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Targeting Paretic Propulsion To Improve Post-Stroke Walking Function: A Preliminary Study

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Abstract

OBJECTIVE—To determine 1) the feasibility and safety of implementing a 12-week locomotor intervention targeting paretic propulsion deficits during walking through the joining of two independent interventions: walking at maximal speed on a treadmill and functional electrical stimulation of the paretic ankle musculature (FastFES), 2) the effects of FastFES training on individual subjects, and 3) the influence of baseline impairment severity on treatment outcomes.

DESIGN—A single group pre-post preliminary study investigating a novel locomotor intervention. Changes following treatment were assessed using pair-wise comparisons and compared to known minimal clinically important differences (MCIDs) or minimal detectable changes (MDCs). Correlation analyses were run to determine the relationship between baseline clinical and biomechanical performance versus improvements in walking speed.

SETTING—University clinical research laboratory.

PARTICIPANTS—Thirteen individuals with locomotor deficits following a stroke.

INTERVENTION—FastFES training was provided for 12 weeks at a frequency of 3 sessions per week and 30 minutes per session.

MAIN OUTCOME MEASURES—Measures of gait mechanics, functional balance, short- and long-distance walking function, and self-perceived participation were collected at baseline, post-training, and at a 3 month follow-up.

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Conflicts of Interest: None.

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RESULTS—Twelve of the 13 subjects recruited completed training. Improvements in paretic propulsion were accompanied by improvements in functional balance, walking function, and self-perceived participation (each $p < 0.02$) – all of which were maintained at the 3 month follow up. Eleven of the 12 subjects achieved meaningful functional improvements. Baseline impairment was predictive of absolute, but not relative functional change following training.

CONCLUSIONS—This report demonstrates the safety and feasibility of the FastFES intervention and supports further study of this promising locomotor intervention for persons post-stroke.

Keywords

Hemiparesis; Rehabilitation; Propulsion; Walking

Despite an emphasis on walking recovery during post-stroke rehabilitation, locomotor deficits^{1–7} that contribute to limitations in activity and community participation persist for most patients^{8,9}. Indeed, a recent critical review by Dickstein and colleagues revealed comparable outcomes following current post-stroke walking therapies and showed that all failed to improve the majority of subjects' capacity for community ambulation, regardless of treatment mode or sophistication¹⁰. Clearly, existing rehabilitation paradigms have failed to address sufficiently the limiters of post-stroke walking performance. Until recently, the clinical measures used to evaluate the recovery of walking performance following gait rehabilitation did not have the capacity to differentiate between the restoration of impaired neuromotor processes versus the strengthening of existing compensatory strategies¹¹. Without an understanding of the changes underlying intervention-mediated improvements in walking function, the ability to target the specific deficits contributing to reduced walking performance in post-stroke individuals has been limited^{11,12}. Recent advances in laboratory instrumentation have allowed a detailed quantification of treatment effects, providing a theoretical foundation from which locomotor therapies can be developed¹¹. Herein we report on the development, implementation, and success of a targeted intervention capable of modifying specific impairments known to limit the walking performance of individuals who have sustained a stroke.

For individuals with hemiparesis following stroke, decreased propulsive force generation by the paretic limb during walking has been identified through simulation and cross-sectional studies as a major contributor to walking dysfunction^{1,2,4,13–18}. Furthermore, recent studies by Bowden and colleagues show that propulsion symmetry during walking is able to differentiate individuals as limited community versus community ambulators¹⁹, and that individuals who achieve clinically meaningful improvements in walking speed also improve propulsion symmetry²⁰. Despite the strong evidence linking paretic propulsive ability to post-stroke walking performance, large scale investigation of interventions specifically designed to improve propulsion during walking are nonexistent^{10,21}. Moreover, previous reports that have considered the effects of gait intervention on measures of paretic propulsion have failed to demonstrate significant changes in the paretic limb's capacity to generate propulsive force following intervention^{12,22,23}, likely due – as posited by Hall and colleagues – to subjects utilizing a variety of compensatory strategies during training¹². Thus, it is currently unknown whether paretic propulsion is modifiable through intervention

specifically targeting this impairment, and whether such improvements would influence walking performance. In contrast to previous interventions, we developed an intervention specifically designed to improve post-stroke walking ability through improvements in paretic propulsion.

