XXIV CONGRESS OF THE INTERNATIONAL SOCIETY OF BIOMECHANICS
XV BRAZILIAN CONGRESS OF BIOMECHANICS

THREE MONTH IMPROVEMENT IN SPATIOTEMPORAL GAIT PARAMETERS OF STROKE PATIENTS

[1,2] Aline A. Carmo, [1]Ana F.R.Kleiner,[1]Paula Sueyoshi ,[3]Hélio M.Yoshida, [3]Fabrício O. Lima, [3]Patrícia H.Garcia, [3]Cristiane A.C.Miranda, [3]Jéssica L. Caldas, [3]Tatiana Rosa and [1]Ricardo M.L.Barros.
[1]Laboratory of Instrumentation for Biomechanics, Faculty of Physical Education, University of Campinas, Campinas – Brazil
[2]University of Brasilia-UnB, Brasília-Brazil
[3] School of Medical Sciences of University of Campinas, Campinas-Brazil.
email: aline.acarmo@ig.com.br, web: www.fef.unicamp.br

SUMMARY
The aim of this work was to investigate the possible changes in spatiotemporal variables in a period of three month in the gait of post-stroke patients. Nine post-stroke patients were analyzed with different post-stroke time. The inclusion criteria were: Aged between 40 and 75 years; post-stroke time less than 12 months (ranging from 2 to 11); affected by only one stroke (ischemic or hemorrhagic); presence of gait alterations. Gait cycle variables were evaluated in both affected and unaffected sides of the body. The DVideo kinematic analysis system was used to obtain three-dimensional coordinates of the passive markers. The subjects were evaluated twice with a interval of three month between the data collections. The following spatiotemporal gait parameters were calculated: self selected velocity, step and stride lengths, step width, cadence and stride time. . The results revealed statistical significant improvements (P<0.05) in the self selected gait velocity (0.63/0.80 m/s), cadence (93.6/104 step/min), step (0.38/0.48 m) and stride lengths (0.80/0.92 m) showing some influence of time in the gait pattern recovery after stroke. All patients presented improvements in the gait related parameters even those with near one year post-stroke.

INTRODUCTION
Evaluation of time and distance parameters during walking is helpful in assessing abnormal gait, especially in stroke gait. According to Kollen [1], time itself appears to be one of the most important factors of functional recovery after stroke. It is well known that neurological and functional recovery occurs mainly within the first 6 months after stroke [2]. However, findings from longitudinal studies with repeated measurements over time indicate that recovery of neurological impairments and disabilities show nonlinear recovery patterns over time [1]. Thus, the aim of this work was to investigate the possible changes in spatiotemporal variables in a period of three months in the gait of post-stroke patients.

METHODS
Nine post-stroke patients were analyzed. The inclusion criteria were: Aged between 40 and 75 years; post-stroke time less than 12 months; affected by only one stroke (ischemic or hemorrhagic); presence of gait alterations.

The average characteristics of the hemiparetic group (HG) were age: 62.83 ± 6.86 years; body mass: 69.50 ± 13.96 kg and height: 1.68 ± 0.06 m; five males and four females; post-injury time: minimum 2 and maximum 11 months after stroke. The subjects were evaluated twice with an interval of three months. The first gait analysis was done in July 2012, the second one in October 2012.

The DVideo kinematic analysis system [3] was used to obtain three-dimensional coordinates of the passive markers on the image sequence captured by video cameras. Six genlocked Basler cameras (model A602fc) were used working at 60 Hz. The three-dimensional coordinates were filtered with a zero-phase forward and reverse 4^{th} order Butterworth digital filter with a 6 Hz cut-off frequency. In order to obtain the spatiotemporal variables the 3D coordinates of the markers positioned on the right and left calcaneous were used. The following spatiotemporal gait parameters were calculated according to Kirthley [4]: velocity, step and stride lengths, step width, cadence and stride time.

Two gait cycles were analyzed separately, the cycle of the affected side (AF) and the cycle of the unaffected side (UF). The data normality was tested (Lilliefors test, $P \leq 0.05$). The comparisons intra-subjects were performed using paired Student test ($P \leq 0.05$). The statistical analysis was done by Matlab® software.

