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RESEARCH PAPER

Fast gait speed and self-perceived balance as valid predictors and discriminators of independent community walking at 6 months post-stroke – a preliminary study

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Abstract

Purpose: To determine the validity of walking speed, muscle strength, function of the hemiparetic lower limb and self-perceived balance to predict and discriminate independent community walkers (ICW) within the first 6 months post-stroke. *Methods*: Inpatients with a first ischemic stroke (<3 months), able to walk, were evaluated (T_0) and re-evaluated after 6 months post-stroke (T_1). Comfortable, fast speed and the difference between fast and comfortable speed, muscle strength of knee flexors and extensors, sensory-motor function of the hemiparetic lower limb and self-perceived balance were assessed at T_0 and T_1. At T_1, a self- reported question was used to discriminate ICW versus Dependent Community Walkers (DCW). ROC curve analysis was used to determine valid predictive (T_0) and discriminative (T_1) cut-offs of ICW. *Results*: Only 25.7% of the 35 participants were ICW at T_1. Valid predictive cut-offs at T_0 were found for fast speed ($\geq$ 0.42 m/s) and Falls Efficacy Scale (<57). Valid discriminators were found at T1 for fast speed (>0.84 m/s) and FES (<18.50). *Conclusion*: Fast speed and self-perceived balance appear to be important characteristics of ICW at 6 months and may be useful early predictors of the potential for patients to achieve this. Further research is needed to ensure the precision of these functional cut-offs.

Implications for Rehabilitation

- Prognostic information is important for people with stroke and health services. The ability to walk faster than 0.42 m/s and a fear of falling on the Falls Efficacy Scale of less than 57 in the first 3 months after stroke predict who will be an independent community walker at 6 months.
- At 6 months after stroke, people who cannot walk faster than 0.84 m/s or who have a have Falls Efficacy Scale score <18.5 are unlikely to be walking independently in the community.
- Rehabilitation to promote independent walking should focus on walking speed, balance re-education and strategies to reduce fear of falling.

Background

Stroke is a major cause of disability worldwide [1,2]. For many patients, improving walking ability after a stroke is one of the most important goals [3], that is only accomplished when they are able to walk independently in the community [3,4].

Community walking (CW) has been defined as the ability to confidently walk in outdoor terrains [5], enabling visits to the supermarket, shopping and banking and enabling participation in social events or recreation activities [3]. Based on this definition, several functional measures have been used to reflect the dimensions of CW, in particular distance and temporal components and postural stability [6]. Walking speed has been considered a key outcome associated with CW [7] based on the assumption that subjects who cannot walk fast enough to safely cross the road or perform activities such as shopping with adequate speed will avoid walking in these out-of-home contexts [8]. However, using walking speed as a proxy measure for CW has been criticized, in part, because there is a lack of consensus about the required speed to walk independently in the community after a stroke [8]. Therefore, other functional measures, such as balance, have been considered relevant for describing the CW [9,10], as it could capture complementary aspects of this ability, providing information on the maintenance of postural stability while walking around physical obstacles [9].

Muscle strength and motor function of the hemiparetic lower limb have also been considered important components of functional walking capacity in the clinical context [11,12], but no studies have explored their relevance for discriminating different dependency levels of CW post-stroke. Theoretically, it may be possible to identify cut-off values for various functional components of walking which may have the potential to predict and discriminate different dependency levels of CW.

The aim of this study was to determine the potential of functional measures such as walking speed, muscle strength, function of the hemiparetic lower limb and self-perceived balance to predict and discriminate independent walkers in community within the first 6 months post-stroke.

