

ORIGINAL ARTICLE

Association of Activity Limitations and Lower-Limb Explosive Extensor Power in Ambulatory People With Stroke

David H. Saunders, MPhil, Carolyn A. Greig, PhD, Archie Young, MD, Gillian E. Mead, MD

ABSTRACT. Saunders DH, Greig CA, Young A, Mead GE. Association of activity limitations and lower-limb explosive extensor power in ambulatory people with stroke. *Arch Phys Med Rehabil* 2008;89:677-83.

Objective: To determine whether the explosive lower-limb extensor power of the affected and unaffected sides, and any asymmetry, are associated with activity limitations after stroke.

Design: Cross-sectional observational study of baseline data from a randomized controlled trial.

Setting: Measurements made in a hospital clinical research facility.

Participants: Community-dwelling (N=66) subjects with stroke who were independently ambulatory. Subjects' mean age was 72±10 years.

Interventions: Not applicable.

Main Outcome Measures: The lower-limb extensor power of each lower limb (in W/kg), performance of specific functional activities (comfortable walking velocity, Functional Reach Test, chair-rise time, Timed Up & Go test), and global indices of activity limitation (FIM instrument, Rivermead Mobility Index, Nottingham Extended Activities of Daily Living).

Results: Low lower-limb extensor power in either lower limb was the principal factor from among the confounders we recorded that significantly (R^2 range, .21–.46) predicted the limitation of specific functional activities, and low lower-limb extensor power in either lower limb was the principal predictive factor for global indices of activity limitation (R^2 range, .13–.38). The degree of asymmetry of lower-limb extensor power between legs was low and had little or no predictive value.

Conclusions: In ambulatory persons with stroke, activity limitations are associated with deficits in lower-limb extensor power of both lower limbs, and not the severity of any residual asymmetry. These findings suggest that interventions to increase lower-limb extensor power in both lower limbs might reduce activity limitations after stroke.

Key Words: Activities of daily living; Cerebrovascular accident; Physical fitness; Rehabilitation.

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THE ABILITY OF MUSCLE to generate force can be described in terms of muscle strength and explosive power. Strength is the magnitude of maximal force generation whereas explosive power output is a velocity-dependent characteristic defined as the greatest rate of work achieved during a single, ballistic, resisted contraction.¹ Explosive power deteriorates faster than strength (3%–4% vs 1%–2% a year) during healthy aging.²

Although strength and power are both important for execution of functional activities, lower-limb extensor power is more important than knee extensor strength for stair climbing, chair rising, and walking,^{3–5} and when impairment is asymmetrical, lower-limb extensor power is a better predictor of the frequency of falling than strength alone.⁶

Although people who have survived a stroke are often elderly, may be less active than prior to their stroke, and may have unilateral limb weakness, surprisingly little is known about the extent to which explosive power might be impaired and whether this might have adverse functional consequences. A pilot study of 11 ambulatory subjects 1 year after stroke with virtually no residual neurologic deficit⁷ found that both lower-limb extensor power and knee extensor muscle strength of both lower limbs were substantially lower than that of age- and sex-matched healthy subjects.^{8,9} Further unpublished data indicated that impairment in lower-limb extensor power was approximately double that of muscle strength.

Bilateral impairment in explosive power,⁷ or muscle strength,^{7,10,11} observed after stroke could arise for several reasons both directly and indirectly associated with stroke. First, bilateral motor deficits can arise directly from a unilateral lesion.¹² Second, reduced habitual physical activity, either before and/or after stroke may cause muscle atrophy.¹³ Third, the presence of comorbid disease (including poor nutrition) before and/or after stroke could impair motor function.

Low muscle strength after stroke is associated with poor performance of walking and stair climbing,¹⁴ chair rising,¹⁵ and impaired motor function.¹⁶ Only 1 small study (N=14) has explored the functional associations of explosive power after stroke.¹⁷ It showed that asymmetry in lower-limb extensor power was associated with reduced walking performance. The participants were unusually young (mean, 46.4±8.4y), and this relationship should be examined in people with stroke of more typical age (ie, >70y).¹⁸ Moreover, the relationship of power with other aspects of activity limitation should be examined to explore the potential benefits that might result from attempts to improve explosive power after stroke. This is important because fitness training can be presented in such a way as to specifically improve explosive power¹⁹ and this might reduce activity limitations, and so reduce participation restriction after stroke.

