

KINEMATIC AND KINETIC CHANGES DURING GAIT BEFORE AND AFTER BOTULINUM TOXIN A TREATMENT IN CHRONIC STROKE

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INTRODUCTION

Following stroke, decreased mobility and reduced function can be attributed in many cases to excessive muscle tone of the plantarflexors (Lamontagne et al., 2002). Botulinum toxin A (BTX-A) is becoming a more common treatment in clinical practice to reduce muscle stiffness. However, the biomechanical effectiveness of BTX-A treatment in the ankle plantarflexors on gait has not been established. This study describes the kinematic and kinetic profiles of the lower limbs during walking to determine the impact of BTX-A injections of the ankle plantarflexors on gait performance.

METHODS AND PROCEDURES

Nine hemiparetic stroke subjects with plantarflexor hypertonicity were recruited for the study. The subjects were instructed to walk at a self-selected pace numerous times over an 8 metre long walkway instrumented with two AMTI force platforms. Full lower limb, three dimensional, bilateral gait analysis (Optotrak 3020 motion analysis system) provided joint angle and power profiles of the ankle, knee and hip throughout stance. Data were collected at baseline, two weeks post BTX-A treatment of the ankle plantarflexors (T1), and 10 weeks post treatment (T2). Repeated measures ANOVA was used to determine if joint kinematics or kinetics changed over time.

RESULTS

Following BTX-A injection, subjects demonstrated reduced plantarflexion ($p=0.05$) and increased ankle range of motion ($p<0.05$) on the affected side throughout stance (Figure 1a). At the knee, a significant reduction in the maximum knee extension angle ($p=0.034$) of the affected leg was seen at T2. The percentage of stance in which the knee was in hyperextension demonstrated a trend towards reduction ($p=0.097$) (average of 59.3% (S.D. 35.3%) to 45.2% (S.D. 34.7%)). (Figure 1b). There were no significant kinematic changes seen at the hip.

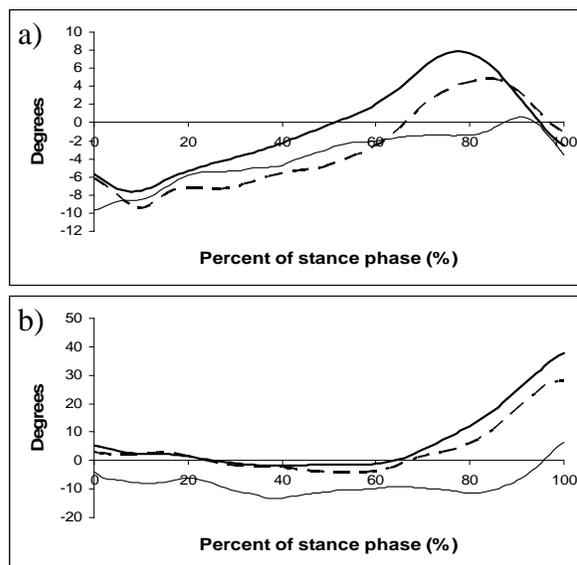


Figure 1. Representative kinematic profiles for one subject of the affected ankle (a) and knee (b) at baseline (thin line), two weeks post treatment (dashed line) and ten weeks post treatment (solid thick line)

Of the kinetic variables, no significant changes were detected post injection relative to baseline. However, examination of the individual data revealed four of the nine subjects were able to increase power generation at the ankle post injection and six subjects demonstrated increased positive work at the hip post treatment (Table 1), with only three subjects demonstrating improvements in both ankle and hip positive power profiles by 10 weeks post-injection.

	Max ankle power (W/kg)	Positive hip work (J/kg)
Baseline	0.44 (0.38)	9.61 (9.12)
T1	0.61 (0.45)	11.36 (10.91)
T2	0.59 (0.40)	12.18 (10.11)

Table 1. Joint power and work variables of the affected ankle and hip. Data are means (SD), from subjects who demonstrated improvements compared to baseline only. T1=Two weeks post-injection; T3=ten weeks post-injection.

DISCUSSION

Hypertonicity of the ankle plantarflexors restricts passive movement and therefore limits rotation of the ankle during stance (Perry et al., 1978). Following BTX-A treatment, subjects were able to achieve increased range at the ankle and reduced hyperextension at the knee. It is likely that increased compliance of the plantarflexor muscles allowed rotation of the leg over the foot, resulting in improved functional kinematics (Sutherland et al., 1999). Kinematic changes were seen at two weeks post-injection, but significance at ten weeks post-injection suggested that gains in muscle distensibility were sustained.

Only four of the nine subjects achieved increased ankle power post treatment. However, six subjects demonstrated increased positive work at the hip. It is possible that decreasing plantarflexor tone would allow the full extent of the plantarflexor muscle

weakness to manifest, and an increase in hip work was required to generate sufficient power as a compensation (Nadeau et al., 1999) in subjects who were not able to take advantage of the normalized ankle and knee kinematics (improved rotation of the leg over the foot in stance). In these subjects, perhaps adjunct therapy (such as strength training of the ankle musculature) should be used in conjunction with BTX-A treatment to maximize the benefits of tone reduction.

SUMMARY

Botulinum Toxin A injection of the ankle plantarflexors results in improved ankle and knee kinematics throughout the stance phase of gait. Although there were no significant changes in terms of kinetics, some subjects were able to increase ankle power generation. In the cases where increased work at the hip was seen with no increases in ankle power, the reduction of tone may have exposed the impact of the underlying weakness of the ankle musculature. BTX-A may be best used as a tool in conjunction with other therapy to maximize the benefits of tone reduction.

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