Methods

Design and participants

A diagnostic study was conducted in four hospitals of the central region of Portugal. The study received full approval from the Institutional Ethics Committees of each hospital. In-patients with stroke were included if they (i) had a first ischemic stroke within the previous 3 months; (ii) were able to walk 5 m without a walking device but with human assistance, if needed; (iii) scored less than 34 on the Fugl-Meyer leg sub-scale indicating a lower limb sensory-motor impairment and (iv) had no previous history of severe cardiovascular diseases [13]. Subjects were excluded if they had (i) involvement of the brainstem or cerebellum structures and (ii) a score less than=27 in the Mini-Mental State Examination, indicative of cognitive impairment [14]. Before data collection, more detailed information about the study was provided and written informed consent was obtained. Forty subjects fulfilled the inclusion criteria and all agreed to participate in the study. Participants were then evaluated (T_0) and re-evaluated at 6 months post-stroke onset in their ambulatory setting (T_1).

Measures and procedures

Sociodemographic and anthropometric data (age, gender and body mass index) and clinical diagnosis [15] (partial anterior circulation syndrome – PACS; posterior circulation syndrome – POCS; and lacunar syndromes – LACS) were obtained to characterize the sample.

Walking speed, muscle strength, sensory-motor function of the hemiparetic lower limb and self-perceived balance were assessed at T_0 and T_1.

Walking speed is an easy and reliable measure of walking function and a highly recommended tool for monitoring the progress of hemiplegic gait [16]. Walking at comfortable and fast speeds provide complementary information on walking function after stroke [17,18]. Subjects with a significant difference between comfortable and fast speeds have greater potential to adapt to different modes of locomotion and, consequently, are more likely to be able to walk in the community. Walking speed was assessed with the 5-m walk test (5mWT), a shortened variation of the 10-m walk test [17] widely used in acute stroke patients to minimize participant fatigue [19]. Tape was placed on the floor, following the standard procedures [19]. Subjects performed three trials at their comfortable speed, with a 5-min interval between each trial and then repeated the same procedures at their fastest speed.

Muscle strength was measured in the knee flexors and extensors of the hemiparetic lower limb. A lack of knee muscle strength has been associated with reduced gait stability after a stroke [20,21]. Maximal isometric contractions values were recorded using a hand held dynamometer (Microfet, Hoogan Health Industries, Draper, UT) following standard procedures [11,22,23]. Three trials were performed for each muscle group, with 30- to 60-s interval between each trial.

Sensory-motor function of the hemiparetic lower limb was assessed using the leg sub-score of the Fugl-Meyer scale.

This scale is a well-designed, feasible and efficient clinical method for measuring sensory-motor stroke recovery [24]. The leg sub-score is a numerical scoring system for measurement of reflexes, joint range of motion, coordination and speed. *Each item is scored on* a three-point ordinal scale: 0 cannot perform; 1 perform partially and 2 perform fully. A maximum score of 34 *can be reached* [25].

Self-perceived balance was assessed using the Falls Efficacy Scale (FES) [26], which measures the fear of falling while performing common daily activities. After a stroke, the fear of falling is a common cause of dependence and decline in social participation. The FES, a valid and reliable measure of self- perceived balance in subjects with stroke [27,28], is a 10-item self-report questionnaire describing common daily activities, each rated from 1 (no fear of falling) to 10 (fear of falling). Subject with no fear of falling scores a minimum of 10; a maximum score of 100, means a substantial fear of falling.

The ability to walk in the community was assessed at T_1 using a self-reported question about difficulties in walking out of home after the stroke. Five responses were provided: (1) have no difficulty in walking in the community and do not require physical assistance or supervision; (2) mild difficulty in walking in the community, requiring supervision to walk far away from home; (3) moderate difficulty, needing supervision to walk near and far away from the home; (4) severe difficulty in walking in the community, always requiring physical assistance from another person; (5) does not walk outside of the home. Subjects who responded to the first category were categorized as ''Independent Community Walkers (ICW)''; those responding with categories 2–5 were categorized as ''Non-Independent Community Walkers (NICW)''.

Statistical analysis

Data analyses were performed using the Statistical Package for Social Sciences, Version 19 (SPSS Inc., Chicago, IL). A significance level of 0.05 was used for all statistical tests.