An immediate increase in the activation of the paretic plantarflexors during walking is achievable through functional electrical stimulation (FES). However, the translation of increased plantarflexor muscle activation during FES into greater forward propulsion depends largely on the paretic limb's posterior position relative to the individual's center of mass during the double support phase of the paretic gait cycle¹⁶. Unfortunately, stroke survivors often do not achieve adequate paretic hip extension during walking⁷. However, walking at a faster speed is known to increase paretic hip extension^{24,25}, effectively increasing the posterior placement of the paretic limb relative to the individual's center of mass during walking. Based on this framework, we hypothesized that an intervention combining fast treadmill walking with FES to the paretic ankle musculature would maximize the translation of increased plantarflexor activity into forward propulsion, ultimately resulting in improved walking function. Thus, the FastFES (Fast + FES) intervention was conceived.

Contemporary concepts from multiple domains were integrated into the design of the FastFES locomotor program to maximize its effectiveness. The 12-week FastFES program follows principles of motor learning and neuroplasticity through massed stepping practice and task specific training on both the treadmill and over ground²⁶. Alternate bouts of walking with and without FES are also included to enhance learning²⁷. From a physiological perspective, FastFES incorporates stimulation patterns that better mimic the nervous system's activation of muscle (i.e. variable-frequency train patterns), facilitating a more rapid rate of rise in force production²⁸ and yielding greater changes in walking kinematics²⁹ as compared to traditionally used FES patterns in persons post-stroke.

Prior to determining the effectiveness of the FastFES program through an RCT, this preliminary investigation was undertaken to investigate whether improvements in paretic limb propulsion could be safely and feasibly achieved through a 12-week gait retraining program that joins walking at maximal speed with the application of FES to the paretic ankle musculature. Moreover, considering the heterogeneity of post-stroke locomotor deficits, the clinical characteristics predictive of an appropriate candidate for this intervention are explored. Measurements across all levels of the World Health Organization's International Classification of Function, Disability and Health (ICF)³⁰ are included in this report.

METHODS

Subjects

Thirteen subjects (Age: 61 ± 8.3 y; Time Since Stroke: 3.22 ± 3.05 y; 7 males; 8 right hemiparetic) with post-stroke hemiparesis participated in this study (Table 1). Subject inclusion criteria included: at least 6 months post-stroke, able to walk continuously for 5 minutes, and have sufficient ankle passive range of motion to allow the paretic ankle joint to reach within 5 degrees of the neutral position with the knee flexed. Exclusion criteria

included: evidence of moderate to severe chronic white matter disease on MRI, more than one previous stroke, congestive heart failure, peripheral artery disease with claudication, uncontrolled diabetes, shortness of breath without exertion, unstable angina, resting heart rate outside of the 40–100 beats per minute range, resting blood pressure outside of the 90/60 to 170/90 mmHg range, an inability to communicate with the investigators, pain in the lower limbs or spine, total knee replacement, cerebellar involvement, neglect (tested via the star cancellation test³¹), and absence of sensation on the skin of the paretic calf or leg. All subjects completed a submaximal cardiac stress test to determine exercise safety prior to participation, and signed informed consent forms approved by the University of Delaware Human Subjects Review Board. Results from each subject's cardiac stress test were used to calculate a target heart rate (THR) which served as a maximum during training. The formula used was: $THR = ((\text{maximum heart rate} - \text{resting heart rate}) \times 70\%) + \text{resting heart rate}$.

Gait and Clinical Testing

Subjects completed biomechanical and clinical evaluations at baseline (PRE), following 12 weeks of FastFES locomotor retraining (POST), and 3 months following the completion of training (FU). Previous work has described in detail the methods used during this investigation^{32,33}. Briefly, kinetic and kinematic data were collected via an 8-camera motion analysis system^a as subjects walked at their self-selected speeds on a dual-belt treadmill instrumented with two independent 6 degree of freedom force platforms^b. Data related to the paretic limb's capacity to generate propulsive force – the specific target of the FastFES intervention – were collected and served as the body structure and function variables of interest. These variables included the paretic propulsive integral (PropIntegral), the paretic peak propulsive force (PeakProp), propulsion symmetry (PropSymm), and the paretic peak trailing limb angle (PeakTLA). PropIntegral was measured as the integral of the paretic leg's anterior GRF from the beginning of the anteriorly directed portion of the GRF through the end of the paretic stance phase, normalized to body weight (%BW.seconds). PeakProp was measured as the maximum anterior GRF, normalized to body weight (%BW). PropSymm was calculated as the ratio of PropIntegral divided by the sum of PropIntegral and the non-paretic PropIntegral (%). PeakTLA was the maximum sagittal plane angle (degrees) between the vertical axis of the lab and a vector joining the paretic limb's lateral malleolus and greater trochanter.

