

Force Fluctuations in Submaximal Isometric Knee Extensor Contractions Post-Stroke

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PURPOSE AND INTRODUCTION

Purpose: To quantify force fluctuations during submaximal isometric contractions of the knee extensors in chronic stroke survivors and correlate with clinical measures of function.

- Individuals post-stroke have difficulty regulating submaximal forces generated by leg musculature^{2,4,7,8}. Regulation of force output is imperative for the completion of many motor tasks, including walking.
- Older adults often have difficulty regulating submaximal isometric knee extensor forces; exacerbated at lower force levels⁶
- Older adults can be trained to decrease fluctuations in force output¹
- Less is known regarding force fluctuations in neurologically impaired populations
- Stroke survivors have greater fluctuation in force output of the hip flexors/extensors during isometric submaximal contractions as compared to controls^{7,8}

MATERIALS AND METHODS

- Procedure is approved by Marquette University IRB
- 13 stroke survivors (8F/5M) and 9 neurologically intact older adults (5F/4M)
- Participants were seated in a Biodex dynamometer (knee and hip at 90°). Stroke survivors used paretic leg, controls used dominant leg.
- Performed three trials of isometric submaximal contractions at 20% of their MVC with both visual and verbal feedback.
- Timing of trials: 4 s incline/decline, 10 s hold at 20%, 30 s rest
- Force fluctuations quantified as the coefficient of variation (COV) of force output; $COV = (SD_{torque}/Mean_{torque}) * 100$

RESULTS – FIGURE 1

Stroke				Control			
Subject ID	Age	Gender	Race	Subject ID	Age	Gender	Race
ICT101	70	F	C	ICT201	64	M	C
ICT102	39	M	C	ICT202	59	F	C
ICT103	53	F	C	ICT203	68	M	C
ICT104	69	F	C	ICT204	64	F	C
ICT105	62	M	C	ICT205	74	M	C
ICT106	83	F	B	ICT208	61	F	C
ICT107	50	F	C	ICT209	54	F	C
ICT108	61	F	L	ICT210	79	M	C
ICT109	60	M	C	ICT211	70	M	B
ICT110	53	M	C				
ICT111	51	F	C				
ICT112	55	M	B				
ICT113	73	F	C				

Figure 1. Participant characteristics. Participants were of similar ages (stroke, 59.92 ± 11.65 years; control, 65.88 ± 7.73 years). Gender: F=female, M=male. Race: C=Caucasian, L=Latinx, B=Black.

RESULTS – FIGURE 2

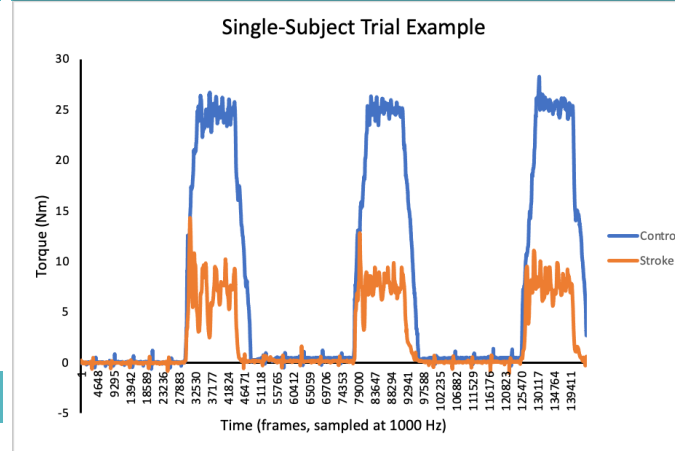


Figure 2. Single trial for an exemplary stroke survivor and control. Participants performed 3 ramp trials at 20% MVC. It can be noted that control participants have increased force output in comparison to stroke survivors, indicative of the generalized weakness experienced in the paretic side of stroke survivors. Force output fluctuates to a greater extent in the stroke participant.

RESULTS – FIGURE 3

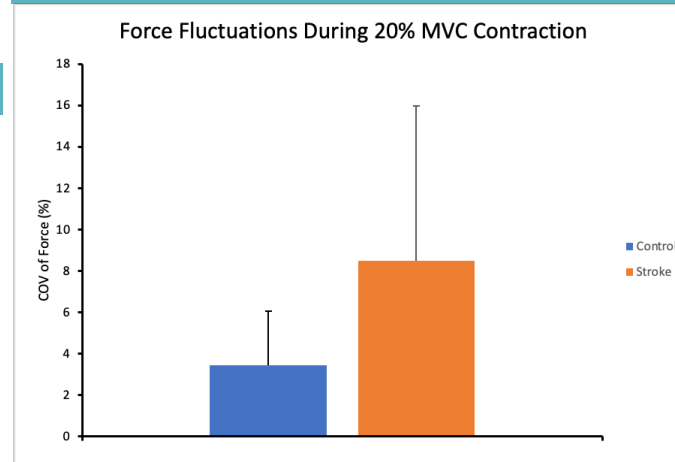


Figure 3. Group comparison of force fluctuations between controls and stroke survivors across the 20% MVC load level. It can be noted that stroke survivors have a greater COV of force in comparison to control participants while undergoing the same relative load level. This suggests that stroke survivors have an impaired ability to regulate force generation at low-load isometric forces.

RESULTS – FIGURE 4

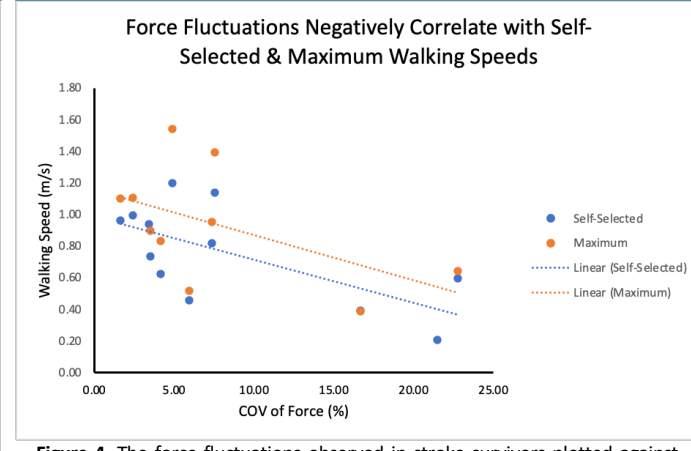


Figure 4. The force fluctuations observed in stroke survivors plotted against their self-selected (blue) and maximum (orange) walking speeds, measured in m/s in accordance with the 10 Meter Walk Test. COV is negatively correlated with self-selected walking speed ($R^2=0.44$) and maximum walking speed ($R^2=0.27$). This suggests that increased force fluctuations of knee extensor muscle contractions are associated with decreased overground walking speed.

DISCUSSION

- Stroke survivors' COV was greater than controls (8.484 ± 7.470 ; 3.428 ± 2.598 respectively)
- COV of force output negatively correlated with self-selected ($R^2=0.44$) and maximum ($R^2=0.46$) walking speeds
- COV of force output did not correlate with Fugl-Meyer motor testing

CONCLUSIONS

- Stroke survivors' impaired ability to regulate force generation of knee extensors under low-load, isometric conditions negatively correlates with walking speeds
- Measurement of COV of submaximal forces may provide another quantitative measure of motor performance post-stroke
- Future studies will investigate load-dependent effects of force regulation and the capacity to improve force regulation in stroke survivors

REFERENCES AND ACKNOWLEDGMENTS

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