Influence of Upper Limb Improvement in Post-Stroke Gait

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2021 – 2022

Abstract

Hemiplegic gait is a common consequence of a stroke affecting about 80% of the patients. The usual treatment tends to focus on analyzing just the affected lower body, neglecting the upper limb. This research is intended to demonstrate how the upper limbs affect the gait cycle, therefore need to be considered while doing the rehabilitation process. The original methodology was intended for post-stroke patients, and the presented was proved with simulated gaits. The subjects were recorded doing 4 types of gait and the data were analyzed to obtain the spatial-temporal and kinematic parameters. The hypothesis is that the best improvement will be seen when "treating" both the upper and lower limb. The results were a comparison and statistical analysis between the 4 gaits, which corroborated the hypothesis stated.

Introduction

Cleveland Clinic described gait as a person's pattern of walking.[2] The capacity to walk and run is usually underestimated. Being able to walk can be understated and taken as a certainty; for the majority that will be true, but not for everyone. A birth defect, a neurogenerative disease, or even an accident can change the whole setting. The CDC stated that approximately every 40 seconds someone in the USA is having a stroke.[3] The National Institute of Neurological Disorders and Stroke stated that if there is a disturbance in one half of the body, as a hemiplegia, the rest of the body would find a way to compensate.[4] The purpose of this research is to study the biomechanics of gaits in people who suffered a stroke and what were the effects in their bodies with simulated circumstances where the treatment is botulinic toxin; which is a neurotoxin used to temporally reduce muscular plasticity.

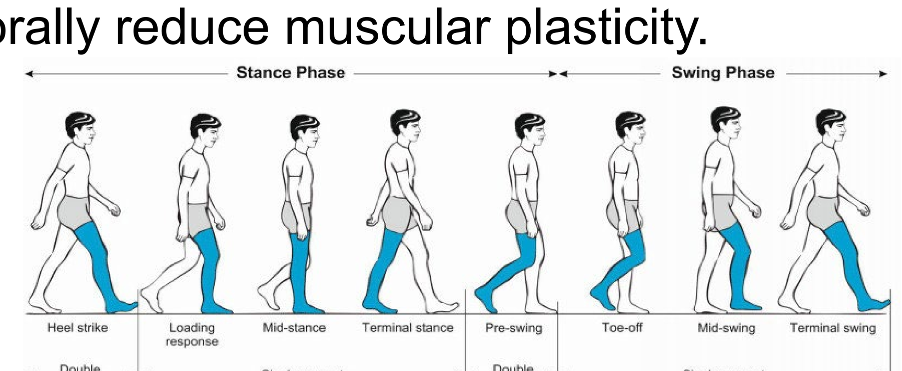

Figure 1. Phases of Normal Gait Cycle [5]

Objectives

- The main objective was to describe and recognize the impact of upper limbs on gait patterns post-stroke hemiplegia by simulating a post-stroke gait with four different conditions: (1) treatment for both limbs, (2) before treatment with both limbs compromised, (3) treatment for lower limb, and (4) treatment for upper limb.
- The second was to present a new methodology and parameters for gait analysis of post-stroke patients with hemiplegia.

Methodology

There were changes from the original methodology. At first, the clinical subjects consisted of a group of post-stroke patients who were about to receive a botulinum toxin injection in their affected upper limb. The final subjects were simulating the four (4) different situations.

Phase 1: Preliminary Tasks
- Establish standards for clinical gait analysis
- Select the spatial-temporal and kinematic parameters
- Informed consents and subject's selection

Phase 2: Data Collection
- Gait and Movement Analysis Laboratory: cameras and video mixer
- Kinovea as video annotation tool