Clinical evaluations measured performance at the level of activity – i.e. the 6-meter walk test³⁴ measured each subject's self-selected (SSWS) and maximum (MWS) walking speeds (m/s), the 6-minute walk test (6MWT)³⁵ measured long-distance walking ability, and the Functional Gait Assessment (FGA)³⁶ measured functional balance. Self-perceived participation was measured via the participation domain of the Stroke Impact Scale (SIS - P)³⁷ - which was also completed during the clinical evaluation. Additionally, the lower extremity motor portion of the Fugl-Meyer Scale³⁸ was completed at baseline to provide information about general sensorimotor impairment. It should be noted that FES was not utilized during any testing.

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Training

A licensed physical therapist administered the FastFES intervention for a goal of 12 weeks of training at a frequency of 3 sessions per week. Each training session consisted of both treadmill (27 minutes) and over ground walking (3 minutes). After completing four 6-minute treadmill bouts where FES was delivered in an alternating pattern of 1-minute on and 1-minute off to the paretic ankle dorsi- and plantarflexor muscle groups, subjects completed 3 consecutive minutes of treadmill walking with the FES followed immediately by 3 consecutive minutes of over ground walking without FES. During all periods of walking without FES, subjects were encouraged to reproduce the same walking pattern as practiced with the FES. The training protocol used has previously been described^{32,33}.

Functional Electrical Stimulation

Details regarding the customized FES system^c used and the methods employed can be found in previous studies put forth by our laboratory^{29,32,33,39,40}. FES was delivered to the ankle dorsiflexor and plantarflexor muscles during walking through self-adhesive surface electrical stimulation electrodes^{d,e}. Two compression-closing foot switches^f attached to the sole of the shoe of the paretic limb were used to control the delivery of FES from a Grass S8800 stimulator in combination with a Grass Model SIU8TB stimulus isolation unit^g. Plantarflexor FES was delivered when the hindfoot switch was turned off (indicating paretic heel off) and ended when the forefoot switch was turned off (indicating paretic toe off). Dorsiflexor FES was delivered when the forefoot switch turned off (paretic toe off) until the hindfoot switch was turned on (paretic heel strike). Footswitch position was modified to accommodate varying foot strike patterns so that the stimulation was consistently delivered during the appropriate time periods.

Data Management and Statistical Analyses

The normality of each variable's distribution was assessed using the D'Agostino-Pearson omnibus test in Microsoft Excel 2007. Statistical analyses were conducted using SPSS version 20^h. The threshold for statistical significance was set to $p > .05$. Wilcoxon Signed Ranks tests or paired t-tests – pending data normalcy – were used to detect differences between baseline versus each POST and FU performance. Spearman's rho correlation analyses were used to determine the influence of baseline abilities on treatment outcomes. Absolute and relative improvements in SSWS following the 12-week training period were considered. Relative improvement was calculated as the ratio of the difference between POST and baseline performance divided by baseline performance.

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^hSPSS Inc. 233 S Wacker Dr, Ste 1100, Chicago, IL 60606. (312) 651-3000.

RESULTS

Twelve of the 13 subjects recruited to this study completed the 12-week FastFES locomotor program. The single subject terminated from the study withdrew for reasons unrelated to training. No adverse events were noted during training with the rest periods provided between bouts being sufficient to alleviate the elevations in blood pressure, heart rate, and ratings of perceived exertion that occurred in response to training. Of the planned thirty-six 30-minute training sessions, subjects completed a median 32 (IQR, 32 – 34) sessions with an average 27.51 ± 2.52 minutes per session (see Table 1). Due to periods of illness throughout the training period, subject # 98 was only able to complete between 10 and 19 minutes of training for 6 visits, and was therefore asked to complete an additional 5 sessions at the end of the 12 weeks for a total of 41 sessions. Similarly, for 4 visits, subject # 108 was only able to complete ~10 minutes of training, and therefore completed additional sessions for a total of 42 visits. The primary reason subjects missed training days were scheduled physician appointments and traveling for the holidays. The primary reason subjects were unable to complete the full 30 minutes of training per session was the termination of a walking bout when the subject's predetermined maximum heart rate was surpassed.