Medians and associated confidence interval at 95% were calculated for each functional measure for ICW and NICW groups. Mann–Whitney tests were performed to explore significant differences between groups at T_0, at T_1 and in their extent of recovery, considering median differences between T_1 and T_0. Data from functional measures were used at T_0 to determine functional predictors and at T_1 to determine discriminative functional characteristics of ICW.

A receiver operating characteristic (ROC) curve analysis was performed, the area under the curve (AUC: fair: 0.50–0.75; good: 0.75–0.92; very good: 0.92–0.97; and excellent: 0.97–1.00, probability [29]), sensitivity (true-positive rate) and specificity (false-negative rate) values and the percentage of agreement (the number of agreement scores divided by the total number of scores; minimum acceptable is of 80% [30]) were calculated to determine optimal cut-offs for functional components. An optimal cut-off is considered to be the one that maximizes the sum of sensitivity and specificity (participants that were DCW and are misclassified as ICW), assuming the highest sensitivity as the most important factor (as the focus was on the ICW identification). The cut-off values obtained were used to stratify subjects by dichotomous variables (i.e. 0 ''walking speed below the cut-off'' or 1 ''walking speed above the cut-off).

Results

Sample characteristics

Forty subjects with stroke (27 men) were assessed at T_0 however, five participants dropped out at T_1 due to: another stroke episode (*n=2*); hip fracture (*n*=1) and no reasons specified (*n=2*). Thirty-five (23 men) subjects with stroke (mean post-stroke onset of 45.5 ± 22.1 days at T_0) completed the study. On average, subjects with stroke were 69.3 ± 11.2 years old and had a mean body mass index of 25.5 ± 3.2 kg/m^2. Nineteen (54%) subjects were affected on the right side and 16 (46%) on the left side. The stroke event was classified as PACS for 15 subjects (43%), POCS for 4 subjects (11%) and LACS for 16 subjects (46%). Socio-demographic, anthropometric and clinical data of subjects with stroke are presented in Table 1.

Based on the self-administered question that distinguishes five levels of CW, 25.7% (*n*=9) of the subjects had no difficulty in walking in the community, 28.6% (*n=1*0) required supervision to walk far away from home, 22.9% (*n*=8) needed supervision to walk near or far away from home, 14.3% (*n*=5) always required physical assistance to walkoutside of the home and 8.6% (*n*= 3) could not walk in the community. Subjects allocated to the first level were classified as ICW (25.7%) and the others were classified as DCW (74.3%).

Results from functional measures of ICW and DCW at T_0, at T_1 and median differences between T_1 and T_0 are presented in Table 2.

Subjects identified as ICW presented with significantly higher comfortable walking speed (*p*=0.005), higher fast speed

Table 1. Socio-demographic, anthropometric and clinical characteristics of the subjects with stroke (n = 35).

Variable	Results
Age$_{(years)}$	69.3 ± 11.2 (44–87)
Gender$_{(F:M)}$	23$_M$;12$_F$;
BMI$_{(Kg/m2)}$	25.5 ± 3.2 (15.0–31.6)
Time post-stroke$_{(days)}$	45.5 ± 22.1 (13.0–90.0)
Hemiparesis$_{(R:L)}$	19$_R$;16$_L$
Stroke classification$_{(PACS;POCS;LACS)}$	15$_{PACS}$;4$_{POCS}$;16$_{LACI}$

PACS, partial anterior circulation syndrome; POCS, posterior circulation syndrome; LACS, lacunar syndromes; F, female; M, male; BMI, Body Mass Index; R, right; L, left.

(p=0.003), larger difference between fast and comfortable speed (p= 0.0004), higher strength of knee extensors (p= 0.016) and lower scores on the FES scale (p= 0.002) at T_0 than DCW. At T_1, ICW presented with significantly higher fast speed (p= 0.001), larger difference between fast and comfortable speed (p= 0.010) and significantly lower scores on the FES scale (p= 0.001) than DCW. Differences between groups in the extent of recovery from T_0 to T_1 (median differences) were borderline significant (p= 0.067) for the difference between fast and comfortable speed.