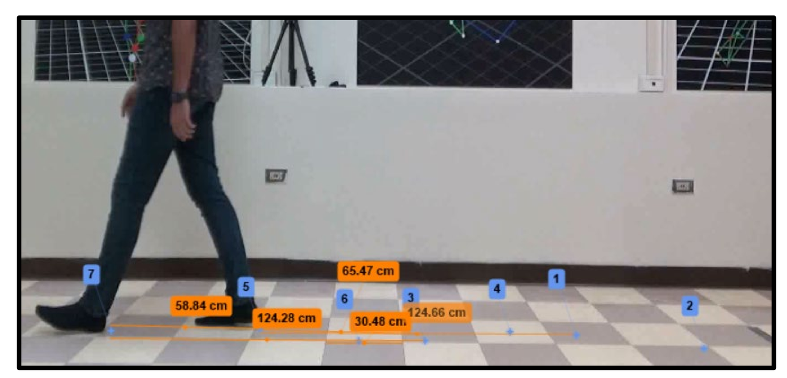

Figure 2. Spatial-Temporal Parameters

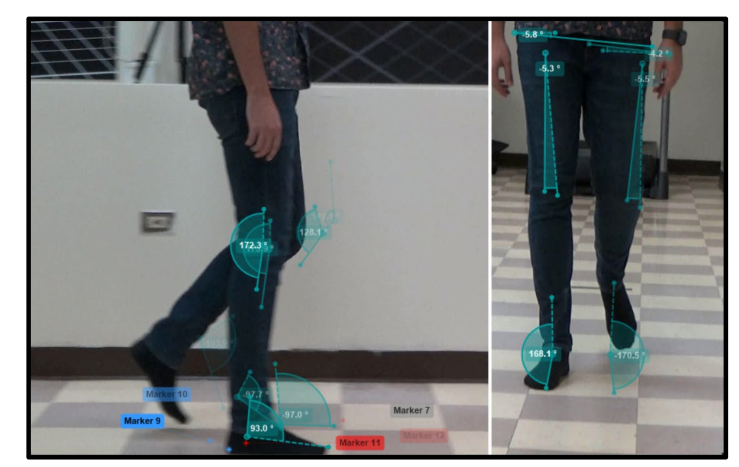

Figure 3. Kinematics Parameters

Phase 3: Data Visualization and Analysis
- Comparison between gait (1) Normal, (2) Hemiplegic, (3) "Botox" in lower limb, and (4) "Botox" in upper limb.
- Statistical analysis such as average, standard deviation and t-tests.

Data and Calculus

		M1	M2	M3	M4
Gait cycle (s)	Ipsi	0.497	0.576	0.516	0.556
	Contra	0.497	0.596	0.519	0.571
Stride length (cm)	Ipsi	115.535	102.161	106.994	102.095
	Contra	117.111	105.596	109.041	104.986
Step Length (cm)	Ipsi	59.774	55.865	54.788	54.755
	Contra	58.324	49.321	53.944	48.479
Stance phase (s)	Ipsi	0.318	0.324	0.323	0.319
	Contra	0.320	0.395	0.328	0.374
Swing phase (s)	Ipsi	0.179	0.252	0.192	0.238
	Contra	0.177	0.180	0.191	0.176
Cadence (step/s)	Ipsi	4.096	3.442	3.915	3.550
	Ipsi	4.115	3.446	3.891	3.588
Velocity (cm/s)	Contra	244.930	193.090	214.610	196.289
	Ipsi	238.772	168.110	210.539	173.969

Table 1. Averages Spatial-Temporal Parameters

		M1	M2	M3	M4
Pelvic Obliquity @ midstance	Ipsi	5.333	6.333	5.066	5.050
	Contra	4.533	5.250	4.017	5.266
Hip Ab/Ad duction @ midstance	Ipsi	8.100	3.666	3.483	4.300
	Contra	7.283	3.750	3.850	3.116
Knee flex /ext @ midstance	Ipsi	6.483	2.800	4.950	2.900
	Contra	5.350	2.617	3.433	3.883
Dosri/plant flex @ midstance	Ipsi	93.167	99.217	99.150	99.833
	Contra	95.000	97.600	96.583	97.617
Hip Ab/Ad duction @midswing	Ipsi	8.200	18.383	3.833	15.483
	Contra	8.533	4.550	4.233	4.700
Knee flex /ext @ midswing	Ipsi	50.900	1.383	47.900	3.033
	Contra	51.433	50.317	46.517	48.050
Dosri/plant flex @ midswing	Ipsi	98.167	94.600	100.450	97.100
	Contra	103.400	96.000	99.233	98.200