Complete clinical data sets were available for all 12 subjects; however, due to technical issues during data collection, propulsion data were not available from baseline testing for 2 subjects and from POST testing for 3 subjects. PeakProp data from FU were also not available for 1 subject. Thus, for POST versus PRE testing involving propulsion data, a sample of only $N = 9$ subjects was available. For FU versus PRE testing involving PeakProp data, only $N = 11$ subjects were available. Additionally, PeakTLA data were not available from baseline or POST for one subject, reducing the PeakTLA subject sample to $N = 11$.

With an average SSWS of 0.5 ± 0.17 m/s and lower extremity Fugl-meyer scores ranging from 13–24, subjects presented with a range of functional abilities at baseline (Table 1). All clinical and biomechanical variables improved following training; most of these improvements were maintained through the 3 month follow up period (see Table 2). Only the propulsive integral improvement from PRE to follow-up ($p = .07$) did not reach statistical significance. The average change in SSWS (SSWS) was 0.18 ± 0.07 m/s. Eight of the 12 subjects studied achieved clinically meaningful improvements in SSWS (> 0.16 m/s)⁴¹. Three of the remaining four subjects achieved respective gains in SSWS of 0.15 m/s, 0.11 m/s, and 0.11 m/s. These subjects also demonstrated gains in the 6MWT of 145m, 93m, and 55m – all larger than the minimal detectable change of 54.1m⁴². Two of these same three achieved the highest SIS-P gains – 53 and 38 points, respectively. The remaining subject, subject # 137, presented with only a 0.03 m/s change in SSWS following training and was the lowest performer on all measures (see tables 1 and 2).

Baseline performance on each clinical and biomechanical measure, except for PeakTLA, was predictive of absolute change in self-selected walking speed following training (R^2 s ranged from 0.28 to 0.56, with each $p < 0.04$), with lower levels of baseline impairment predicting larger gains (Figure 1). However, baseline abilities were not predictive of relative improvements in SSWS (each $R^2 < .12$ and each $p > 0.05$; Figure 2), with subjects achieving a median improvement of 39% (IQR, 28% - 39%) following training.

DISCUSSION

In this preliminary report we demonstrate the feasibility and safety of an intervention joining two independent therapies, fast treadmill walking and functional electrical stimulation (FastFES), for the treatment of post-stroke walking dysfunction. All subjects tolerated this combined therapy, with all but one subject – for reasons unrelated to the training – completing the entire training protocol. Indeed, only periods of illness or scheduling conflicts prevented subjects from completing the prescribed training dosage of 12 weeks, at a frequency of 3 sessions of 36 minutes per week. Consistent with our hypothesis that improvements in walking function would accompany improvements in paretic propulsion, 11 of the 12 subjects who completed the 12 weeks of gait training achieved meaningful improvements (greater than known MCID or MDC values) across the domains of the ICF.

The FastFES program is the first post-stroke therapeutic intervention shown to improve the paretic limb's ability to generate propulsive force while also improving functional performance. To the best of our knowledge, previous intervention studies concerned with paretic propulsion have been limited to the study of propulsion symmetry^{12,21,22,42}, with none showing significant group changes post- versus pre-treatment. However, when dichotomizing subjects based on their response to treatment, Bowden et al reported a significant improvement in propulsion symmetry for responders versus non-responders²⁰. While propulsion symmetry is an important measure of lower limb coordination and control during walking, improvements in symmetry are not necessarily indicative of increased propulsive force generation by the paretic limb, rather may reflect changes in the function of the non-paretic limb. In contrast to prior intervention studies examining changes in propulsion symmetry, a recent study by Hase and colleagues reported that a 3-week prosthetic-based gait program had a greater effect on the propulsive force generated by the paretic limb than a 3-week fast treadmill walking program⁴³. However, subjects received only 10–15 minutes of treadmill training per day for 10 days, and only achieved an average 0.05 m/s improvement in walking speed (prosthesis training subjects improved an average of 0.06 m/s). Similarly, a review of the GRF plots presented revealed that their representative subject achieved approximately a 1% increase in PeakProp following training. In contrast, subjects in the present study completed a median 32 sessions with an average 27.51 minutes of training per session, ultimately achieving a 0.18 m/s average improvement in walking speed and a median gain in PeakProp of 3.28% (IQR 1.23% – 3.59). These findings call for further study of the training dosage necessary to produce an optimal therapeutic response.

