationship between CCI of the VLGL; CCI increased with increasing jerk, and CCI of the VLGL increased with a decline in gait speed. Additionally, the CCI of the VLGL increased with age. Multiple regression analysis adjusted for age and gait speed revealed a relationship between jerks and CCI. The CCI of the VLGL is most closely related to lower-leg jerks, which affect the gait of the elderly and could be a novel index for gait analysis in the elderly.

Conclusions

The CC of the lower-extremity and the jerk during gait were related.

Acknowledgments

This work was supported by JSPS KAKENHI (grant number JP22K17622)).

References

[1] T Hortobágyi et al (2000). *J Electromyogr Kinesiol, 10*

[2] R Hirabayashi et al (2019). Front Hum Neurosci

[3] Lo, J. et al. *Gait Posture*. 53: 110-114, 2017.

Table 1: Correlation between CCI of VLGL and lower-leg jerks (jerk x, jerk y, jerk z), gait speed, age

			First half of stance phase			Second half of stance phase				
			jerk x	jerk y	jerk z	jerk x	jerk y	jerk z	gait speed	age
CCI	entire stance phase	VLGL	0.30	0.003	0.15	**0.59****	-0.20	0.02	**-0.36***	0.27
	First half of stance phase		0.23	0.02	0.26	**0.44***	0.01	0.20	-0.11	0.10
	Second half of stance phase		0.23	0.05	-0.03	**0.39***	-0.31	-0.25	**-0.53****	**0.50****

(*p<0.05, **p<0.01)