The aim of this study was to determine in older, ambulatory people with stroke, whether the lower-limb extensor power of the affected and unaffected sides, and any asymmetry, were associated with (1) performance of specific functional activities (reaching, walking, and rising from a chair), and (2) global indices of activity limitation (FIM instrument, Nottingham

From the Department of Physical Education, Sport and Leisure Studies (Saunders), and Geriatric Medicine, School of Clinical Sciences and Community Health, University of Edinburgh, Edinburgh, UK (Greig, Young, Mead).

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Reprint requests to David H. Saunders, MPhil, Scottish Centre for Physical Education Sport and Leisure Studies, University of Edinburgh, St Leonards Land, Holyrood Rd, Edinburgh, EH8 8AQ, Scotland, e-mail: Dave.Saunders@ed.ac.uk.

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Table 1: Participant Characteristics

Characteristics	n	Mean $\pm$ SD	Median (IQR)
Age (y)	NA	71.85 $\pm$ 9.91	NA
Sex (male/female)	36/30	NA	NA
Stature (m)	NA	1.67 $\pm$ 0.09	NA
Time from stroke (d)	NA	NA	152 (83–278)
Smoking history			
Smoker/Ex-/Non-/UC	25/12/28/1	NA	NA
Walking aids			
Stick/orthosis/zimmer/none	28/4/2/32	NA	NA
Body mass (kg)	NA	72.64 $\pm$ 15.29	NA
Stroke type (TAC/LAC/PAC/POC/UC)	2/19/32/12/1	NA	NA
Lesion type (ischemic/hemorrhagic/UC)	60/5/1	NA	NA
Lesion side (left/right/both/UC)	37/27/1/1	NA	NA
Hospital care (inpatient/outpatient)	56/10	NA	NA
Inpatient length of stay (d)	NA	NA	19 (9–44)
Blood pressure			
Systolic (mmHg)	NA	140.03 $\pm$ 18.10	NA
Diastolic (mmHg)	NA	73.16 $\pm$ 9.50	NA
Comorbidities			
Prior stroke	11	NA	NA
Prior transient ischemic attack	4	NA	NA
Ischemic heart disease	22	NA	NA
Left ventricular failure	2	NA	NA
Hypertension	31	NA	NA
Prior malignancy	7	NA	NA
Diabetes	3	NA	NA
Miscellaneous	50	NA	NA
None	5	NA	NA
Total no. per participant	NA	1.97 $\pm$ 1.35	NA

Abbreviations: IQR, interquartile range; LAC, lacunar; NA, not applicable; PAC, partial anterior circulation; POC, posterior circulation; SD, standard deviation; TAC, total anterior circulation; UC, unclear.

Extended Activities of Daily Living [NEADL], Rivermead Mobility Index [RMI]).

METHODS

Participants

All participants in this study (N=66) were recruited to a randomized trial of exercise or relaxation after stroke (table 1).²⁰ We

selected these 66 patients after screening 301 patients for trial eligibility (all 301 had required either inpatient or outpatient care after an acute stroke in 1 of 4 Edinburgh hospitals). Trial inclusion criteria were (1) independently ambulatory (with or without walking aids), (2) living within the recruitment catchment area, (3) completion of inpatient and outpatient stroke rehabilitation, and (4) absence of dysphasia or confusion judged severe enough to prevent safe participation in exercise

Table 2: Untransformed Data for Lower-Limb Extensor Power, Measures of Performance of Specific Functional Activities, and Global Indices of Activity Limitation

Variable	n	Mean $\pm$ SD	Median (IQR)
Lower-limb extensor power			
Affected side LLEP (W/kg)	64	NA	0.92 (0.53–1.49)*†
Unaffected side LLEP (W/kg)	61	NA	1.05 (0.73–1.56)†
Asymmetry ratio (aff LLEP/unaff LLEP)	60	0.89 $\pm$ 0.24	NA
Specific functional activities			
FRT (cm)	63	26.53 $\pm$ 6.65	NA
Comfortable walking velocity (m/s)	64	0.67 $\pm$ 0.24	NA
TUG test (s)	61	NA	11.68 (8.17–16.09)‡
Chair-rise time (s)	60	NA	1.28 (0.83–1.70)‡
Global indices of activity limitation			
FIM instrument	66	NA	117.5 (114–122)§
RMI	66	NA	13 (11–14)§
NEADL	65	NA	17 (12–19)§

Abbreviations: aff, affected; LLEP, lower-limb extensor power; unaff, unaffected.

*Affected LLEP lower than unaffected LLEP ($t=3.77$, $P<.001$).

†The non-normal data included in this table could be transformed to a normal distribution using square root.

‡The non-normal data included in this table could be transformed to a normal distribution using reciprocal.

§The non-normal data included in this table could be transformed to a normal distribution using square root of reflected data.

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