The findings of the present study build upon recent work demonstrating an association between changes in paretic ankle plantarflexor function and improved post-stroke walking speed^{44,45}. These studies, consistent with the early work of Olney and colleagues⁶, provide insight into the biomechanical mechanisms that may underlie the improvements in propulsion observed in the present study. Specifically, improvements in A2 power and the positive work produced by the paretic plantarflexors may be major contributors to the improvements in walking speed observed. The present study, by joining treadmill training at maximal speed to plantarflexor FES, facilitates a second means of improving paretic propulsion – that is, through improving the paretic trailing limb position. Indeed, the FastFES program is designed to improve paretic propulsion through the synergistic effect of

increasing the paretic trailing limb angle via faster walking and increasing the activation of the paretic plantarflexors via FES. However, improvements in one of these components may have a larger effect on propulsion deficits than improvements in the other. For example, although improvements in paretic propulsion may be realized solely through increased trailing limb angle, changes in plantarflexor activation alone may not be sufficient to increase propulsion without an adequate initial trailing limb position. However, for individuals with an adequate trailing limb position at baseline, improvements in propulsion may only be realized from improvements in plantarflexor force generation. For such individuals, FES-induced increases in plantarflexor muscle activation must carryover to improvements in voluntary muscle activation. Further study of the individual contribution of improvements in each trailing limb angle and plantarflexor force generation to improvements in walking performance is warranted and may influence the selection of treatment parameters. Moreover, considering individuals with chronic stroke have been shown to increase walking speeds preferentially through increased work at the hip versus at the ankle⁴⁶, future study of FastFES's effect on preexisting gait compensations is warranted.

Consistent with the findings of Sullivan and colleagues⁴⁷ and Mulroy and colleagues¹⁴, the present study demonstrated that better baseline performance was predictive of larger SSWS gains. In contrast, Barbeau and Visintin demonstrated that in the earlier phases post-stroke (~2 months), subjects with greater gait impairments at baseline benefited the most from locomotor training⁴⁸. Taken together, these findings suggest that gait intervention during the earlier phases of stroke recovery may have a larger positive effect on those with greater initial impairments while gait intervention during the later phases of stroke recovery may produce larger gains in higher functioning individuals. However, the present study also demonstrates comparable relative improvements in SSWS, with subjects achieving a median SSWS improvement of 39% (IQR, 28% – 39) regardless of baseline level of impairment. To the best of our knowledge, previous investigations have not examined the effect of baseline impairment severity on relative treatment outcomes. As such, whether this finding is unique to the FastFES intervention, or generalizable across interventions, is currently unknown.

Limitations

As a preliminary study without a control group, this report is unable to determine the effectiveness of the FastFES program. Moreover, the individual contribution of the intervention components – the Fast walking speed or the FES – to the gains observed is unknown. However, it should be noted that these two components were selected for this intervention based on previously published work that demonstrated that the combination of fast treadmill walking plus FES produced larger immediate gait changes than either alone³⁹.

Conclusions

This is the first study to demonstrate that post-stroke individuals are capable of learning to generate greater propulsive force via their paretic leg during walking. Moreover, we show that the combination of walking at maximal speed with functional electrical stimulation of the paretic ankle musculature is safe and feasible for persons in the chronic phase of stroke, and promising for individuals across different levels of baseline impairment severity.

Further study of this intervention will include a randomized controlled trial studying the additive therapeutic effect of FES to Fast treadmill training alone.

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Abbreviations

FastFES	Fast treadmill training combined with functional electrical stimulation to the paretic ankle musculature
FES	Functional Electrical Stimulation
6MWT	Six Minute Walk Test
SSWS	Self Selected Walking Speed
MWS	Maximal Walking Speed
FGA	Functional Gait Assessment
SIS-P	Stroke Impact Scale Participation Domain
PropIntegral	Paretic Propulsion Integral
PeakProp	Peak Paretic Propulsive Force
PropSymm	Propulsion Symmetry
PeakTLA	Peak Paretic Trailing Limb Angle

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Figure 1.

Scatter plots presenting the relationships between baseline clinical (SSWS, MWS, 6MWT, and SIS-P; Panels A–D) and biomechanical (PeakProp, PropInt, PropSymm, and PeakTLA; Panels E–H) performance versus improvements in SSWS following FastFES training. Baseline performance on all measures, except PeakTLA, related to improvements in SSWS. Baseline PropInt and PropSymm performance very strongly related to improvements in SSWS (each Spearman rho = 0.70, $p < 0.05$). Baseline PeakProp, 6MWT, MWS, SSWS, and SIS-P performance strongly related to improvements in SSWS (each Spearman Rho 0.50, $p < 0.05$). Baseline PeakTLA was not related to improvements in SSWS.

Figure 2.