RESULTS AND DISCUSSION
The results of the changes in spatiotemporal gait parameters are presented at the table 1. The results showed that all variables present some modification between the first examination (E_1) and second examination (E_2).

In the comparison between E_1 and E_2 the spatiotemporal variables presented significant differences for both cycles analyzed (affected and unaffected). Compared to the first examination, in the second examination the subjects presented higher step length (P=0.008(AF); P=0.009(UF)), higher cadence (P=0.002(AF); P≤0.001(UF)) and consequently, higher velocity (P=0.002(AF); P≤0.001(UF)). Moreover, there were higher stride length (P=0.031(AF); P=0.025(UF)) and lower stride time (P=0.004(AF);

P≤0.001(UF)). The only variable that not presented significant differences between E_1 and E_2 was the step width.

These changes in the spatiotemporal variables observed over time revealed an improvement of the gait pattern of the post-stroke patients, showing that time is an important factor in the functional recovery after stroke [1]. However, several longitudinal studies have shown a nonlinear relationship recovery patterns over time 3-5, because there are many factors involved in the recovery process, such as restitution of noninfarcted penumbral tissue surrounding the infracted area, resolution of diaschisis, recovery of neurotransmission in spared tissue near and physicaltherapy treatment [5].

Studies based on evaluations from functional scales showed decrease of the evolution level after 6 month from stroke. Moreover, almost no evolution was observed after 12 month from injury [2]. In the present study, all patients presented improvements in the gait related parameters even those with near one year post-stroke. This finding may suggest that using an accurate system for gait analysis was possible to quantify improvements even in the chronic stage of stroke.

CONCLUSIONS

Analyzing an interval of three months between first and second examinations there were a significant increase of gait velocity, cadence, step and stride lengths for all patients analyzed in the present study. These findings may suggest that even a short time interval could provide changes in the spatiotemporal gait parameters for both acute and chronic stages post-stroke.

ACKNOWLEDGEMENTS

This research was supported by FAPESP (06/05234-6), CNPq (473729/2008-3; 304975/2009-5; 478120/2011-7) and CAPES.

REFERENCES

1. Kollen B, et al., *Stroke*. **36**;2676-2680, 2005.
2. Jorgensen H.S, et al., *Arch Phys Med Rehabil*.76:406-12,1995.
3. Figueroa PJ et al., *Computer Methods and Programs in Biomedicine*. **72**: 155-65, 2003.
4. Kirtley C. *Elsevier Churchill livingstone.* 2006.
5. Kwakkel G. et al., *Stroke.* **37**;2348-2353, 2006.

Table 1: Mean and standard deviation of the spatiotemporal variables at the examinations 1 (E_1) and 2 (E_2) for the affected cycle and unaffected cycle.

SPATIOTEMPORAL VARIABLES

AFFECTED CYCLE												
N=9	Velocity (m/s)		Step length (m)		Step width (m)		Stride time (s)		Stride length (m)		Cadence (step/min)	
	E_1	E_2	E_1	E_2	E_1	E_2	E_1	E_2	E_1	E_2	E_1	E_2
Mean	0.63*	0.80*	0.38*	0.48*	0.12	0.13	1.30*	1.17*	0.80*	0.92*	93.6*	104*
(SD)	(0.24)	(0.29)	(0.16)	(0.18)	(0.05)	(0.08)	(0.16)	(0.14)	(0.29)	(0.31)	(10.6)	(11.7)

UNAFFECTED CYCLE												
N=9	Velocity (m/s)		Step length (m)		Step width (m)		Stride time (s)		Stride length (m)		Cadence (step/min)	
	E_1	E_2	E_1	E_2	E_1	E_2	E_1	E_2	E_1	E_2	E_1	E_2
Mean	0.62♦	0.84♦	0.38♦	0.47♦	0.10	0.13	1.34♦	1.12♦	0.81♦	0.94♦	90.9♦	108♦
(SD)	(0.23)	(0.30)	(0.16)	(0.16)	(0.05)	(0.08)	(0.18)	(0.10)	(0.29)	(0.32)	(11.7)	(9.3)

Legend: E_1= Examination 1; E_2= Examination 2;

*Significant differences between pre and post test with three month interval E1 and E2 for the affected cycle;

♦Significant differences between pre and post test with three month interval E1 and E2 for the unaffected cycle;