Functional predictors of independent walkers in the community

Table 3 presents cut-offs, AUC, sensitivity and specificity values and the percentage of agreement between dichotomous functional measures at T_0 and the subsequent classification into ICW or DCW (T_1).

Valid cut-offs, with a good probability (AUC between 0.75 and 0.92) of accurately predicting ICW subjects at an early stage post-stroke (T_0) were found for fast walking speed (AUC 0.83; p=0.004) and for the FES scale (AUC 0.83; p=0.003). A cut-off of $>$0.42 m/s for fast speed correctly allocated 8 ICW and 20 NICW and misclassified eight subjects as ICW who were DCW (80% agreement). A cut-off for FES scale $<$57 allocated correctly 8 ICW and 20 DCW and misclassified six subjects as DCW and one subject as ICW (80% agreement).

Functional discriminators of independent walkers in the community

Table 4 presents cut-offs, AUC, sensitivity and specificity values and the percentage of agreement between dichotomous functional measures (T_1) and the classification into ICW or DCW (T_1). Valid discriminative characteristics of ICW after a stroke were found for fast speed (AUC 0.95; p=0.001) and for FES scale (AUC 0.90; p= 0.001). A cut-off of $>$0.84 m/s for fast speed reveals that a very good probability (AUC between 0.92 and 0.97)to properly classify ICW's. This cut-off misclassified only three DCW that in fact were ICW (91.40% agreement). A cut-off of 518.50 for the FES scale reveals that a good probability of correctly classifying ICW's (AUC between 0.75 and 0.92). Using this cut-off, only five subjects who were ICW were incorrectly classified as DCW (85.71% agreement).

Table 2. Median (95% Confidence Interval) at T_0 and T_1 and median differences ($T_1 - T_0$) values of walking speed, balance, muscle strength and sensory-motor function of the hemiparetic lower limb for walking groups (Independent Community Walkers and Dependent Community Walkers).

Functional measures		ICW	DCW	p Value
Comfortable speed (m/s)	T_0	0.31 (0.19–0.49)	0.14 (0.13–0.21)	0.005**
	T_1	0.40 (0.29–0.69)	0.30 (0.26–0.39)	0.061
	MD	0.06 (-0.09–0.38)	0.17 (0.10–0.21)	0.469
Fast speed (m/s)	T_0	0.64 (0.43–1.04)	0.21 (0.22–0.42)	0.003**
	T_1	0.98 (0.91–1.27)	0.60 (0.43–0.67)	0.001**
	MD	0.34 (0.13–0.60)	0.16 (0.14–0.33)	0.210
Fast – Comfortable (m/s)	T_0	0.31 (0.17–0.61)	0.10 (0.07–0.23)	0.004**
	T_1	0.58 (0.39–0.83)	0.19 (0.13–0.32)	0.001**
	MD	0.28 (−0.09 to 53.31)	0.06 (−0.01 to (−0.16))	0.067
Knee extensors strength (kg/f)	T_0	7.57 (5.98–11.10)	6.02 (4.31–6.52)	0.016*
	T_1	8.67 (6.93–10.25)	7.45 (6.13–8.00)	0.101
	MD	−0.4 (−2.27 to 2.37)	1.7 (0.87–2.42)	0.239
Knee flexors strength (kg/f)	T_0	6.0 (4.30–7.11)	4.68 (3.30–5.63)	0.342
	T_1	7.27 (6.09–9.63)	6.90 (4.77–7.06)	0.197
	MD	2.1 (0.23–4.08)	1.53 (0.89–2.01)	0.271
Leg Sub-score (Fugl-Meyer)	T_0	24.00 (21.49–26.73)	24.50 (21.25–26.06)	0.838
	T_1	29.00 (24.73–31.94)	28.50 (24.22–29.40)	0.697
	MD	5.00 (0.68–7.76)	3.00 (1.72–4.59)	0.446
Falls Efficacy Scale	T_0	28.00 (16.16–52.51)	66.50 (56.00–70.92)	0.002**
	T_1	7.00 (3.69–13.65)	43.00 (32.27–51.65)	0.001**
	MD	−23.00 (−45.01 to (−6.32))	−19.00 (−30.89 to (−12.11))	0.643

Walking speed was assessed in meters per second (m/s); Knee extensor and flexor strength was assessed in kilograms of force (kg/f). ICW, Independent Community Walkers; DCW, Dependent Community Walkers; MD, median differences.