Scatter plots presenting the relationships between baseline clinical (SSWS, MWS, 6MWT, and SIS-P; Panels A–D) and biomechanical (PeakProp, PropInt, PropSymm, and PeakTLA; Panels E–H) performance versus relative improvements in SSWS following FastFES training. Baseline performance was not related to relative improvements in SSWS (all Spearman ρ hos < 0.35 , $p > 0.05$).

Table 1

Subject Baseline Characteristics and Training Information

Sub #	Sex	Age (y)	Side of Hemiparesis (L/R)	Time Since Stroke (y)	Self-Selected Speed (m/s)	Fugl-Meyer (LE) (Score)	# of Sessions Completed (#)	Average Minutes/Session (min)
1	M	67	L	1.83	0.70	21	34	26.88
2	M	51	L	9.25	0.90	24	33	29.64
9	M	58	R	9.17	0.50	15	33	27.82
53	M	71	R	5.83	0.50	14	34	24.63
98	M	66	R	1.58	0.30	21	41	22.03
108	M	70	L	1.75	0.50	13	43	24.70
110	F	65	R	1.25	0.70	18	32	27.48
120*	F	52	L	2.75	0.80	19	13	--
128	F	65	R	1.50	0.50	18	27	29.15
129	F	54	R	4.58	0.50	17	32	29.41
136	F	58	R	1.00	0.30	13	32	28.87
137	M	46	R	0.67	0.40	15	30	29.53
142	F	70	L	0.75	0.30	22	32	30.00
AVG±SD		61 ± 8.31		3.22 ± 3.05	0.53 ± 0.19	17.69 ± 3.59	Median: 32 IQR(32 – 34)	27.51 ± 2.52

* subject terminated from study

Table 2

Group (n=12) pretesting, posttesting, follow-up, and change score values

Variable	PRE		POST		Follow Up		CHANGE (POST – PRE)		CHANGE (Follow Up – PRE)	
	Mean (SD)		Mean (SD)		Mean (SD)		Mean (SD) 95% CI	P	Mean (SD) 95% CI	P
6MWT (m)	215±92		303±125		268±122		89±64 53 – 126	.001	53±58 20 – 86	.005
SSWS (m/s)	0.50±0.17		0.68±0.22		0.62±0.21		0.18±0.07 0.13 – 0.22	.001	0.10 (0.03)* 0.06 – 0.15 / ‡	.001
MWS (m/s)	0.67±0.27		0.85±0.31		0.81±0.31		0.18±0.09 0.13 – 0.23	.001	0.14±0.09 0.09 – 0.19	.001
FGA (score)	9.75±2.73		12.83±4.24		11.67±4.81		3.08±2.68 1.57 – 4.60	.001	1.92±3.53 –0.08 – 3.91	.043
SIS – P (score)	67.71±23.81		76.30±21.76		79.17±18.19		8.59±12.23 0.82 – 16.36	.017	6.23 (11.72)* 0.00 – 18.75 / ‡	.020
PropInt (% BW.s)	0.48±0.50 #		1.05±0.94 ¶		0.99±0.82		0.29 (0.32)* 0.10 – 0.65 / ‡	.006	0.24 (0.52)* –0.12 – 0.72 / §	.070
PeakProp (% BW)	2.89±1.83 #		6.05±2.81 ¶		5.17 (3.03) * ^		3.28 (2.36)* 0.80 – 4.47 /	.005	2.25 (2.74)* 0.34 – 8.00 / §	.003
PropSymm (%)	10.57±11.38 #		16.26±13.24 ¶		21.57±19.75		5.46±4.32 2.64 – 8.28	.003	4.03 (8.38)* 0.00 – 14.68 / §	.014
PeakTLA (deg)	9.7±6.1 ^		14.38±5.57 ^		13.8±4.9		4.69±5.04 1.71 – 7.67	.006	3.67±4.66 0.91 – 6.42	.013

Abbreviations: CI, confidence interval; FGA, Functional Gait Assessment; %BW.s, percent body weight; %BW.s, percent body weight second; SIS-P, Stroke Impact Scale participation domain.

* If data were not normally distributed, data are presented as median (interquartile range).

¶ If data were not normally distributed, data are presented as CI for the median.

‡ 95% CI for the median actual coverage is 96.1%.

§ 95% CI for the median actual coverage is 97.9%.

|| 95% CI for the median actual coverage is 98.8%.

¶ Data for only 9 subjects were available.

Data for only 10 subjects were available.

^ Data for only 11 subjects were available.

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