Table 2. Averages Kinematics Parameters

Hip abduction/adduction @midswing				
	M1	M2	M3	M4
M1	1	0.06459	0.01109	0.00624
M2		1	0.02923	0.40145
M3			1	0.00025
M4				1

Table 3. T-test for hip abduction/adduction @midswing for ipsilateral limb

Knee flexion /extension @ midswing				
	M1	M2	M3	M4
M1	1	3.897E-07	0.6300	1.444E-07
M2		1	0.01264	0.0360
M3			1	0.0134
M4				1

Table 5. T-test for knee flexion/ extension @midswing for ipsilateral limb

Hip abduction/adduction @midswing				
	M1	M2	M3	M4
M1	1	0.0676	0.0676	0.0222
M2		1	0.8031	0.9117
M3			1	0.5321
M4				1

Table 4. T-test for hip abduction/adduction @midswing for contralateral limb

Knee flexion /extension @ midswing				
	M1	M2	M3	M4
M1	1	0.8716	0.47434	0.4198
M2		1	0.67061	0.7652
M3			1	0.8288
M4				1

Table 6. T-test for knee flexion/ extension @midswing contralateral limb

Analysis and Results

The spatial-temporal parameters were gait cycle(s), stride length (cm), step length (cm), stance phase (s), swing phase (s), cadence (steps/s), and velocity (cm/s). The kinematic parameters are the measurements of the angles and the selected for midstance were pelvic obliquity, hip abduction/adduction, knee flexion/extension, and dorsi/plantar flexion; for midswing were the same, but without pelvic obliquity.

The spatial-temporal parameters from Gait 1 were as expected, where the ipsilateral and contralateral values were similar and between the standards. From Gait 2, the ipsilateral values had considerably smaller distances at stride and step length and more time at swing phase. From Gait 3, the ipsilateral values were similar to contralateral, but with less differences than Gait 2. From Gait 4, the values were similar to Gait 2 meaning that treating just the arm makes little improvement. The most relevant angles analyzed in kinematics were those at midswing as knee flexion/extension and hip abduction/adduction. Gait 2 and 3 had the most significant differences at knee flexion/extension as the ipsilateral limb was straight at all times. Besides, hip abduction/adduction of ipsilateral limb had greater values at the leg was separated from the body in order to compensate and be able to complete the midswing phase. The comparisons were confirmed using two tailed t-test statistical test with two-sample unequal sample which was the heteroscedastic type.

Conclusions and Recommendations

The original methodology had to be modified because it was intended for post-stroke patients with hemiplegia and the research was done with subjects simulating the condition. The spatial-temporal and kinematic parameters were analyzed qualitatively with the visual assumptions and quantitatively with the statistical analysis. The results showed that the greatest improvement was observed at Gait 3, followed by Gait 4 which also showed some, but considerably less improvement. The conclusion is that the hypothesis was accepted as results demonstrated the differences between gaits at two crucial parameters: reduction in stride length and lower gait cycle caused by the lower swing phase. A recommendation would be to use a laboratory to capture 3D images of the subject walking while using electrodes in specific anatomical positions.

Future Work

A proposal is to do another research using the established and proved methodology with clinical patients with post-stroke hemiplegia, and not a simulation. In order to have more variables to back up the hypothesis, a measurement of energy consumption is recommended.

Acknowledgements

I would like to thank URP-HS SAFRA III for providing the opportunity, my mentor Prof. Ricardo Bravo for his biomechanical expertise, and Prof. Juan Valera for his statistical expertise. Most importantly, I would like to thank the students of the Biomechanics Laboratory who volunteered to be the subjects.

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