**p* Values of Mann–Whitney test <0.05; ***p* values < 0.01, for comparison between Independent Community Walkers and Dependent Community Walkers.

Table 3. Cut-off specified with area under the curve, sensitive and specificity values and percentage of agreement between dichotomonous functional measures at T_0 and the classification into ''Independent Community Walkers'' and ''Dependent Community Walkers'' at T_1.

Functional measures			Walking in the community (self-reported question)		
T_0	AUC	Cut-off	ICW	DCW	Agreement (%)
Comfortable Speed	0.81	>0.24 m/s <0.24 m/s	$2_{(TP)}$ $7_{(FN)}$ Sensitivity = 0.40	$3_{(FP)}$ $23_{(TN)}$ Specificity = 0.23	71.43
Fast Speed	0.83	>0.42 m/s <0.42 m/s	$8_{(TP)}$ $1_{(FN)}$ Sensitivity = 0.89	$6_{(FP)}$ $20_{(TN)}$ Specificity = 0.23	80.00
Fast Speed-Comfortable Speed	0.82	>0.16 m/s <0.16 m/s	$8_{(TP)}$ $1_{(FN)}$ Sensitivity = 0.89	$8_{(FP)}$ $18_{(TN)}$ Specificity = 0.31	74.28
Knee extensor strength (Kg/f)	0.77	>6.22 kg/f <6.22 kg/f	$9_{(TP)}$ $0_{(FN)}$ Sensitivity = 1.00	$12_{(FP)}$ $14_{(TN)}$ Specificity = 0.46	65.71
Knee flexor strength (kg/f)	0.61	>5.77 <5.77	$6_{(TP)}$ $3_{(FN)}$ Sensitivity = 0.27	$10_{(FP)}$ $16_{(TN)}$ Specificity = 0.78	25.71
Leg Sub-score (Fugl-Meyer)	0.48	>22.50 <22.50	$7_{(TP)}$ $2_{(FN)}$ Sensitivity = 0.78	$16_{(FP)}$ $10_{(TN)}$ Specificity = 0.62	48.57
Falls Efficacy Scale	0.83	<57.00 >57.00	$8_{(TP)}$ $1_{(FN)}$ Sensitivity = 89.0	$6_{(FP)}$ $20_{(TN)}$ Specificity = 23.0	80.0

AUC: Area under the curve. AUC values should be interpreted as follows: 0.50–0.75 = fair; 0.75–0.92 = good; 0.92–0.97 = very good; 0.97–1.00 = excellent probability. TP, number of true positive results; FP, number of false positive results; FN, number of false negative results; TN, number of true negative results. Sensitivity = TP/(TP + FN); Specificity = FP/(FP + TN). Agreement % = number of accurate results/total. ICW, Independent Community Walkers; DCW, Dependent Community Walkers.

Table 4. Cut-off specified with area under the curve, sensitive and specificity values and percentage of agreement between dichotomonous functional measures at T_1 and walking in the community classification (Independent Community Walkers and Dependent Community Walkers), at T_1.

Functional measures T_1	AUC	Cut-off	Walking in the community (self-reported question) ICW	NICW	Agreement (%)
Comfortable speed	0.71	>0.29 m/s <0.29 m/s	$7_{(TP)}$ $2_{(FN)}$ Sensitivity = 77.8	$12_{(FP)}$ $14_{(TN)}$ Specificity = 46.15	60.0
Fast speed	0.95	>0.84 m/s <0.84 m/s	$9_{(TP)}$ $0_{(FN)}$ Sensitivity = 1.0	$3_{(FP)}$ $23_{(TN)}$ Specificity = 11.54	91.40
Fast speed–Comfortable speed	0.86	>0.37 m/s <0.37 m/s	$8_{(TP)}$ $1_{(FN)}$ Sensitivity = 89.0	$8_{(FP)}$ $18_{(TN)}$ Specificity = 30.77	74.29
Knee extensors strength (kg/f)	0.69	>7.44 kg/f <7.44 kg/f	$7_{(TP)}$ $2_{(FN)}$ Sensitivity = 77.8	$13_{(FP)}$ $13_{(TN)}$ Specificity = 50.0	57.14
Knee flexors strength (kg/f)	0.65	>5.92 <5.92	$7_{(TP)}$ $2_{(FN)}$ Sensitivity = 77.8	$15_{(FP)}$ $11_{(TN)}$ Specificity = 44.0	51.43
Leg sub-score (Fulg–Meyer)	0.54	>23.50 <23.50	$8_{(TP)}$ $1_{(FN)}$ Sensitivity = 89.0	$18_{(FP)}$ $8_{(TN)}$ Specificity = 69.23	45.71
Falls efficacy scale	0.90	<18.50 >18.50	$9_{(TP)}$ $0_{(FN)}$ Sensitivity = 1.0	$5_{(FP)}$ $21_{(TN)}$ Specificity = 19.23	85.71

AUC: Area under the curve. AUC values should be interpreted as follows: 0.50–0.75 = fair; 0.75–0.92 = good; 0.92–0.97 = very good; 0.97–1.00 = excellent probability. TP, number of true positive results; FP, number of false positive results; FN, number of false negative results; TN, number of true negative results. Sensitivity = TP/(TP + FN); Specificity = FP/(FP + TN). Agreement % = number of accurate results/total. ICW, Independent Community Walkers; DCW, Dependent-Community Walkers.

Discussion

The main findings of this study were that fast speed and self- perceived balance were valid predictors (≤3 months post-stroke) and functional discriminative characteristics of ICW at 6 months post-stroke. These findings confirm the importance of walking speed for CW demonstrated in previous research. However, our findings are novel in identifying the importance of self- perceived balance as a predictor and characteristic of independent CW.

From a total of 35 subjects included, only 9 (25.7%) became ICW. In previous studies, 20–67% of subjects became ICW, after 9–48 months post-stroke [31,32]. The variability found in these percentages might be a result of differences in the sample characteristics (e.g. degree of functional impairment), in the time post-stroke when ICW were assessed or in the classification of CW. For example, some authors consider limited walkers (''independent in at least one moderate community activity .. .'') as ICW [32], whereas this study and that of Lafuente et al. [31] used more stringent definitions e.g. an ICW is a ''patient that could walk to stores, friends or activities in the vicinity without physical assistance or supervision''.

In this study, fast speed ≥0.42 m/s and FES scale scores ≤57 (at ≤3 months post-stroke) were valid predictors of ICW at 6 months. No other studies have conducted longitudinal research which enables the prediction of CW ability at 6 months post- stroke, based on parameters measured in the first 3 months. However, the predictive ability of functional measures has been tested in other periods of early rehabilitation. Uitman et al. [33] found a cut-off ≥0.86 m/s for comfortable speed, from inpatients (Functional Ambulation Categories 3) at discharge from a rehabilitation setting, as a valid predictor for ICW at approximately 9 months post-stroke. In addition, Bland et al. [34] found a score of ≥20 for Berg Balance Scale at a rehabilitation centre admission, as predictive of ICW at discharge 1–2 months post-stroke [34]. These previous results revealed a tendency for walking speed and measures of balance to predict ICW, which reinforce our results. There is, however, a noteworthy difference between these results and those of this study regarding the cut-offs for walking speed. In contrast to the Uitman et al. [33] study, who found valid cut-offs for comfortable speed, this study only demonstrated validity cut-offs for fast speed. The potential of fast walking training has been demonstrated by Lamontagne and Fung [17], in terms of improvement of kinematics and muscle activation patterns. Research to test whether training fast walking speed improves the number of ICW is needed.

Fast walking speeds ≥0.84 m/s demonstrated validity to functionally characterize ICW at 6 months post-stroke. The measurement of fast speed is currently not routinely undertaken during the first month of recovery, due to fears of causing fatigue or increasing the risk of falls [35]. However, given the relevance of fast speed to CW ability, it is advisable that research exploring the impact of various gait interventions include assessment of

fast walking speed.
Interestingly, the cut-off for fast speed identified in this study ($>$0.84 m/s) was lower than the cut-off for comfortable speed proposed by Lord and Rochester [3], despite both studies being conducted in similar periods of stroke recovery. These differences might reflect the variability in the walking test used: a 10-m walk test was used by Lord and Rochester [3] and a 5-m walk test was used in this study. It is known that walking speed achieved in longer distances tend to be higher, compared with speed attained over short distances [29]. Therefore, an accepted, standardized measure of walking speed is crucial for the establishment of accurate cut-offs to identify ICW.
In this study, ICW were characterized by FES scores $<$18.50,a very low fear of falling. The FES scale assesses self- perceived balance [36], whereas other measures, such as Berg Balance scale or Dynamic Gait Index [33], assess balance using direct observation. Importantly, FES is a simple and quick test that may be usefully undertaken in busy clinical settings to predict future walking outcomes. Functional balance and self-perceived balance are not always correlated [36] and therefore these two types of measures should be combined in future studies to further understand the contribution of balance to a patient's reintegration in the community.
False positive and false negative cases demonstrated some percentage of error when using the cut-offs for predicting ICW. Furthermore, the magnitude of the error may change if applied to subjects with different characteristics from those included in this study. Thus, these cut-offs should be applied with caution and used to inform clinicians about likely outcomes and most relevant treatment plans rather than for deciding on therapy discharge. Regular follow-ups to monitor recovery and accurately identify misclassified cases are recommended.

Study limitations and recommendations for future research

A number of possible limitations must be considered, regarding the present results. First, it must be noted that the definition used to discriminate ICW from NICW is different from others previously employed [4,32]. A standard definition of ICW is needed to allow a more equitable comparison of results across studies. Its development should account for the self- reported opinion of people with stroke and their caregivers about which criteria are really of importance for defining this activity.
In this study, subjects were assessed during the first 3 months post-stroke and followed up at 6 months post-stroke. Additional gains in walking ability may be possible beyond this time-point and the probability of more subjects becoming ICW might subsequently increase. Therefore, follow-up subjects at longer periods post-stroke, i.e. 12 months, might provide information on the statistical robustness of the cut-offs, by increasing the numerical representation of ICW.
Data collection on muscle strength was limited to isometric strength of the knee extensors and knee flexors muscles of the hemiparetic lower limb. Further research should collect data on isometric muscle strength for other hip muscles and for leg muscles in both hemiparetic and non-hemiparetic lower limbs. Thus, more comprehensive information will be provided about the contribution of lower limb muscle strength to CW.
In this study, a small sample was recruited (N=35). The construction of a logistic regression model, which is a ¼ popular statistical procedure to control the influence of potential cofounders, was therefore not possible. To further ensure the precision of cut-offs, future studies should recruit larger samples and the influence of factors, e.g. age, gender and time post-stroke at baseline or BMI should be considered in logistic regression models.

Conclusion

This research has confirmed that fast gait speed and self- perceived balance can predict and discriminate (with 80% accuracy) those able to walk independently in the community at 6 months post-stroke. The 5-mWT and the FES are quick, easy and cheap tests to perform in clinical practice and should be used routinely to guide goal setting and treatment planning and to reduce patient uncertainty about outcomes. Interventional research should target increasing walking speed, improving balance and reducing fear of falling to enhance community independence post-stroke.

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Declaration of interest

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